

Diverticular disease hospital admissions are increasing, with poor outcomes in the elderly and emergency admissions

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SUMMARY

Background

Diverticular disease has a changing disease pattern with limited epidemiological data.

Aim

To describe diverticular disease admission rates and associated outcomes through national population study.

Methods

Data were obtained from the English 'Hospital Episode Statistics' database between 1996 and 2006. Primary outcomes examined were 30-day overall and 1-year mortality, 28-day readmission rates and extended length of stay (LOS) beyond the 75th percentile (median inpatient LOS = 6 days). Multiple logistic regression analysis was used to determine independent predictors of these outcomes.

Results

Between the study dates 560 281 admissions with a primary diagnosis of diverticular disease were recorded in England. The national admission rate increased from 0.56 to 1.20 per 1000 population/year. 232 047 (41.4%) were inpatient admissions and, of these, 55 519 (23.9%) were elective and 176 528 (76.1%) emergency. Surgery was undertaken in 37 767 (16.3%). The 30-day mortality was 5.1% ($n = 6735$) and 1-year mortality was 14.5% ($n = 11 567$). The 28-day readmission rate was 9.6% ($n = 21 160$). Increasing age, comorbidity and emergency admission were independent predictors of all primary outcomes.

Conclusions

Diverticular disease admissions increased over the course of the study. Patients of increasing age, admitted as emergency and significant comorbidity should be identified, allowing management modification to optimize outcomes.

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INTRODUCTION

Diverticular disease (DD) is traditionally thought to be a disease of developed westernized countries with the prevalence reported to be rare prior to the age of 40, but increasing with age to up to 65% of patients in patients aged over 80 years.^{1, 2} Of major importance is that approximately 4–5% of those with diverticulae develop a complication. It is also estimated that 1–2% will require hospitalization and approximately half of those will require a surgical procedure. It has been estimated that twenty-nine percent of patients with an initial episode of conservatively managed acute diverticulitis, suffer either persistent symptoms or recurrence of diverticulitis at 5 years.³ The percentage of recurrent diverticulitis with complications was much higher (up to 54% at 5 years) in patients aged 50 years and younger who had an initial presentation of severe diverticulitis evident on CT.³ Despite this, mortality rates within this subgroup remains low (0–5%).^{3, 4}

There are several risk factors thought to be associated with the development of diverticulitis including obesity,⁵ red meat intake,⁶ smoking^{7, 8} and nonsteroidal anti-inflammatory drugs usage.⁹ Younger patients are thought to have a more aggressive course with more complications, higher recurrence rates and increased need for surgical interventions with young male patients being particularly susceptible.¹⁰

There is little contemporary epidemiological information that seeks to describe the current prevalence and outcomes associated with admission for complications of diverticular disease. In this study, we aimed to describe the admission rates for DD in the England and the associated outcomes. We also aimed to identify factors related to poor outcomes during admission.

METHODS

Data from 1996 to 2006 were obtained from the Hospital Episode Statistics (HES) database kept by the Department of Health which comprises patient-level data gathered from all individual English NHS (i.e. public) hospital trusts through Patient Administration Systems (PAS) or Hospital Information Systems (HIS).¹¹ It contains demographic details, clinical and administrative details of all inpatient and day case treatments delivered by National Health Service (NHS) hospitals in England. The data quality has been found to be appropriate for

the national monitoring of surgical outcomes.^{12, 13} The dataset included age, gender, admission methods, main diagnosis, up to thirteen diagnosis fields (six before April 2002), twelve operation fields (four prior to April 2002) coded using the Office of Population Censuses and Surveys Classification of Surgical Operations and Procedures (4th revision) (OPCS-4), length of hospital stay, ethnic group and mode of discharge. Ethnic groups within the database are presented as White, Black, Chinese, Indian subcontinent, 'Other' and 'Unknown'. In this study, to simplify presentation, we have considered only White, Black and consolidated the other groups to 'Other' and 'Unknown', and only the known ethnicities were used in logistic regression analysis.

Diagnoses are coded by International Statistical Classification of Diseases and Related Health Problems 10th revision (ICD-10). Records for all patients with Diverticular Disease as a primary cause for admission or comorbidity (ICD-10 code: K572 – DD of large intestine with perforation and abscess, K573 – DD of large intestine without perforation or abscess, K574 – DD of both small and large intestine with perforation and abscess, K575 – DD of both small and large intestine without perforation or abscess, K578 – DD of intestine part unspecified with perforation and abscess and K579 – DD of intestine part unspecified without perforation or abscess) were retrieved. The Charlson index was used to categorize comorbidities derived from secondary diagnosis codes.¹⁴ This is a score which predicts 1-year mortality for a patient who may have a range of comorbidities. Each condition is assigned with a score of 1 or above depending on the risk of dying associated with it and an amalgamation of these individual scores gives a total score which predicts mortality.

The number of admissions for Diverticular Disease coded by HES was examined and these admissions were aggregated using anonymized unique patient identifiers to evaluate the number of individual patients represented by the admissions within the study. Admissions were aggregated to identify the number of patients by year, the total number of patients admitted as inpatients and also segregated by mode of admission. Comparisons were drawn between the population within the study and the national English population data obtained from the United Kingdom Census.¹⁵ Mid-year population estimates were used as figures for comparison.

The primary outcomes examined were 30-day and 1-year mortality, 28-day readmission, the recurrent

admissions within 1-year of last admission (subcategorized 1-year readmission) and extended length of stay. Mortality outcomes included 30-day and 365-day all-cause mortality figures. Deaths occurring out of hospital were derived by linking Office of National Statistics (ONS) death certificate data to the HES record (HES/ONS linkage methodology–2002). We did not hold data used to calculate 365-day mortality rates before 2000. Furthermore, a time-lag exists between late death and this information being updated onto HES. For these reasons, only data relating to the period between 2000 and 2005 were used to determine 30-day mortality and data between 2000 and 2004 for 365-day mortality rates. Admissions with subsequent mortality were excluded from 28 day readmission data analysis and 1-year readmission was only evaluated from 1997 onwards as the capture of data from 1996 meant that this information pertaining to prior admissions was not available for this initial study year.

Multiple logistic regression analysis was performed to identify the independent predictors of these primary outcomes. Surgical intervention was a variable used throughout regression analysis, but was also regressed as an outcome specifically to identify if recurrent admission was an independent predictor of this. Statistical Package for Social Sciences version 14 for Windows (SPSS Inc., Chicago, IL, USA) was used. Where it was necessary to describe data with respect to the number of admissions in a corresponding number of patients, we described this as x [a% (y patients, b%)] admissions – where x = the absolute number of admissions and y = the absolute number of patients and a% = the percentage of total admissions and b% = the percentage of total patients.

RESULTS

Admission demographics

In total, there were 560 281 admissions (in 477 875 patients) to English NHS hospitals with a primary diagnosis of DD from 1996 to 2006. The latter included all in-patient and day case admissions. The number of patients with a primary diagnosis of DD increased from 27 067/48.519 million population to 60 772/50.714 million population which equated to 0.56 per 1000 population to 1.20 per 1000 population using English population Census data. The trends of admissions for DD are shown in Figure 1.

Overall median age at admission was 70 years (range 30–90 years). The mean age overall was 67.2 years (s.d. 12.6). Mean age of admissions to NHS hospitals decreased from 67.8 years (s.d. 12.44, 95% CI 67.7–68.0 years) in 1996 to 66.8 years (s.d. 12.75, 95% CI 66.7–66.8 years) in 2006 ($P < 0.001$). 42 796 admissions [7.6% ($n = 36\,034$ patients, 7.5%)] were for patients aged less than 50 years, 79 979 [14.3% ($n = 67\,970$ patients, 14.3%)] were for patients aged 50–59 years, 135 237 [24.1% ($n = 114\,032$ patients, 23.9%)] were for patients aged 60–69, 180 673 [32.2% ($n = 153\,552$ patients, 32.1%)] were for patients aged 70–79, 121 596 [21.7% ($n = 106\,287$ patients, 22.2%)] were for patients aged greater than 80 years. The age distribution for admissions for DD is shown in Figure 2 where it is compared with the English population age distribution obtained from the National Census data from 2001.¹⁵ Of total admissions, gender distribution equated to 216 369 [38.6% (186 720 patients, 39.1%)] male admissions compared with 343 912 [61.4% (291 155 patients, 60.9%)] female admissions with a male-to-female ratio of 1:1.59.

Comorbidity was categorized by Charlson index and 487 491 [87.0% ($n = 412\,101$ patients, 86.2%)] admissions were for patients who had an index score 0, 53 295 [9.5% ($n = 47\,598$ patients, 10.0%)] score 1, 13 550 [2.4% ($n = 12\,509$ patients, 2.6%)] score 2, 3760 [0.7% ($n = 3573$ patients, 0.7%)] score 3, 984 [0.2% ($n = 938$ patients, 0.2%)] score 4, 882 [0.2% ($n = 846$ patients, 0.2%)] score 5 and 319 [0.1% ($n = 310$ patients, 0.1%)] score 6 + . Ethnic group distribution of admissions was: 286 973 [71.7% ($n = 234\,548$ patients, 68.0%)] admissions for white patients, 2757 [0.7% ($n = 2188$, 0.6%)] admissions for black patients, 5114 [1.3% ($n = 12153$ patients, 3.5%)] admissions for patients assigned to 'other' ethnicity category and 105 504 [26.4% ($n = 96\,105$, 27.9%)] admissions for patients assigned to the 'unknown' ethnicity group. The categorization into ethnicities was

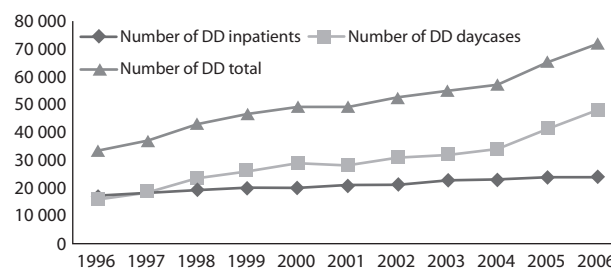


Figure 1. Number of DD admissions by year.

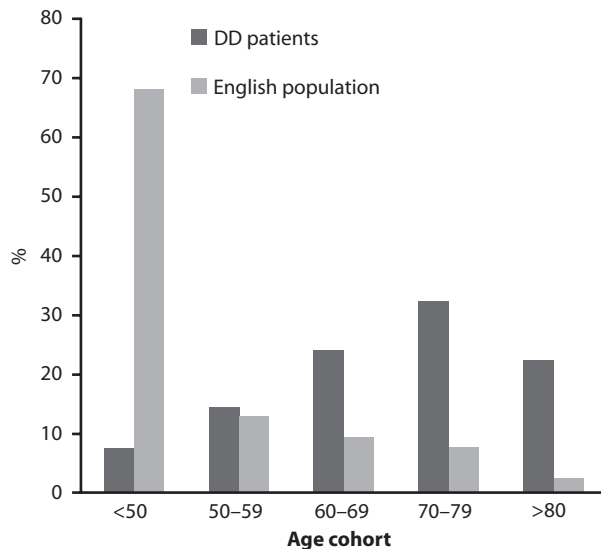


Figure 2. Percentage of DD patients compared with national population according to age cohorts (*x*-axis).

only available between 2000 and 2006. During this time, the proportion of admissions for white patients increased from 63.0% in 2000 to 81.8% (55.3% to 80.6% patients) in 2006 (Table 1). The proportion of black admissions increased from 0.4% to 0.9% (0.4% to 0.9% patients) (Table 1). Although these changes are small, they are statistically significant (admission as well as patient trends $P < 0.001$). Admissions from the Black ethnic group also represented a larger proportion of admissions from the youngest age group ($P < 0.001$) shown in Table 2.

Admissions were categorized into inpatients and day cases. The day case admissions were mostly for endoscopic procedures ($n = 315\,692$, 96.2%) and are not

considered further in the outcome analysis. Inpatient admissions were subcategorized as elective and emergency admissions. In total, 41.4% (232\,047/560\,281) overall admissions in 207\,981 patients were classified as inpatient admissions. Of inpatient admissions, 23.9% (55\,519/232\,047) were elective admissions in 52\,514 patients. The remaining 76.1% of inpatient admissions comprised 176\,528 emergency admissions in 155\,467 patients. The demographic characteristics of emergency and elective inpatient admissions to NHS hospitals are summarized in Table 3.

Admissions that included operative intervention occurred in 37\,767 [16.3% ($n = 37\,500$ patients, 18.0%)] cases. These interventions were undertaken on an emergency basis in 21\,926 (58.1%) admissions and on an elective basis in 15\,841 (41.9%). Right hemicolectomy was performed in 1883 (5.0%) cases, 2373 (6.3%) cases underwent left hemicolectomy, 10\,568 (28.0%) sigmoid colectomy, 4016 (10.6%) anterior resection, 14\,087 (37.3%) Hartmann's procedure and 4840 (12.8%) 'other' gastrointestinal surgery. The most common elective surgical admission was for sigmoid colectomy (42.9%, $n = 6801/15\,841$) and the most common emergency admission that included an operation was for Hartmann's procedure (56.9%, $n = 12\,473/21\,926$).

Inpatient endoscopy was undertaken in 63\,950 [27.6% ($n = 63\,243$ patients, 29.4%)] admissions. Five hundred and twenty-five (0.6%) admissions were recorded to have had ITU admissions, but these data were only available from 2003 onwards.

Outcomes

These were examined across all inpatient admissions for DD.

Table 1. Distribution of all diverticular disease admissions between 2000 and 2006 by ethnicity and by year

			Year of admission							<i>P</i> value
			2000	2001	2002	2003	2004	2005	2006	
Ethnicity	White	<i>N</i>	30967	30304	35281	38327	42007	51255	58832	<0.001
		%	63.0	61.6	67.2	69.8	73.6	78.2	81.8	
	Black	<i>N</i>	218	277	302	367	445	510	638	<0.001
		%	0.4	0.6	0.6	0.7	0.8	0.8	0.9	
	Other	<i>N</i>	700	415	620	561	674	1017	1127	<0.001
		%	1.4	0.8	1.2	1.0	1.2	1.6	1.6	
	Unknown	<i>N</i>	17306	18188	16318	15623	13944	12757	11368	
		%	35.2	37.0	31.1	28.5	24.4	19.5	15.8	
	Total	<i>N</i>	49191	49184	52521	54878	57070	65539	71965	

Table 2. Distribution of all diverticular disease admissions between 2000 and 2006 by age group and ethnicity

			Age group				
			<50	50–59	60–69	70–79	>80
Ethnicity	White	N admissions	21813	40572	67314	92569	64705
		%	68.9	69.0	70.8	72.7	74.0
		N patients	17861	33477	54949	74946	53315
	Black	%	66.5	66.0	67.3	68.6	69.8
		N admissions	449	332	793	887	296
		%	1.4	0.6	0.8	0.7	0.3
	Other	N patients	361	280	636	682	229
		%	1.3	0.6	0.8	0.6	0.3
		N admissions	674	931	1369	1417	723
	Unknown	%	2.1	1.6	1.4	1.1	0.8
		N patients	827	1540	2887	4244	2655
		%	3.1	3.0	3.5	3.9	3.5
	Total	N admissions	8740	16948	25659	32380	21777
		%	27.6	28.8	27.0	25.5	24.9
		N patients	7807	15412	23220	29432	20234
		%	29.1	30.4	28.4	26.9	26.5
		N admissions	31676	58783	95135	127253	87501
		%	100	100	100	100	100
		N patients	26856	50709	81692	109304	76433
		%	100	100	100	100	100

Percentages refer to the column totals, i.e. % within each age group.

Mortality. The 30-day mortality rate (between study years 2000 and 2005) occurred in 5.1% (6735/132 751 admissions; $n = 6607$ patients) and 1-year mortality in 14.5% ($n = 11\ 567/79\ 581$ patients) (Table 4). One-year mortality was calculated in individual patients rather than admissions to prevent double counting in repeat admissions. Overall surgical admission mortality between April 2000 and March 2005 was 10.1% (2109/18 822) and 15.5% (2159/13 916) at 30-days and 1-year respectively. Of those who underwent elective surgery, the mortality rate was 2.1% and the 1-year mortality rate was 5.3% (Table 4). In those who underwent emergency surgery, the 30-day and 1-year admission mortality rates were 15.9% and 22.8% respectively (Table 4).

Re-admissions. The overall 28-day readmission rate following index admission was 9.6% (21 160/220 336) (Table 5). Of inpatient admissions, 85.1% (182 632/214 739) had been admitted within the year prior to index admission (therefore qualifying as readmission within 1-year) (Table 5). Both 28-day and

1-year readmission was more likely in patients aged over 80 years, women, of white ethnicity, increasing Charlson index, admitted as an emergency as well as those who had undergone surgery (Table 5). From 1997 onwards, of the 34 674 admissions who underwent surgery 26 047 (75.1%) had been admitted at least once in the preceding year [$n = 26\ 056/34\ 482$, 75.6% patients]. Of the admissions who underwent emergency surgery, 99.5% (20 046/20 150) were admitted in the preceding year [$n = 20\ 010/20\ 111$, 99.5% patients].

Length of stay. For inpatients, median length of stay (LOS) was 6 days (interquartile range 9 days) with the 75th percentile equating to 12 days. Of inpatient admissions, 23.4% (54 279/232 047) exceeded the 75th percentile for admission stay. Most admissions that exceeded the 75th percentile were aged >80 years, women, were of white ethnicity, an emergency admission and patients who underwent surgery (Table 5). Of those who underwent surgery, an extended LOS was more

Table 3. Demographic characteristics of all in-patient DD admissions from 1996 to 2006

		Emergency			Elective			Total		
		<i>N</i> admissions	%	<i>N</i> patients	<i>N</i> admissions	%	<i>N</i> patients	<i>N</i> admissions	%	<i>N</i> patients
Total		176 528	76.1	(155 467)	55 519	23.9	(52 514)	232 047	100.0	(207 981)
Age	<50	16 609	9.4	(14 543)	2989	5.4	(2784)	19 598	8.5	(17 327)
	50–59	22 347	12.7	(19 600)	5584	10.1	(5272)	27 931	12.0	(24 872)
	60–69	32 236	18.3	(28304)	10 267	18.5	(9640)	42 503	18.3	(37 944)
	70–79	50 686	28.7	(44372)	18 534	33.4	(17 458)	69 220	29.8	(61 830)
	≥80	54 650	31.0	(48648)	18 145	32.7	(17 360)	72 795	31.4	(66 008)
Gender	Male	60 850	34.5	(54702)	19 364	34.9	(18 402)	80 214	34.6	(73 104)
	Female	115 678	65.5	(100765)	36 155	65.1	(34 112)	151 833	65.4	(134 877)
Ethnic group*	White	88 026	72.7	(75712)	27 410	76.8	(25 775)	115 436	73.6	(101 487)
	Black	916	0.8	(760)	212	0.6	(204)	1128	0.7	(964)
	Other	1624	1.3	(51443)	20 178	56.5	(19 180)	77 210	49.2	(70 623)
	Unknown	30 554	25.2	(27552)	7719	21.6	(7355)	38 273	24.4	(34 907)
Quintile of Deprivation	1	27 868	15.8	(24933)	8261	14.9	(7853)	36 129	15.6	(32 786)
	2	35 545	20.1	(31458)	11 276	20.3	(10 659)	46 821	20.2	(42 117)
5 = most deprived	3	38 089	21.6	(33604)	11 832	21.3	(11 203)	49 921	21.5	(44 807)
	4	39 346	22.3	(34175)	12 399	22.3	(11 692)	51 745	22.3	(45 867)
	5	34 674	19.6	(30300)	11 493	20.7	(10 852)	46 167	19.9	(41 152)
Charlson comorbidity	0	134 445	76.2	(116982)	44 776	80.7	(42 123)	179 221	77.2	(159 105)
	1	29 188	16.5	(26368)	7929	14.3	(7641)	37 117	16.0	(34 009)
	2	8508	4.8	(7904)	2025	3.7	(1977)	10 533	4.5	(9881)
	3	2723	1.5	(2604)	536	1.0	(526)	3259	1.4	(3130)
	4	732	0.4	(706)	145	0.3	(142)	877	0.4	(848)
	5	674	0.4	(650)	86	0.2	(83)	760	0.3	(733)
	6+	258	0.2	(253)	22	0.04	(22)	280	0.1	(275)
Surgery		21 926	12.4	(21850)	15 841	28.5	(15 650)	37 767	16.3	(37 500)

* The denominator for ethnic group was different from that for the other variables as data were only available from 2000 to 2006.

The numbers of patients admitted are represented in parentheses.

commonly seen following emergency surgery (64.7%) (Table 5).

Multivariate analysis

All primary outcomes were regressed in regression models and adjusted for: age, gender, ethnicity (White, Black and Other), Charlson index score, category of admission (emergency/elective) and whether patients underwent bowel surgery.

Mortality. Independent predictors of mortality were investigated in logistic regression analyses. Significant covariates predictive of 30-day and 1-year mortality included: increasing age, Caucasian ethnicity, emergency admission status, surgical intervention and the

presence of comorbidity (Table 6). Interestingly, female gender was identified as an independent predictor of 30-day mortality (OR = 1.10, $P = 0.009$); however, women were less likely than male counterparts to die within 1-year of admission (OR = 0.86, $P < 0.001$).

Readmission. In the regression models 1-year readmission was less likely in admissions for all older age groups compared with those under 50 years ($P < 0.001$) (Table 7). Short-term readmission rates (i.e. within 28 days) were less likely in the 50–59 year age group (OR = 0.92, $P = 0.020$), but increasingly likely amongst older age groups ($P < 0.001$). Increasing Charlson index score up to 6 was independently and positively related to both 28 day and 1-year readmission ($P < 0.001$). Emergency admission independently predicted 28 day

Table 4. Subgroup analysis of inpatient admissions resulting in 30-day and 1-year mortality

		30-day death			One-year death		
		<i>N</i> Admissions			<i>N</i> Patients‡		
		Yes	No	%*	Yes	No	%*
Total		6735/132751†	115036	5.1	11567/79581‡	68014	14.5
Age	<50	41	11747	0.4	66	6846	1.0
	50–59	173	16414	1.0	279	9650	2.8
	60–69	588	23102	2.5	1050	12930	7.5
	70–79	2023	36495	5.3	3390	19559	14.8
	≥80	3910	38258	9.3	6782	19029	26.3
Gender	Males	1958	44387	4.2	3809	24396	13.5
	Females	4777	81629	5.5	7758	43618	15.1
Ethnicity	White	4676	90799	4.9	8175	47359	14.7
	Black	12	896	1.3	32	481	6.2
	Other	54	1536	3.4	168	1484	10.2
Charlson Index	0	3505	97220	3.5	6599	53279	11.0
	1	1629	20768	7.3	2620	10975	19.3
	2	859	5544	13.4	1305	2692	32.7
	3	377	1612	19.0	563	758	42.6
	4	120	442	21.4	168	185	47.6
	5	166	318	34.3	213	101	67.8
	6+	79	112	41.4	99	24	80.5
Admission category	Emergency	6268	96049	6.1	9897	50388	16.4
	Elective	467	29967	1.5	1670	17626	8.7
Surgery	Yes	2109	18822	10.1	2159	11757	15.5
	Emergency surgery	1923	10198	15.9	1852	6281	22.8
	Elective surgery	186	8624	2.1	307	5476	5.3

* The percentage is calculated within each variable subgroup, e.g. 30-day mortality occurred in 0.35% of admissions under the age of 50.

† The denominator for 30-day admissions was from 2000–2005 as prior to this, these variables were invalid.

‡ Aggregated patient numbers were used to quantify 1-year mortality so as to prevent double counting of mortality subsequent to repeat admissions; patients from only 2000–2004 were used as the data were only valid between these dates.

and 1-year readmission (OR = 1.93, $P < 0.001$ and OR = 349.63, $P < 0.001$ respectively). When the need to undergo surgery (or not) was used as a binary outcome measure and adjusted for age, gender, comorbidity and type of admission, admission within the preceding year represented an independent predictor for surgical intervention (OR = 1.14, $P < 0.001$).

Length of stay. Increasing age was an independent predictor of an inpatient hospital stay exceeding the 75th percentile of 12 days. Table 7 describes the multiple logistic regression for extended LOS. Admissions aged over 80 had significantly enhanced risk of an extended stay (OR = 6.38, $P < 0.001$) when compared with those aged <50 years. Women were also more

likely to have an extended stay than men (OR = 1.15, $P < 0.001$). Increasing comorbidity score predicted increasing likelihood of extended LOS ($P < 0.001$). Similarly, emergency admission (OR = 3.36, $P < 0.001$) and undergoing surgery was more likely to result in prolonged LOS (OR = 12.74, $P < 0.001$).

DISCUSSION

Initial writings suggest the incidence of colonic diverticula to be 30% at the age of 50, 50% in those over 70 and in 66% in people over 85 based on post-mortem studies.¹⁶ The frequency of symptomatic disease resulting in hospital admissions has been shown to be increased in the last century. Hospital admission rates for colonic diverticulitis in north-east Scotland showed

Table 5. Subgroup analysis of inpatient admissions resulting in 28-day readmission, 1-year readmission and extended LOS (≥ 12 days)

		One-year readmission <i>N</i> = 214739†			28-day readmission <i>N</i> = 220336‡			In-patient LOS > 12 days <i>N</i> = 232047§		
		Yes	No	%*	Yes	No	%*	Yes	No	%*
Total		182632	32107	85.1	21160	199176	9.6	54279	177768	23.4
Age	<50	17004	1404	92.4	1679	17846	8.6	2322	17276	11.9
	50–59	23031	3087	88.2	2149	25474	7.8	4333	23598	15.5
	60–69	33050	6137	84.3	3761	37656	9.1	8554	33949	20.1
	70–79	52688	11085	82.6	6454	59080	9.9	17554	51666	25.4
	≥ 80	56859	10394	84.5	7117	59120	10.7	21516	51279	29.6
Gender	Males	63657	10937	85.3	7157	69746	9.3	16994	63220	21.2
	Females	118975	21170	84.9	14003	129430	9.8	37285	114548	24.6
Ethnicity	White	98959	16477	85.7	11796	98076	10.7	27291	88145	23.6
	Black	1021	107	90.5	107	1002	9.7	229	899	20.3
	Other	49668	10234	82.9	6373	66859	8.7	18319	58891	23.7
Charlson Index	0	138228	26444	83.9	15236	157879	8.8	37464	141757	20.9
	1	30868	4286	87.8	3961	30263	11.6	10790	26327	29.1
	2	8974	1004	89.9	1348	7686	14.9	3854	6679	36.6
	3	2834	268	91.4	390	2213	15.0	1329	1930	40.8
	4	774	63	92.5	119	558	17.6	389	488	44.4
	5	695	31	95.7	86	434	16.5	333	427	43.8
	6+	259	11	95.9	20	143	12.3	120	160	42.9
Admission	Emergency	163155	716	99.6	17803	147666	10.8	45156	131372	25.6
Category	Elective	19477	31391	38.3	3357	51510	6.1	9123	46396	16.4
Surgery	Yes	26047	8627	75.1	3320	30134	9.9	20823	16944	55.1
	Emergency	20046	104	99.5	1832	16175	10.2	14188	7738	64.7
	Elective	6001	8523	41.3	1488	13959	9.6	6635	9206	41.9

* The percentage is calculated within each variable subgroup as for Table 5.

† The denominator for 1-year readmissions only included cases from 1997 onwards as this variable was not valid prior to 1997.

‡ The denominator for 28-day readmission excluded all index admissions ending in death.

§ All inpatient admissions were included.

an increase from 12.8 to 23.5 per 100 000 population per year between 1958–1961 and 1968–1971.¹⁷ In Finland, the incidence of admissions for perforated sigmoid diverticular disease increased from 2.4 per 100 000 population in 1986 to 3.8 in 2000.¹⁸ In the UK, the incidence of perforated diverticular disease has a reported increase of 4.0 per 100 000 per year.¹⁹

Demographics

In this study, we have examined the number of hospital admissions for Diverticular Disease in England reflecting the frequency of symptomatic disease. There has been a doubling in admission rates from 0.56 to 1.20 per 1000 population between 1996 and 2006. This is in keeping with the increases seen in the stud-

ies above as well as in the studies of other authors.²⁰ The overall patterns are described for all Diverticular Disease admissions as categorized by ICD codes K572–579; however, the outcome analysis is only for inpatient admissions. Although it is fair to conclude that inpatient admissions were for symptomatic Diverticular Disease, we have not differentiated between diverticulitis and symptomatic DD as despite coding differences, no clinical, biochemical or radiological data are available from this dataset and therefore we did not feel that these distinctions could be made reliably. As we aimed to describe the epidemiology and admission patterns of this disease, we do not feel that the lack of this distinction detracts from the analysis.

In the year 2005/6, we found that 23, 942 inpatient admissions for DD took place. In comparison, inpatient

Table 6. Multiple logistic regression analysis for 30-day (between 2000 and 2005) and 1-year total mortality (between 2000 and 2004) in primary inpatient admissions for diverticular disease

		30-day death Cases included in analysis = 97 973				One-year death Cases included in analysis = 78 078			
Factor		OR	95% CI		P value	OR	95% CI		P value
Age	<50				<0.001				<0.001
	50–59 vs. <50	2.80	1.88	4.16	<0.001	3.01	2.29	3.95	<0.001
	60–69 vs. <50	6.39	4.42	9.23	<0.001	7.58	5.88	9.77	<0.001
	70–79 vs. <50	14.50	10.13	20.77	<0.001	16.77	13.08	21.51	<0.001
	≥80 vs. <50	32.15	22.47	45.99	<0.001	37.67	29.39	48.27	<0.001
Gender	Males vs. Females	1.10	1.02	1.17	0.009	0.86	0.82	0.90	<0.001
Ethnicity					<0.001				<0.001
	Black vs. White	0.32	0.18	0.58	<0.001	0.53	0.39	0.72	<0.001
	Other vs. White	0.86	0.64	1.14	0.291	0.87	0.71	1.06	0.167
Charlson Index					<0.001				<0.001
	1 vs. 0	1.84	1.71	1.98	<0.001	1.62	1.54	1.71	<0.001
	2 vs. 0	3.23	2.93	3.57	<0.001	3.04	2.81	3.29	<0.001
	3 vs. 0	4.58	3.96	5.30	<0.001	4.47	3.93	5.07	<0.001
	4 vs. 0	6.03	4.70	7.73	<0.001	6.71	5.32	8.46	<0.001
	5 vs. 0	10.09	7.88	12.93	<0.001	15.66	11.98	20.47	<0.001
	6 + vs. 0	17.11	11.80	24.79	<0.001	36.13	21.49	60.75	<0.001
Admission category	Emergency vs. Elective	5.15	4.60	5.76	<0.001	2.34	2.20	2.48	<0.001
Management	Surgery vs. Conservative	4.84	4.50	5.20	<0.001	1.88	1.77	2.00	<0.001

admissions for Inflammatory Bowel Disease, accounted for 34 754 admissions (Ulcerative Colitis = 16 082, Crohn's Disease = 18 672) as coded by the HES database overall.²¹ In comparison, colonic cancer accounted for 36 167 inpatient admissions over the same period.²¹ DD therefore has a significant impact on health care in the UK for Digestive Disease as the morbidity from it outweighs that caused by Inflammatory Bowel Disease. Sixteen percent of DD admissions underwent surgery; the 28-day readmission rate was 9.6% and 1-year readmission 85.1% with 23.4% having extended inpatient length of stay. There was 5.1% and 14.5% mortality at 30-days and 1-year respectively. All these findings support the assumption that DD is an important health problem and is likely to impact cost, quality of life and service provision.

Although the increase in admissions seen in this study may, in part, be attributable to an ageing population in the UK based on Census data¹⁵ the mean age within the study is seen to decrease significantly from 67.8 in 1996 to 66.8 years in 2006, although this change is small.

There is an increasing proportion of patients overall from the Black ethnic population from 0.4% in 2000 to 0.9% in 2006. This subgroup is traditionally thought to be exempt from this condition because of

higher fibre diets.²² This may not be true for migrant populations as it is known that adaptation to local dietary habits occurs.²³ We suggest that the pathophysiological mechanisms involved in the development of this condition are more complex than traditionally believed including ageing bowel, dietary, social and behavioural factors. Intrinsic physiological mechanisms may have a role such as neurotransmitter imbalances. However, during the course of the study, there was growth in the migrant population to the UK, which may also contribute to the increase.¹⁵ Ethnic data, however, need to be considered with caution as ethnic codes were only introduced in 1996, and from April 2001 the codes were changed to conform to Census classification.²¹ Up to 2007, ethnicity is known to be only 70% accurate with a fair proportion recorded as 'Other', when most are probably 'White'. Prior to this period, there were even more inaccuracies making it difficult to draw firm conclusions about the role of ethnicity within this study. The increase in DD has also previously been attributed to overdiagnosis.²⁰ While this may be the case, this study represents a symptomatic population and the increase seen in this group may be real. The preponderance of females with DD seen in this study is in agreement with most other

Table 7. Multiple logistic regression analysis of readmission within 28 days, 1-year and extended inpatient stay (≥ 12 days i.e. 75th percentile) in primary inpatient admissions for diverticular disease

Factor	Readmission 28 days Cases included in analysis = 184 213				Readmission 1-year Cases included in analysis = 176 466				Inpatient LOS>12 days Cases included in analysis = 193 774			
	OR	95% CI	<i>P</i> value		OR	95% CI	<i>P</i> value		OR	95% CI	<i>P</i> value	
Age			<0.001				<0.001				<0.001	
	50–59 vs. <50	0.92 0.85 0.99	0.020		0.67 0.60 0.73	<0.001			1.58 1.48 1.69	<0.001		
	60–69 vs. <50	1.07 1.00 1.15	0.039		0.52 0.48 0.57	<0.001			2.38 2.24 2.53	<0.001		
	70–79 vs. <50	1.17 1.10 1.25	<0.001		0.52 0.48 0.57	<0.001			4.01 3.79 4.25	<0.001		
	≥ 80 vs. <50	1.32 1.24 1.41	<0.001		0.62 0.56 0.68	<0.001			6.38 6.02 6.76	<0.001		
Gender	Males vs. females	1.03 1.00 1.07	0.053		0.94 0.91 0.98	0.006			1.15 1.12 1.18	<0.001		
Ethnicity			<0.001				<0.001				0.679	
	Black vs. White	0.89 0.72 1.08	0.240		1.38 1.06 1.80	0.018			1.06 0.90 1.24	0.493		
	Other vs. White	0.82 0.79 0.85	<0.001		0.82 0.79 0.86	<0.001			0.99 0.97 1.02	0.611		
Charlson Index			<0.001				<0.001				<0.001	
	1 vs. 0	1.29 1.24 1.34	<0.001		1.40 1.33 1.48	<0.001			1.48 1.43 1.52	<0.001		
	2 vs. 0	1.69 1.58 1.80	<0.001		1.69 1.53 1.86	<0.001			1.90 1.80 1.99	<0.001		
	3 vs. 0	1.70 1.51 1.91	<0.001		1.73 1.44 2.08	<0.001			2.21 2.03 2.41	<0.001		
	4 vs. 0	2.00 1.61 2.47	<0.001		2.37 1.64 3.42	<0.001			2.76 2.35 3.24	<0.001		
	5 vs. 0	1.68 1.30 2.17	<0.001		2.87 1.80 4.57	<0.001			2.06 1.71 2.47	<0.001		
	6 + vs. 0	1.08 0.62 1.88	0.793		1.53 0.61 3.85	0.362			1.67 1.22 2.27	0.001		
Admission Category	Emergency vs. Elective	1.93 1.85 2.02	<0.001		349.63 321.62 380.08	<0.001			3.36 3.25 3.47	<0.001		
Management	Surgery vs. Conservative	0.92 0.85 0.99	<0.001		1.14 1.09 1.19	<0.001			12.74 12.34 13.16	<0.001		

studies.^{17, 24} The male-to-female ratio here is 1:1.6 compared with a national population ratio of 1:1.1.

Outcomes and logistic regression analysis

There is an overall 30-day mortality rate of 5.1% and a 1-year mortality rate of 14.5%. Other studies have quoted an overall mortality rates in the region of 3%.^{25, 26} Surgical mortality has been varyingly reported to be 16.7%²⁷ or 6.1%²⁶ which is similar to the current mortality rates of 10.1% and 15.5% at 30-days and 1-year respectively.

For both categories of mortality, increasing age was an important predictor with high odds ratios. It was also a significant predictor of 28 day readmission and extended LOS. Elderly patients are traditionally thought to be most commonly affected by DD^{1, 16} and have previously been cited to be of higher risk of poor outcomes although usually confounded by comorbidity.²⁵ In this study, the largest number of admissions was seen in the 70–79 age group, but the worst outcomes are seen in the oldest group; also, as regressed against comorbidity, we know that age in itself in an

important predictor. Readmission at 1-year, however, was less likely in the older age groups. This may be related to the likelihood of death.

Gender differences (male vs. female) were significant in the regression models investigating 30-day mortality (OR = 1.10, $P = 0.009$), 1-year mortality (OR = 0.86, $P < 0.001$), 1-year readmission (OR = 0.94, $P = 0.006$) and extended LOS (OR = 1.15, $P < 0.001$). As these are not pronounced differences, these may not be particularly important predictors of outcomes. White ethnic groups were also most likely to suffer mortality but this, despite changes seen in ethnic minorities, remains the largest population with DD. This group was also more likely to have a readmission. Again, the population size is likely to explain this finding.

Increasing comorbidity measured by Charlson index correlates well with increasing mortality both at 30-days and 1-year as well as conferring a risk for readmission. These are independent outcome predictors and may be used as a marker in planned management of this condition as this can be assessed and optimized electively.

Undergoing surgery was an independent predictor of mortality and extended LOS. However, for readmission, the ORs were relatively small, although statistically significant. When the need to undergo surgery was regressed as an outcome measure, admission in the preceding year was identified as a positive predictor. In contrast, surgery did not strongly predispose to recurrent admission, suggesting that surgery, emergency or otherwise, may still benefit symptomatic patients.

The patient groups most at risk of mortality are the elderly as well as patients with co morbidities, those admitted as emergencies and patients that undergo emergency surgery. Surgery, particularly emergency surgery, presents an extremely high risk to the elderly with significant co morbidity. However, this may be unavoidable in this cohort of patients.²⁸ Where possible, preventative measures that seek to avoid the need for future surgery represent an ideal. As recurrent admission is a clear risk factor for surgery, careful follow-up with the use of antibiotics, mesalazine (mesalamine)^{29, 30} and perhaps probiotics³⁰ may be serve to avoid future adverse outcomes. Further investigation in this area is required to determine whether patient groups at substantial risk of repeat episodes that potentially lead to surgery can be protected once the disease has been established.

Hospital Episode Statistics has been previously used in the assessment of clinical outcomes and although its accuracy has been questioned because of data omissions and erroneous data entry.³¹ However, when evaluated against national, prospectively collected

datasets in colorectal, vascular and cardiac specialties, it has found to be comparable.³² More specifically and possibly of more relevance is that when it was compared with a UK national colorectal database, it showed that overall there was agreement between reported caseload and mortality at a national level, but at hospital level, reporting was not as accurate with the colorectal database.³³ Additionally, the wide coverage and ease of access offered by HES it can be used as a tool that permits service audit, facilitating strategic and political decision making.³⁴

This represents the first study of its kind, presenting national epidemiological data relating to DD from the early 21st century. The most significant findings are that the presentation for this disease is increasing. The worst clinical outcomes are strongly and consistently predicted by advanced patient age and comorbidity. Poor outcomes that relate to the latter patient characteristics are further exaggerated when patients undergo emergency admission or require surgery. In the future, preventative medical management strategies may improve outcomes amongst these high-risk patient groups.

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