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ORIGINAL ARTICLE

Diverticular disease epidemiology: acute hospitalisations are growing fastest in young men

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Abstract

Background Older age has long been linked to risk of diverticulitis, but the epidemiology is seldom described for a national population. The aim of this study was to investigate age- and gender differences in incidence, temporal trends, lifetime risk and prevalence related to acute diverticulitis hospitalisations in New Zealand.

Methods Records of all hospitalisations with diverticulitis the primary diagnosis were obtained from the Ministry of Health for the period 2000–2015. The first acute diverticulitis admission recorded for an individual was taken as an incident event; all others were classified as recurrent. Trends in age- and sex-specific and age-standardised incidence rates are described, and lifetime risk and prevalence estimated.

Results Over the 16 years from 2000 to 2015, 37,234 acute hospitalisations for diverticulitis were recorded in 28,329 people aged 30 + years (median = 66 years). Rates of incident hospitalisations rose with age, from 5/10,000 person-years at age 50–54 years to 19/10,000py by age 80–84 years. Rates for women were lower than men before age 55 years, but higher thereafter. Age-standardised rates rose 0.2/10,000py annually, but approximately doubled among men aged < 50 years. Lifetime risk was estimated at over 5%, with the prevalence pool rising to over 1.5% of the population aged 30+ in 2030.

Conclusions Rapid increases in diverticulitis admissions among young men since 2000 correspond with increases reported elsewhere but remain unexplained; notably young women follow similar trends 5–10 years later. Increasing incidence, combined with population ageing, adds urgency to explain diverticular formation, to understand factors that trigger or provoke their inflammation/infection, and to clarify treatment and (self-)management pathways.

Keywords Diverticulitis · Diverticulum · Colon · Epidemiology · Sex factors · Age factors

Introduction

Inflammation of colonic diverticula, diverticulitis, is the third most common gastrointestinal discharge diagnosis for hospital admissions in the USA. Diverticulitis is one of the most important of all gastrointestinal diseases in terms of direct and indirect health costs. Recent attention paid to the epidemiology, pathophysiology and treatment of the condition, has brought a plethora of at-times contradictory evidence, much recently summarised by Strate et al. [1] Besides the puzzling discrepancies in evidence for risk factors, reports of rising trends in incidence over time are diverse and are difficult to reconcile with the emerging aetiological evidence. In New Zealand (NZ), diverticular disease is described only in studies based on single hospitals or practices [2–5] and as national counts [6]. The aims of this study were to use national hospitalisation and mortality data to characterise temporal trends in incident (i.e. first-in-a-lifetime) hospitalisation rates for the total population of NZ, and to estimate lifetime risk and prevalence.

Methods

Hospitalisations

In NZ, Ministry of Health (MoH) databases record mortality, hospital discharges and health services including both

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publicly and privately provided (if publicly funded). Trained medical coders record reasons for admission using the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM) system. Each hospitalisation is coded as acute, or otherwise (booked or wait-listed). We selected all acute hospital admissions for people aged 30 years or over with a diverticular disease diagnosis (ICD-10-AM codes of K57.0–K57.9) as the primary discharge diagnosis during the calendar years 2000–2015, a 16-year period. The first (since 2000) such stay for each person was classified as an incident admission and included as an incident event in this study. MoH mortality records for the years 2000–2015 were searched for diverticulitis as the primary cause of death using the same ICD codes.

Rates and risk estimation

Age-specific annual rates of acute diverticulitis were calculated for men and women separately. The June resident population estimates (aged 30+ years from 2000 to 2015, by age group and prioritised self-identified ethnicity obtained from Statistics NZ) were used as the denominator for rates calculations. We assumed a stable population, for which population counts approximate the annual number of person-years. We derived age-standardised rates for incident acute diverticulitis admissions, and applied our age-specific rates to the World Health Organisation (WHO) World Standard Population aged 30+ years to remove the impact of population ageing from the trends [7]. To estimate lifetime risk, we took the cumulative incidence, i.e., the sum of the most recent age-specific annual incidence rates from age 30 to age 86 (current life expectancy of someone aged 30 in 2016).

To estimate prevalence in 2015, we counted all people with incident diverticulitis 2000–2015 and with no record of death before December 2015. To estimate prevalence in 2030, we projected the number of incident cases between 2016 and 2030 based upon population projections for 2000–2015 (and withdrew estimated deaths from the incident cases), and then divided the accumulated cases 2000–2030 by the estimated population aged over 30 years in 2030.

Analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC, USA) and Microsoft Excel 2016.

Results

Acute admissions with primary diagnosis of diverticulitis

During the 16-year period (2000–2015), 37,234 acute hospitalisations were recorded with a primary diagnosis of diverticular disease. Of them, 8,905 (23.9%) were classified as recurrent and excluded. The remaining 28,329 (76.1%) were classified as incident acute diverticulitis (median age 66 years, 54.6% women), with national incidence rising annually from 1306 (median age 68 years) in 2000, to 2411 (median age 64 years) in 2015. Median length of the incident stay was 4 days in 2000, falling to 3 days in 2015. Based on population projections, annual incident acute diverticular admissions will reach over 3460 by the year 2030, plus 830 recurrent admissions, total of 4310.

Of the incident hospitalisations, 21,204 (74.8%) were coded as relating to diverticula of the large intestine (Table 1), more than doubling from 752 in 2000, to 1960 in 2015. The part was unspecified in 6489 (22.9%), with 503 (1.8%) coded to the small intestine alone. Based on ICD-10-AM classifications, 17,368 (61.3%) were coded as uncomplicated (no perforation, abscess, fistula or haemorrhage).

By age group, sex and ethnicity

Incidence rates for women were markedly lower than for men at ages below 50 years, but higher after age 55 years (Fig. 1). Average annual incident diverticulitis admission rates rose with age from 6 per 10,000 at age 50–54 years for both men and women, to 17 per 10,000 for men and 19.7 per 10,000 for women at age 70–79 years. Incidence among those aged 85+ years is approximately tenfold those aged 30–55 years (Table 2).

Observed rates differ for some ethnic groups in comparison to European and other. Maori, the indigenous people of NZ, appear to have lower rates, while Pacific peoples showed similar rates. Asians, recognised in other jurisdictions as having low rates, also have low rates in NZ. A range of factors may be at play. The reliability of these rates is questionable, however, because annual counts of 10-year age bands were below 20 in more than 80% of the cells for each of these ethnic groups.

Lifetime risk

Based on observed rates and life expectancy of 86, the current lifetime risk of at least one diverticulitis admission for someone aged 30 years in 2016 is approximately 5%, or one in twenty.

Trends in incidence

Age-standardised rates (ASRs) of incident diverticulitis admission are shown in Fig. 2. After a period of relative stability from 2000 to 2005 during which ASRs were below 6 per 10,000 for both men and women, ASRs increased linearly by about 0.2 per 10,000 per year since 2006, to 7

Table 1 Characteristics of incident acute diverticulitis hospitalisations between 2000 and 2015

Characteristic	All ($n=28,329$)	Men ($n=12,861$)	Women ($n=15,468$)
Age groups, *n* (%)			
30–44	2741 (9.7)	1841 (14.3)	900 (5.8)
45–54	4884 (17.2)	2515 (19.6)	2369 (15.3)
55–64	5899 (20.8)	2675 (20.8)	3224 (20.8)
65–74	6063 (21.4)	2607 (20.3)	3456 (22.4)
75–84	5856 (20.7)	2331 (18.1)	3525 (22.8)
85+ years	2886 (10.2)	892 (6.9)	1994 (12.9)
Ethnicity, *n* (%)			
European/other	24,780 (87.5)	11,195 (87.1)	13,585 (87.8)
Maori	2054 (7.2)	866 (6.7)	1188 (7.7)
Pacific	902 (3.2)	482 (3.7)	420 (2.7)
Asian	593 (2.1)	318 (2.5)	275 (1.8)
Disease location, *n* (%)			
Small intestine	503 (1.8)	265 (2.1)	238 (1.5)
Large intestine	21,204 (74.8)	9918 (77.1)	11,286 (73.0)
Both small and large intestine	133 (0.5)	68 (0.5)	65 (0.4)
Part unspecified	6489 (22.9)	2610 (20.3)	3879 (25.1)
Disease complexity*, *n* (%)			
No perforation, no abscess and no haemorrhage	17,368 (61.3)	9885 (63.9)	7483 (58.2)
No perforation, no abscess and haemorrhage	5677 (20.1)	2982 (19.3)	2695 (21.0)
Perforation or abscess, and no haemorrhage	5050 (17.8)	2476 (16.0)	2574 (20.0)
Perforation or abscess, with haemorrhage	234 (0.8)	125 (0.8)	109 (0.8)

No perforation, no abscess and no haemorrhage: K5710, K5712, K5730, K5732, K5750, K5752, K5790, K5792

No perforation, no abscess and haemorrhage: K5711, K5713, K5731, K5733, K5751, K5753, K5791, K5793

Perforation, abscess, and no haemorrhage: K5700, K5702, K5720, K5722, K5740, K5742, K5780, K5782

Perforation, abscess, and haemorrhage: K5701, K5703, K5721, K5723, K5741, K5743, K5781, K5783

*Primary diagnosis (ICD-10-AM classification) of disease complexity:

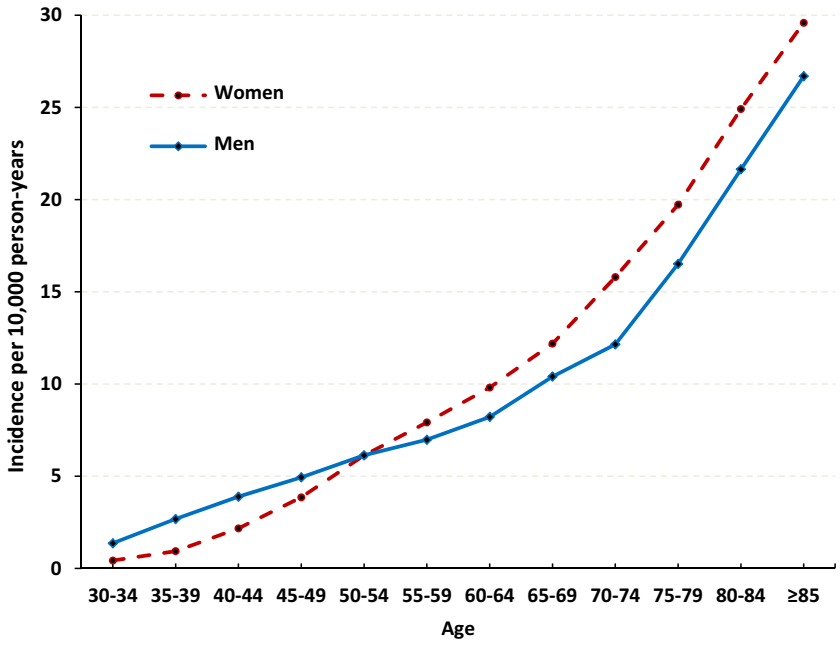

Fig. 1 Mean annual incidence of acute hospitalisation for diverticular disease, 2000–2015, by sex

Table 2 Age- and gender-specific rates of acute incident diverticulitis hospitalisations, 2000–2015, per 10,000 person-years

Year	Men					Women				
	30–54	55–64	65–74	75–84	85+ years	30–54	55–64	65–74	75–84	85+ years
2000	2.3	7.2	10.5	18.6	24.5	2.1	8.0	12.3	22.2	30.5
2001	2.7	7.2	13.2	19.2	25.6	2.0	8.2	14.0	21.3	27.8
2002	2.9	6.5	11.0	17.7	23.5	2.0	8.7	13.3	22.6	27.0
2003	3.0	7.2	9.6	18.7	19.8	2.0	7.9	13.9	21.5	29.6
2004	3.3	6.5	10.3	18.9	24.8	1.8	7.2	12.9	21.9	28.7
2005	3.1	6.2	9.1	19.3	29.3	2.2	9.0	13.4	21.0	25.3
2006	3.5	6.9	12.6	14.8	30.3	2.2	6.7	11.1	20.1	22.3
2007	3.4	6.5	8.3	18.4	34.1	2.4	8.4	12.1	21.7	31.4
2008	4.0	7.5	10.1	17.4	31.2	2.7	8.4	15.2	18.8	34.7
2009	4.1	7.6	12.0	19.3	20.7	2.8	9.7	13.0	25.2	31.5
2010	4.8	8.1	12.6	20.1	23.8	2.9	8.8	13.9	22.3	29.5
2011	4.3	7.7	12.3	18.2	27.1	3.3	9.6	15.6	22.7	34.5
2012	4.3	9.4	12.4	17.1	28.0	3.1	9.2	15.3	22.9	28.0
2013	4.6	8.3	11.3	21.7	31.7	3.7	10.9	14.7	24.5	29.5
2014	5.0	9.6	12.4	18.3	24.2	3.4	10.0	15.9	20.9	31.9
2015	5.9	8.4	11.1	19.1	28.7	4.1	10.1	14.5	22.3	31.3

per 10,000 in 2015. If this rate of increase continues, ASRs could reach 10 per 10,000 by 2030. Rates of total, complicated and uncomplicated DD admissions showed similar increases.

Relative to the year 2000, age-specific rates of acute incident hospitalisations among women and men increased fairly consistently, except the rate of increase was markedly higher among those aged under 55 years. Increases were particularly high among young men (relative rate = 2.6, Fig. 3) from 2000, but also from 2005 among young women.

Deaths

Death registrations seldom report diverticulitis as the primary cause of death. In NZ, during the 16 years, 913 deaths aged 30 years or over were registered with diverticulitis as the primary cause of death. Most (740, 81.1%) were of people aged 75 years or over; very few were aged under 50. No clear trends in age-standardised rates of diverticulitis-related death were apparent for men or women, and are not further reported.

Prevalence

In December 2015, 21,158 people were alive who had at least one hospitalisation for acute diverticulitis since 2000. Prevalence was, therefore, estimated as 0.8% in 2015 for those aged 30 or over. For those aged 65+ years and 80+ years, prevalence was 1.0% and 2.6%, respectively. When the current rate of increase of DD was applied to the official projected population estimates for 2016–2030, and projected deaths were removed, we anticipate that prevalence will rise to 1.5% of those aged 30+ by 2030.

Discussion

This is the first study describing incidence and trends of acute DD hospitalisation rates in NZ. It found increasing age-specific rates in most age groups and in both men and women, but markedly steeper increase in incidence rates in young people, most notably young men. Despite the rising median age of the total population during the period, indicating population ageing, the median age of incident acute diverticulitis hospitalisations reduced from 66 years in 2000 to 64 years in 2015. In consequence, the clinical importance and prevalence of the condition will rise.

Gender differences in age-specific incidence

Before the age of 55 years, women in NZ have lower rates of hospitalisation for incident diverticulitis than men. Whether this is really lower incidence is not well understood. It may in part be artefactual; under-diagnosis is likely among young women for several reasons. Firstly, clinical presentation of abdominal discomfort in pre-menopausal women may be presumed (by the women herself and/or by her clinician) to be of gynaecological rather than gastrointestinal origin. Secondly, women's greater frequency of consultation during periods of contraception, child-bearing and child-rearing, may make them more familiar and comfortable with primary care than men. Women may, therefore, in general seek assistance from a family physician in primary care, rather than a

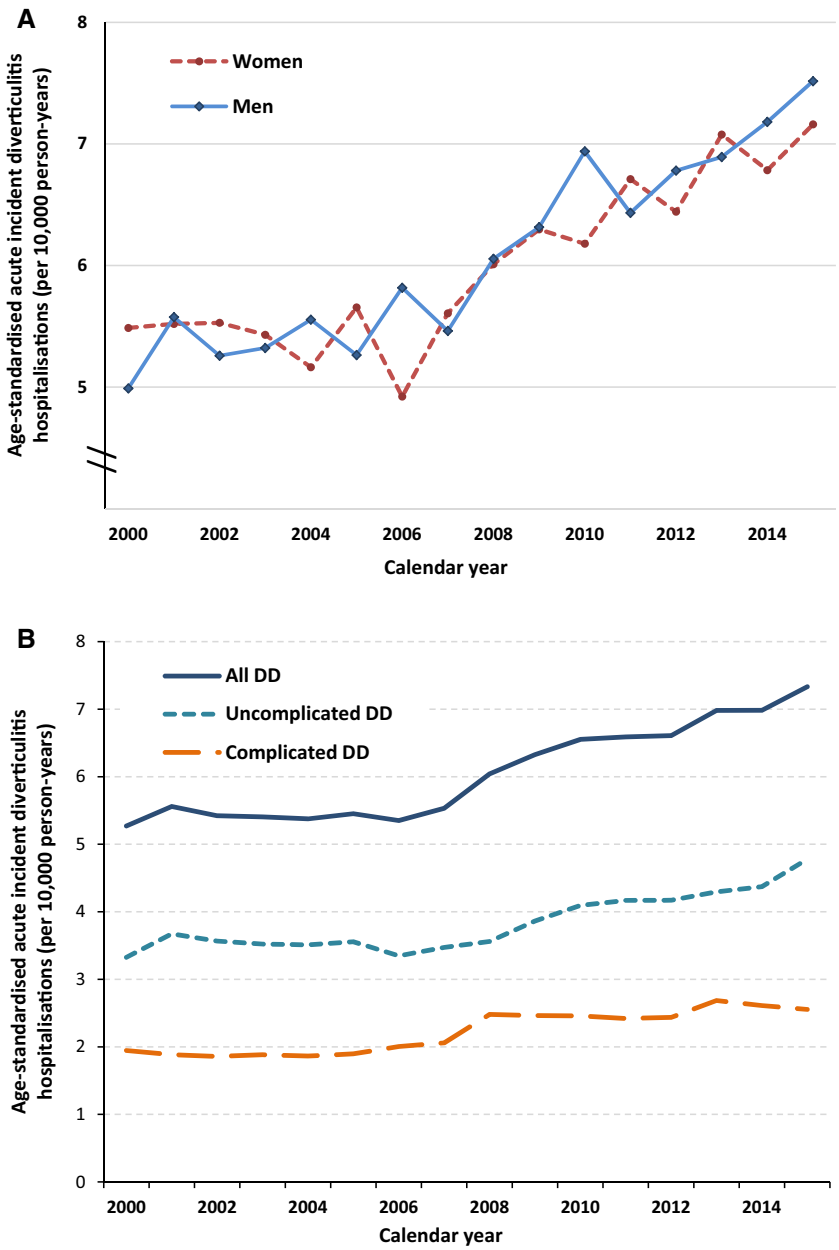

Fig. 2 Trends in age-standardised incidence of acute hospitalisation for diverticular disease, **a** by sex, **b** by complicated/uncomplicated disease

hospital, and thus not be included in the hospitalisations data we report. Thirdly, clinicians may choose not to perform computed tomography (CT) scanning on women presenting with abdominal pain during their reproductive ages because CT scans expose them to levels of radiation approximately 150 times that of chest X-rays [8]. The real extent of diverticulitis in pre-menopausal women is, thus, probably understated. Gender differences in young people were not apparent in analyses for selected earlier years 1992–2001 (not shown), possibly because in NZ CT scanning for diagnosing diverticulitis became common only after 2003 [6].

In contrast, after age 55 years, incidence is higher among women. Disturbances of the pelvic floor function have been mooted and may relate through connective tissue malfunction [9, 10]. Abdominal forces exerted during childbirth may initiate or exacerbate the formation of diverticula, the inflammation/infection of which much later may lead to diverticulitis. We do not report severity of disease, although Longstreth and others report greater severity in men as reported by CT scans. This could arise if men typically presented at later stages of the progressive disease, rather than arising from a different or more severe form [11, 12]

Increased incidence over time

Mean age-standardised incident hospitalisation rates in the NZ population rose annually about 0.2 per 10,000 between 2006 and 2015, an absolute increase of 2.1 per 10,000. This

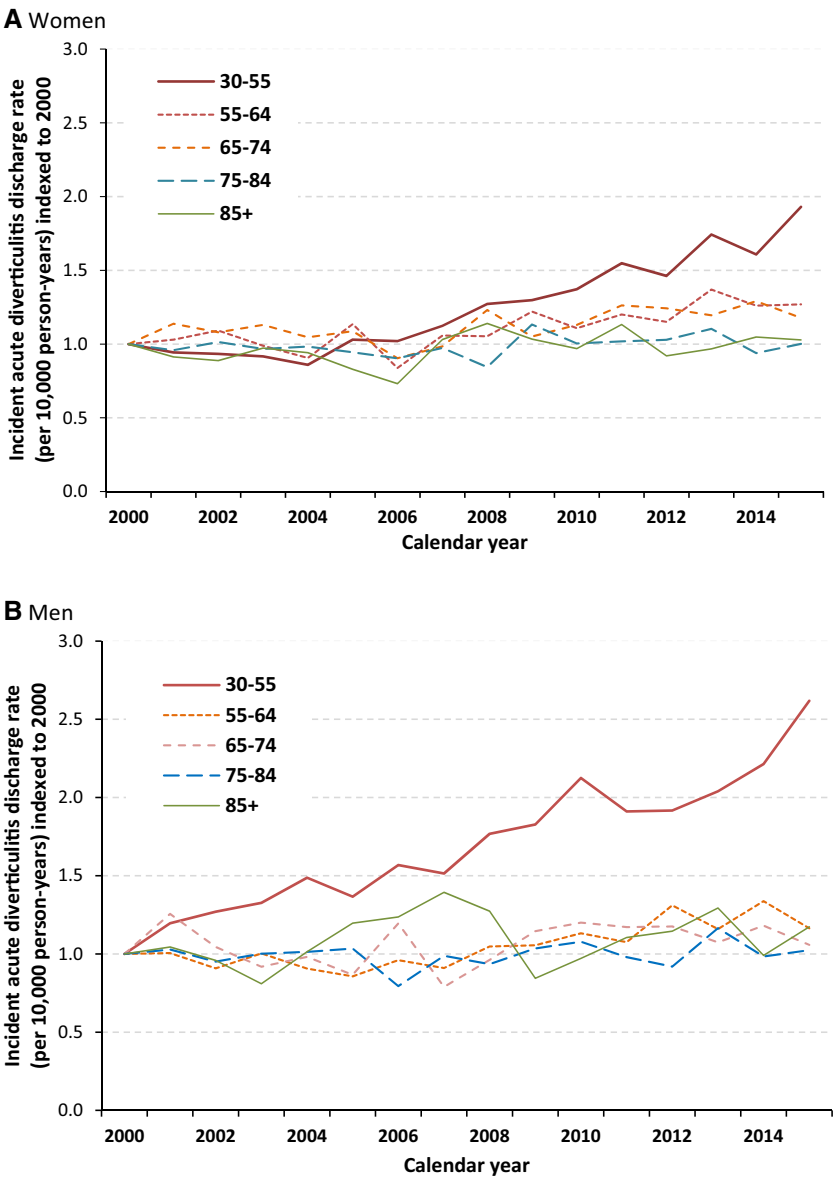

Fig. 3 Trends in incident hospitalisation rates for acute diverticular disease, 2000–2015, relative to the index year (2000), by gender and age groups

rate of increase is faster than population growth and population ageing. Recent rate increases were also evident among the next age group, 60–64 years, potentially indicating a birth cohort effect. Increased rates have been reported from Italy [13, 14], England [15], Norway [16], Denmark [17], Spain [18], and the USA (California [19], New York [20], Minnesota [21] and nationally [22, 23]) and now NZ. Following recent positive trials of antibiotics avoidance [24] in uncomplicated diverticulitis and also with home-based management after acute assessment in hospital [25], changes in clinical practice are likely. Hospitals will take the opportunity to adapt management pathways; if not, annual acute incident admissions will rise, at current rates in NZ, from 1306 in 2000 to over 3460 by 2030.

The fast growth in incidence in younger men is reported in at least five other populations [23, 26–29] Greater availability of CT scans may partly explain the rise in young people, particularly in young men—their atypical symptoms (for example presenting more with right rather than left lower quadrant pain) may now correctly diagnose previously misattributed diagnoses of diverticulitis [12]. Investigating other reasons for the rise may inform understandings about causes, risk factors and triggers for diverticulitis that have thus far proven elusive. It is sometimes assumed that whatever process leads to the formation of diverticula (diverticulosis) also leads to their inflammation and/or infection (diverticulitis). This is unlikely in our opinion. To this end, we review briefly the potential causes.

For diverticulosis, age is the most recognised risk factor, the number of diverticula and the number of intestinal segments involved increase with age [30, 31]. A genetic component is also well evidenced, with about 50% of the

risk recognised as genetic [32–36] probably via a connective tissue disorder [10, 37]. A recent meta-analysis demonstrates that the risk of colonic diverticulosis in obese subjects was significantly higher than in those without obesity [38].

Risk factors for diverticulitis (as distinct from diverticulosis) may also include visceral fat [39], exercise [40], the gut microbiome [41, 42], low levels of Vitamin D [43, 44], obesity, smoking, some drugs and low-fibre diets [45]. As yet the evidence is insufficient to explain the rising rates in young men [46]. Lee et al. investigated the role of obesity, and demonstrated that increased abdominal fat explains only part of the rise in diverticulitis [47]. Obesity is rising in many countries [38, 48, 49] and in the USA, rates of obesity have risen more steeply among young men than other age groups [50]. In NZ, increases in obesity are greater in young adults than in older people or children [51]. While it is, thus, plausible that increased obesity partly explains the rise in diverticulitis seen among young people, Lee et al. in a later study showed that the trends to higher incidence occurred in people with a low body mass index (BMI) and not in those with higher BMI [52].

Dietary fibre has long been the focus of attention as a risk factor for diverticular disease. Mahmood et al. recently showed that fruit and vegetable fibre, but not cereal fibre, is associated with lower risk of diverticulitis admission [53]. Rates of diverticulitis have not improved even though dietary improvements are apparent [54]. Positioning during defecation (squatting vs sitting) has been proposed as a risk factor [44, 55] but is difficult to research. Alternatively, variant forms of diverticulitis may be at play—one with faster progression from asymptomatic diverticulosis to acute diverticulitis among younger people [56, 57], or with congenital changes in connective tissue [58].

Strengths and limitations

For almost 30 years NZ residents have been ascribed a single unique identifier that is used in almost all health service encounters. Tracking of hospitalisations and deaths of individuals (anonymously) over time is possible, regardless of where in NZ they reside or which health service provider they currently use. We can be reasonably sure that acute hospital stays for diverticulitis were recorded because virtually all acute hospital care in NZ is provided in public hospitals. However, some reported stays, particularly during the first 3–5 years, will be recurrent events that have been misclassified as incident because those with incident events prior to June 1999 were excluded from analyses. Further, people were not included if they were admitted and discharged with non-specific acute abdominal pain that was in reality undiagnosed diverticulitis. A further limitation is that the data did not include people with diverticulitis who presented, were diagnosed and managed entirely within primary care, or within the private hospital or private consulting sector. On balance, our incidence rates and prevalence estimates were likely under-estimated, although rising.

Implications

Population trends are used not only to anticipate demand, but also to guide research priorities and inform research hypotheses. Diverticulosis is the most common gut disorder, with diverticula reported to be present in over 50% of people aged over 65 years and 70% in those aged over 80 years [59, 60]. Although most with diverticulosis remain unaware of their diverticula, we estimate that 5% of all who reach the age of 30 years in NZ will eventually experience an acute episode of diverticulitis for which they present to hospital. Some experience persistent symptoms and/or recurrent episodes, with perhaps 10–20% requiring additional acute admissions and/or surgery. Loss of productivity and reduced quality of life follow. An unknown number present only to primary care. With the mean length of acute hospital stays of 3 days, avoiding even a small proportion of incident hospitalisations could lead to sizeable savings.

Conclusions

Rapid increases in diverticulitis admissions among young men since 2000 correspond with increases reported elsewhere but remain unexplained. Increasing incidence, combined with population ageing, adds urgency to explain diverticular formation, to understand factors that trigger or provoke their inflammation/infection, and to clarify treatment and (self-)management pathways.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The University of Auckland Human Participants Ethics Committee gave ethical approval (Ref. 8944).

Informed consent The Ethics Committee determined that no informed consent was required for this study.

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