Original article

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Surgical treatment of uncomplicated diverticulitis in Switzerland: comparison of population-based data over two time periods

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Abstract

Aim The standard of care for acute uncomplicated diverticulitis used to be an elective colon resection after the second or third episode. This practice was replaced by a more conservative and individualized approach. This study investigates current surgical practice in the treatment of acute uncomplicated diverticulitis in Switzerland.

Method Retrospective cross-sectional analysis of all hospital admissions due to uncomplicated diverticulitis in Switzerland using prospectively collected data from the Swiss Federal Statistical Office in two periods: 2004/2005 and 2010/2011. Treatment options were compared between the two periods with adjustment for baseline characteristics of patients and treating institutions.

Results A total of 24 497 patients (11 835 in 2004/2005; 12 662 in 2010/2011) were admitted to Swiss hospitals for uncomplicated diverticulitis. Between periods, the incidence increased from 81 to 85 admissions per 10^5 inhabitants per year. Elective admissions decreased from 46% ($n = 5490$) to 34% ($n = 4294$). The unadjusted resection rate decreased from 40% ($n = 4730$) to 34% ($n = 4308$). In the adjusted analysis, inpatients were more likely to have a resection in 2010/2011 than in 2004/2005 [odds ratio of 1.38 (95% confidence interval 1.25–1.54)]. In addition, private insurance, elective mode of admission and younger age increased the odds for resection while there was no evidence of an association between resection and either gender or comorbidities.

Conclusion The probability of colon resection for patients hospitalized with acute uncomplicated diverticulitis increased between periods while the overall number of colon resections declined. A change of practice expected given the paradigm shift towards conservative treatment could not be confirmed in this analysis.

Keywords Diverticulitis, epidemiology, overtreatment

What does this paper add to the literature?
Conservative treatment of uncomplicated diverticulitis has become the standard of care. This population-based study investigated the proportion of colon resections for uncomplicated diverticulitis in Switzerland. It showed persistent high resection rates of 34%. This highlights the importance of implementing changing guidelines to prevent overtreatment for this benign condition.

Background

During the past two decades, a paradigm shift has evolved in the treatment of acute diverticulitis. In the early years of this century an operation for recurrent acute uncomplicated diverticulitis after the second episode was the standard of care, as stated in the 2000 guidelines of the American Society of Colon and Rectal Surgeons [1]. This regimen was abandoned in the revisions of 2006 in favour of a more individualized and conservative approach, due to evidence on the natural benign course of the disease and the low risk of severe complications in subsequent episodes [2–11].

Several authors tried to determine the need for elective surgery according to risk factors for severe complications, such as purulent or faeculent peritonitis in

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recurrent diverticulitis [8,12]. In contrast to former beliefs, recurrent episodes were less frequent (range from 10% to 34%) and severe complications were mainly seen in the first episode [13,14]. In consideration of these data, the indication for elective colonic resection in acute uncomplicated diverticulitis remains unclear [2].

The adoption of this change of practice seems to be regionally different. In Scandinavia, the UK or the Netherlands, protocols without resection, even for perforated diverticulitis (Hinchey III), were tested in large trials and cohort studies [15–18]. However, in Germany and the United States (US), a colon resection due to chronic recurrent uncomplicated diverticulitis is still performed in a high proportion of patients [16,19–23]. Current arguments for a resection in these patients focus on the reduction of quality of life, the need for recurrent antibiotic treatment and the problem of sick leave in younger patients [2–4,22,24–27].

Another aspect influencing the indication for surgery in diverticulitis might be remuneration. In the context of changes in funding towards case-based reimbursement, such as diagnosis-related groups (DRG), in many countries, there is a growing incentive for hospitals and surgeons to increase their operative caseload [28]. This has been shown for hip replacements and spine surgery in Germany or hysterectomy in patients with private insurance in Switzerland [29,30]. So far, clear evidence is missing as to whether economic factors might prevent a change in practice and eventually result in poorly indicated high resection rates.

The aim of the present study is to investigate whether or not the evidence-based shift in the treatment of uncomplicated diverticulitis has been implemented in Switzerland and led to a decline of elective colonic resections between the two time periods of 2004/2005 and 2010/2011.

Method

All hospitals in Switzerland are obliged to report irreversible anonymized data for all inpatient cases, their treatment and outcome measures to the Swiss Federal Statistical (SFS) Office. Based on this prospective consecutive routine dataset a cross-sectional study was performed, comparing two time periods including the years 2004/2005 and 2010/2011. In effect this was a variation on the cross-sectional design since it included a pre- and postintervention data set.

All cases with a main diagnosis of acute uncomplicated diverticulitis according to the International Classification of Diseases (ICD) codes K57, K57.0-, K57.1-, K57.3-, K57.5- and K57.9- were extracted for the analysis. Uncomplicated diverticulitis was defined as any diverticulitis without abscess formation, perforation or bleeding. Given the dataset as defined above, no information was available on outpatients diagnosed with uncomplicated diverticulitis.

Patient health status was analysed based on the ICD-10 classification codes for primary and secondary diagnoses and expressed as the Charlson Comorbidity Index (CCI) [31]. This index evaluates comorbidities which affect 1-year mortality. Therefore a CCI of zero does not necessarily indicate that there were no comorbidities, but that these comorbidities did not affect the predicted 1-year mortality. CHOP codes (Swiss classification of surgical procedures, a four- to six-digit code for surgical and nonsurgical procedures) were used for the main and secondary treatments.

The following variables were studied according to the SFS statistical manual [32]: age, sex and insurance class, in-hospital mortality according to the mode of discharge, regional distribution of the hospitals according to the cantonal origin of the hospital merged within the two language regions, the German speaking part and the French and Italian speaking part (these were referred to as the 'Latin speaking part' for clarity in the text and figures), the mode of admission, the number of recurrent hospital admissions with the same diagnosis within the investigated periods, length of hospital stay, the treating department and the size and caseload of the treating institution were analysed. The treating departments were either medicine or surgery. The hospital size was categorized according to the total number of hospital admissions (medical centre > 9000 hospitalizations per year or basic medical care ≤ 9000 hospitalizations per year, according to the categories of the SFS). The hospital expertise was investigated according to the number of hospital admissions for diverticulitis per year in the corresponding hospital.

The primary outcome was the risk-adjusted resection rate defined as the number of colon resections due to uncomplicated diverticulitis divided by the number of patients admitted for acute uncomplicated diverticulitis in each time interval. Patient comorbidities (indexed via CCI), age, gender, insurance class, mode of admission and regional distribution were considered as potential risk factors in a multivariable regression analysis.

A treatment class (conservative, resection and other) was assigned to each case in the data set according to a defined procedure based on the respective treatment CHOP codes (for details see the Supporting Information Appendix S1). For inferential statistics, the patient's first hospitalization in each time period was used in order to analyse a time-independent data set. The reasoning behind this was to prevent the

introduction of bias by assumptions, which were time dependent, as a longitudinal dataset was not available. Thus, admissions for uncomplicated diverticulitis before, between or after each time period could not be accounted for. For descriptive statistics the most invasive treatment of each patient within all hospitalizations during the corresponding time period was reported. As such, a patient with three hospital admissions in one time period who was conservatively treated for the first two and operated on during the third admission was counted as a resected patient for descriptive analysis (variable '*most invasive treatment*') and as conservatively treated for inferential statistics (variable '*treatment class*'). A clinically relevant decline was *a priori* defined as a drop in the resection rate of > 5% as the smallest possible change indicating any effective change of practice.

Secondary outcomes were the incidence of hospital admissions and colon resections due to uncomplicated diverticulitis in relation to the total population living in Switzerland at the corresponding time points as published by the SFS. In-hospital mortality of patients treated for uncomplicated diverticulitis was calculated in relation to the total number of inpatients treated for this condition.

Statistical analysis

The anonymized datasets were handed over to independent statisticians for analysis. All statistical analyses were performed in R version 3.2.1 (R Foundation for Statistical Computing, Vienna, Austria). Specifically, for model estimation the 'MCMCglmm' and for summary statistics the "reporttools" package were used [33–35]

Summary statistics

Patient baseline characteristics were summarized for both time periods using descriptive statistics. Median and interquartile range or numbers and proportions are given as appropriate. The two different time periods, as well as the cantons and linguistic regions of Switzerland, were compared according to the variable '*most invasive treatment*'.

Modelling

The inferential analysis of the resection rate had to be adjusted for potential confounders. Therefore a Bayesian baseline category logit model with random intercept was used. The reasons for this were the categorical outcomes with three different treatment types (surgery, conservative and others), a hierarchical data structure (patients clustered in hospitals) and multiple risk factors. Risk factors analysed included period, gender, age, comorbidity according to CCI, insurance class and mode of admission. For further details see the Supporting Information Appendix S1.

Sample size

The sample size was given by the number of patients admitted to hospitals in Switzerland in the years 2004/2005 and 2010/2011 with a total of 5 585 152 cases. The dataset allowed the multivariable analysis to control for potential confounders. A complete case analysis was conducted because there were relatively few missing data (< 1% of patients with incomplete data).

Results

Inclusion and exclusion of patients

In both time periods together 5 585 152 in-hospital cases were recorded in the SFS database. Of these, 28 300 were hospitalizations with the main diagnosis 'uncomplicated diverticulitis' as defined above. After exclusion of readmissions within each time period a total of 24 497 patients were available for baseline analysis and 24 334 patients for the model statistics. Figure 1 shows a detailed flow chart of patient selection and criteria.

Demographic results

Taking both time periods together 24 497 inpatients were treated for uncomplicated diverticulitis in Swiss hospitals (2004/2005, 11 835; 2010/2011, 12 662). The majority of patients were female (57% overall; 58% in 2004/2005, 56% in 2010/2011) and the median age was 65 years (interquartile range (IQR) 55–76 years). Most patients (79%) had no relevant comorbidities that would contribute to 1-year mortality with a CCI of 0. Sixteen per cent had mild medical conditions with a CCI of 1 or 2. More severe illness (CCI > 2) was rare, at 5%. There was a trend towards more comorbidities in the second time period (CCI > 0 of 19% *vs* 23%) (see Tables 1 and 2).

Administrative results

Eighty-eight per cent of the patients were hospitalized only once due to acute uncomplicated diverticulitis in the corresponding time period. The majority of patients were admitted as emergency cases (59%), with an increase from 52% in 2004/2005 to 66% in 2010/2011.

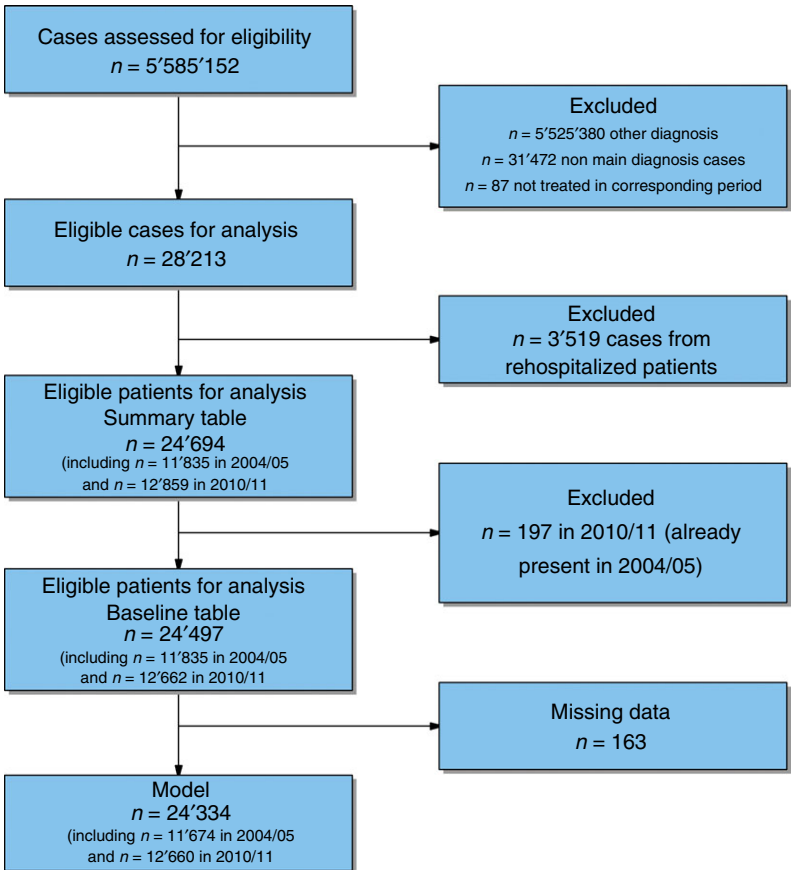

Figure 1 Flow diagram of cases and patients in- and excluded in the analysis.

Table 1 Summary table of the included cases or patients, respectively.

	2004/05		2010/11	
	n	%	*n*	%
Number of cases	13 627		14 586	
Number of patients	11 835		12 859	
Hospitalization* rate				
1	10 250	87	11 367	88
2	1401	12	1300	10
3	162	1	160	1
4	21	< 1	27	< 1
> 4	1	< 1	5	< 1

*Within the observation periods.

Corresponding to this, elective hospitalizations dropped from 46% in 2004/2005 to 34% in 2010/2011 (see also Table 2). Looking only at elective cases, the proportion and overall number of elective conservative hospitalizations due to uncomplicated diverticulitis (e.g. for interval colonoscopies) dropped from 39% ($n = 2136$) in 2004/2005 to 24% ($n = 1052$) in 2010/2011.

Surgical treatment

Focusing on surgical management according to the most invasive treatment (as defined above, namely patients with colon resection in any of their hospitalizations), 37% of all patients had colon resections for uncomplicated diverticulitis during the study period. The resection rate and the overall number of colon resections dropped from 40% ($n = 4730$) in 2004/2005 to 34% ($n = 4308$) in 2010/2011. There were regional differences in the resection rate between the first and second study period. While the resection rate in the German-speaking region dropped by 5% from 42% to 37%, the resection rate in the Latin-speaking region declined by 11% from 34% to 23%.

Multivariable model

Multivariable logistic regression analysis suggested there were four factors influencing the odds for operative treatment: treatment in the second time period [with an estimated multiplicative effect on the odds ratio (OR) for a colon resection of 1.38 (95% CI: 1.25–1.54) and private instead of basic insurance of the patient (OR 1.6; 95% CI: 1.44–1.76), respectively] increased the

Table 2 Baseline table of characteristics of all patients diagnosed with uncomplicated diverticulitis for the two time periods and overall.

Characteristic	2004/05 (n = 11 835)	2010/11 (n = 12 662)	All patients (n = 24 497)
Age at admission (years), median (IQR)	65 (55, 75)	66 (55, 77)	65 (55, 76)
Sex, n (%)			
Female	6872 (58)	7080 (56)	13 952 (57)
Male	4963 (42)	5582 (44)	10 545 (43)
Region, n (%)			
German	8764 (74)	9659 (76)	18 423 (75)
Latin	3071 (26)	3003 (24)	6074 (25)
Insurance class*, n (%)			
Basic	7752 (66)	8216 (65)	15 968 (65)
Private	4047 (34)	4446 (35)	8493 (35)
Patient health† (CCI), n (%)			
0	9610 (81)	9724 (77)	19 334 (79)
1–2	1766 (15)	2185 (17)	3951 (16)
3–4	378 (3)	567 (4)	945 (4)
> 4	81 (1)	186 (1)	267 (1)
Hospitalizations (count), median (range)	1 (1, 5)	1 (1, 8)	1 (1, 8)
Mode of admission‡, n (%)			
Elective	5490 (46)	4294 (34)	9784 (40)
Emergency	6196 (52)	8340 (66)	14 536 (59)
Other	24 (< 1)	26 (< 1)	50 (< 1)
Treatment class, n (%) (first observed case of each patient)			
Conservative	8068 (68)	9133 (72)	17 201 (70)
Others	122 (1)	94 (1)	216 (1)
Resection	3645 (31)	3435 (27)	7080 (29)
Treatment class whole period, n (%)(case with most invasive treatment of each patient)			
Conservative	6980 (59)	8264 (65)	15 244 (62)
Others	125 (1)	90 (1)	215 (1)
Resection	4730 (40)	4308 (34)	9038 (37)
Duration of stay (OECD) (days), median (IQR)	8 (5, 11)	7 (5, 9)	7 (5, 10)
Hospital size category, n (%)			
Basic medical care	4755 (40)	3527 (28)	8282 (34)
Medical centre	7080 (60)	9135 (72)	16 215 (66)
Department, n (%)			
Surgery	7976 (67)	8692 (69)	16 668 (68)
Medicine	3859 (33)	3970 (31)	7829 (32)
Hospital expertise, median (IQR)	74 (42, 118)	106 (64,163)	88 (51, 144)

IQR, interquartile range; CCI, Charlson comorbidity index; OECD, Organisation for Economic Co-operation and Development.
*Missing in 36 (0.15%) patients.
†CCI predicts 1-year mortality. A CCI of zero means that comorbidities did not affect 1-year mortality, but not necessarily the absence of comorbidities.
‡Missing in 127 (0.52%) patients.

odds. Emergency as mode of admission was more frequent in the second time period and was estimated to have a decreasing effect on the odds for resection [0.01 (95% CI: 0.01–0.01)]. From the investigated patient factors only rising age had a statistically significant decreasing effect on the odds for a resection [10-year aging effect of 0.73 (95% CI: 0.71–0.76)]. For the other two potential risk factors (comorbidity and gender) there was no evidence of an impact on the odds for operative treatment (see Fig. 2 and Table 3).

According to the estimated model coefficients a reference patient with uncomplicated diverticulitis (period 2004/05, female gender, CCI = 0, basic insurance class, elective admission, age 65 years) had an estimated probability of 45% for a colon resection. The same patient had an estimated probability of 57% for a colon

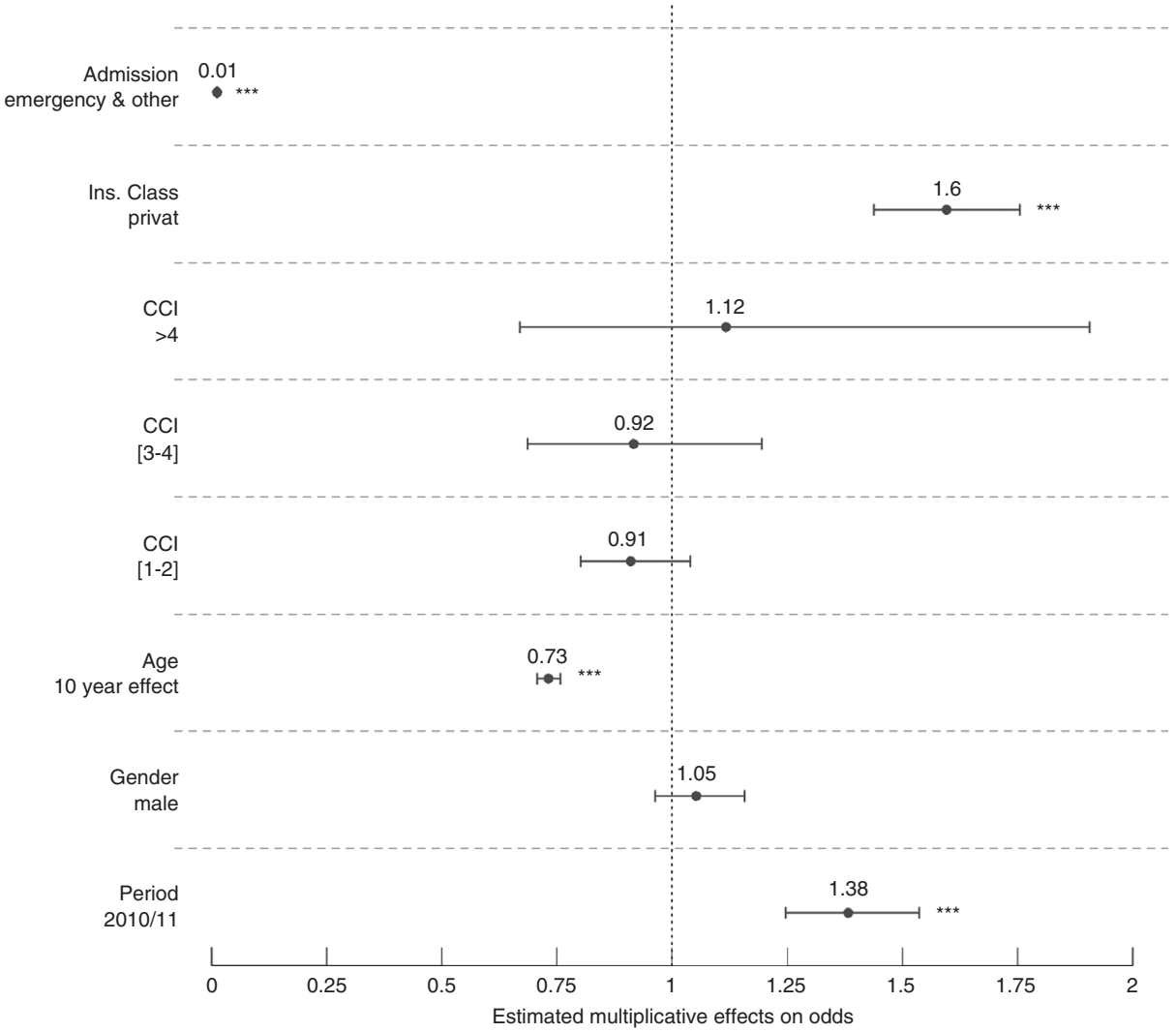

Figure 2 Estimated effects of the co-variables on the odds - dots represent the posterior means – whiskers (the horizontal lines flanked by dashes) represent the 95% Confidence intervals. The vertical dashed black line marks an effect factor on the odds of 1 (no effect) to ease comparability. Baseline response category: conservative. The reference categories are period 2004/05, female, Charlson comorbidity index of 0, basic insurance class, elective mode of admission and age of 65 years. Significance codes: ≤ 0.001 [***]. The shown age effect, represents the effect of being 10 years older.

resection if hospitalized in the period 2010/2011. Figure 3 shows the influence on the estimated probability of resection for patients that differ from the reference patient in one patient characteristic (e.g. a patient that was seen in period 2010/2011 instead of 2004/05 with all other characteristics being the same).

A moderate linguistic regional effect on the resection rate but no obvious hospital size effect (basic medical care *vs* medical centre) was noted in the density plots of the estimated random intercepts for the different hospitals. The visualized increasing effect on the resection rate of the German- compared with the Latin-speaking part of Switzerland was congruent with descriptive observations.

Incidence and mortality

The incidence of hospitalization due to acute uncomplicated diverticulitis rose from 81 per 100 000 inhabitants per year in 2004 to 85 per 100 000 in 2011. The in-hospital mortality of the disease was 0.90% (11 835 patients/107 deaths) in the first time period and 0.72% (12 859 patients/92 deaths) in the second period. The mortality for conservative and operative treatment in 2004/2005 was 0.79% and 1.06%, respectively. In 2010/2011 the rates declined to 0.63% and 0.84%, respectively. The incidence of colon resections for uncomplicated diverticulitis in Switzerland dropped from 35 per 100 000 inhabitants in 2004 to 27 per 100 000 inhabitants in 2011.

Table 3 Estimated multiplicative effects on odds (posterior mean) for resection *vs* conservative treatment, from a random intercept logit model with a baseline category conservative treatment. All possible response categories: conservative; others; resection. 95% CIs are in parentheses. The reference patient is characterized by period 2004/05, female gender, Charlson comorbidity index of 0, basic insurance class, elective mode of admission and an age of 65 years.

	Adjusted estimates			
Characteristic	Estimate	95% CI	*P*-value	Unadjusted estimate [95% CI]
Ref. patient	0.95	[0.73, 1.2]	0.7	
Period				
2010/11	1.38	[1.25, 1.54]	< 0.001	0.87 [0.81, 0.94]
Gender				
Male	1.05	[0.96, 1.16]	0.28	1.06 [1.00, 1.14]
Age (per 10-year increase)	0.73	[0.71, 0.76]	< 0.001	0.79 [0.78, 0.81]
Charlson comorbidity index				
1–2	0.91	[0.8, 1.04]	0.17	0.61 [0.55, 0.67]
3–4	0.92	[0.69, 1.19]	0.56	0.43 [0.35, 0.53]
> 4	1.12	[0.67, 1.91]	0.69	0.32 [0.21, 0.47]
Insurance class				
Private	1.6	[1.44, 1.76]	< 0.001	1.44 [1.34, 1.55]
Mode of admission				
Emergency and other	0.01	[0.01, 0.01]	< 0.001	0.01 [0.01, 0.01]

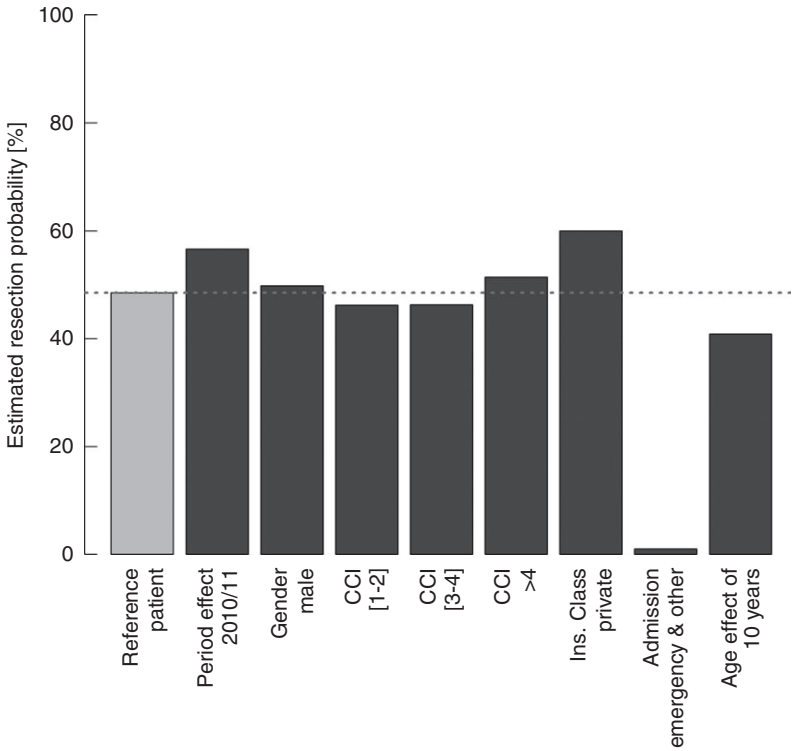

Figure 3 Estimated probabilities for being treated with surgery for the reference patient (first bar on the left - light grey). All the remaining bars (dark grey) show the estimated treatment probabilities for patients that differ from the reference patient in one patient characteristic. Reference patient: Period=2004/05, Gender=female, CCI=0, insurance class=basic, mode of admission=elective, Age=65 years. The grey dotted line shows the probability of the reference patient to ease comparability. The shown age effect represents the effect of getting 10 years older.

Discussion

The present work is the first population-based analysis of treatment modalities for uncomplicated diverticulitis in Switzerland.

The crude resection rate and overall number of colon resections as well as the incidence of colon resections for uncomplicated diverticulitis in relation to the overall Swiss population dropped between 2004/2005 and 2010/2011. However, the probability of a colon

resection for patients hospitalized with acute uncomplicated diverticulitis based on the multivariable analysis increased between periods.

This finding needs to be interpreted in the context of changing hospitalization policies as described above. The relevant drop of conservative treatment in elective hospitalizations in the second time period (for interval colonoscopies, for example) led to a relative increase of resections in this group while the overall number of elective resections remained stable. This factor led mainly to the increasing odds in the multivariable analysis. On the other hand the relative and overall increase in emergency admissions (with no need for colon resection) might well explain a relevant part of the drop in the crude resection rate.

Moreover the multivariable model revealed a strong relation between resection rate and insurance class of patients, meaning that patients with private insurance were more likely to undergo a colon resection than conservative treatment for uncomplicated diverticulitis than patients with basic insurance.

Epidemiological data on treatment modalities for uncomplicated diverticulitis are only sparsely available, and only a small number of recent studies have reported exactly on this issue. Therefore, comparing results from this Swiss investigation with those of other studies may be difficult. Most data come from the US or from reports of single institutions or surgical departments [6,24,36–43]. Etzioni *et al.* reported elective resection rates of 14% for an inpatient sample in the US in the millennial years with a marked increase of 29% between 1998 and 2005, especially in younger patients [41]. Simianu *et al.* reported a rise in elective colon resections for uncomplicated diverticulitis for the Washington State population between 1987 and 2012 from 8 to 17 resections per 100 000 inhabitants without a drop in emergency colectomies. None of the available data demonstrated a significant drop in colon resection rates for uncomplicated diverticulitis. This might be due to the fact that some of the studies date from a time period before the investigated paradigm shift [24,41]. Other reasons might be the rising importance of laparoscopic surgery as an appealing and 'easy' minimal invasive method of colon resection and this might have been partly responsible for the persistently high resection rates in our population. However reported rates are difficult to compare, because single-institution reports usually only refer to all types of diverticulitis and patients only treated in surgical departments [40].

In comparison with these studies, the crude Swiss resection rate for uncomplicated diverticulitis dropped but was still remarkably high at 34% in 2010/2011, while the odds for a colon resection rose in the second time period according to multivariable analysis. The incidence of colon resections was still almost twice as high as the reported incidence in the US.

Nonetheless a third of all patients hospitalized for uncomplicated diverticulitis will have a colon resection with relevant operative risks such as anastomotic leakage for a disease now well known for its benign course [8,10,44,45]. These resections are nowadays mainly indicated by patient choice, the problem of sick leave in younger patients and symptom control in chronic disease [27].

One of the possible reasons for this finding may be the rising importance of hospital caseload in DRG reimbursement and attractive payment for the procedure, which seem to have had an additional impact on the resection rate. This phenomenon has been well established for different types of orthopaedic surgery in Germany and for hysterectomy in Switzerland [28,30]. The present study revealed private insurance to be an independent driver of higher resection rates in multivariable analysis, though no data were available on other confounding factors concerning this question, such as patient preferences and the reasons for higher resection rates in patients with private insurance.

So what is the most effective way to prevent possible unnecessary colon resections? As shown in the regional analysis, surgeons from the Latin-speaking part adapted more closely to the paradigm shift than surgeons in the German-speaking part. A reason for this finding might be that some of the publications that drove the treatment shift in the early 2000s came from university hospitals in the French-speaking part of Switzerland, leading to a faster local adoption of the regime [46–50]. Such a positive impact on regional practice highlights the importance of clinical research activity.

Another established instrument of compliance is peer review and the establishment of institutional interdisciplinary guidelines. Indications that are monitored by interdisciplinary boards and guided by consensus guidelines, as in cancer surgery, tend to be less prone to violation of defined standards of care [51–54]. Such interdisciplinary boards could discuss indications for elective surgery for uncomplicated diverticulitis (and other benign conditions such as inflammatory bowel disease). By balancing risks and benefits in these boards a truly patient-centred approach and individualized decision-making could be developed.

The present study does have important limitations, however. Since there were no longitudinal data it was not possible to include every case in the multivariable analysis without causing bias. Individual records could

therefore not be analysed as true first, second or third episodes of the disease and the multivariable model had to be restricted to the first observed case of each patient in each period.

A relevant proportion of patients with acute uncomplicated diverticulitis will be treated as outpatients. The proportion of patients treated as inpatients will most likely be in poorer medical condition. Since the analysis only accounted for patients actually hospitalized for acute uncomplicated diverticulitis, a possible drop in elective admissions due to surgeons' restraints on elective colon resections could not be addressed by the analysis.

Another difficulty in this study is the limited quality of administrative data, which are missing important information on surgical outcomes, and the poor validity of the data set concerning conservative treatment regimes as well as possible underreporting of comorbidities, especially in the first time interval. This might have contributed to the low proportion of patients with raised CCI in our investigation.

Conclusion

The present population-based analysis of colon resections for uncomplicated diverticulitis in Switzerland found no evidence for a change of practice towards conservative treatment for this benign disease.

Interdisciplinary boards and expeditious implementation of the results of clinical research in clinical practice could help to prevent unnecessary colon resections for this widespread and benign condition.

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Conflicts of interest

Rachel Rosenthal has been an employee of F. Hoffmann-La Roche Ltd. since 2014. The present study has no connection to her employment by the company. Rachel Rosenthal continues to be affiliated with the University of Basel. The other authors do declare no conflicts of interest either.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:
Appendix S1. Supplements.