Follow-up of 3 Million Persons Undergoing Colonoscopy in Germany: Utilization of Repeat Colonoscopies and Polypectomies Within 10 Years

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INTRODUCTION: **Given the sparsity of longitudinal studies on colonoscopy use, we quantified utilization of repeat colonoscopy within 10 years and the proportion of persons with polypectomies at first repeat colonoscopy using a large German claims database.**

METHODS: **Based on the German Pharmacoepidemiological Research Database, we identified persons who underwent colonoscopy between 2006 and 2015 (index colonoscopy) and assessed colonoscopies and polypectomies during follow-up. We defined 3 subcohorts based on available procedure/diagnosis codes at index colonoscopy: persons with snare polypectomy, which is reimbursable for lesions ≥5 mm in size (cohort 1), with a forceps polypectomy (cohort 2), and without such procedures/diagnoses (cohort 3). We stratified all analyses by diagnostic vs screening index colonoscopy.**

RESULTS: **Overall, we included 3,076,657 persons (cohort 1–3: 15%, 13%, 72%). Among persons with screening index colonoscopy (30%), the proportions with a repeat colonoscopy within 10 years in cohorts 1, 2, and 3 were 78%, 66%, and 43%, respectively, and a snare polypectomy at first repeat colonoscopy was performed in 27%, 17%, and 12%, respectively. In cohort 1, 32% of persons with a (first) repeat colonoscopy after 9 years had a snare polypectomy (after 3 years: 25%). Among persons with diagnostic index colonoscopies, 80%, 78%, and 65% had a repeat colonoscopy, and 27%, 17%, and 10% had a snare polypectomy at first repeat colonoscopy, respectively.**

DISCUSSION: **Our study suggests substantial underuse of repeat colonoscopy among persons with previous snare polypectomy and overuse among lower risk groups. One-quarter of persons with a snare polypectomy at baseline had another snare polypectomy at first repeat colonoscopy.**

SUPPLEMENTARY MATERIAL accompanies this paper at http://links.lww.com/CTG/A474

Clinical and Translational Gastroenterology 2021;12:e00279. https://doi.org/10.14309/ctg.0000000000000279

INTRODUCTION

Colonoscopy is widely used in the context of gastrointestinal symptoms for early detection of colorectal cancer (CRC) and for surveillance of persons with previous diagnosis of colorectal neoplasia. Recent use or lifetime use of colonoscopies has been investigated in more than 70 studies, mainly with a cross-sectional design, showing a large variation, e.g., between countries, age groups, and sex (1,2). Although this aspect is of high relevance, less is known about repeat use of colonoscopy (3–14). First, persons with advanced adenomas detected and removed at (index) colonoscopy are considered to be at increased long-term risk of developing CRC (15–17). Most guidelines therefore recommend colonoscopy surveillance in these persons (18,19). Second, monitoring of repeat colonoscopies is important in view of potential overuse leading to unnecessary burden and costs as well as to inadequate allocation of colonoscopy capacities, which are rather limited in some countries.

The few available studies on the use of repeat colonoscopies conducted in Australia, Canada, Germany, and the United States underline the relevance of this topic. A recent study from Germany including 6,407 persons showed substantial overuse of repeat colonoscopies in persons with negative findings and underuse in persons with low- and high-risk adenomas at baseline. However, that study was restricted to screening participants

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Received May 4, 2020; accepted November 3, 2020; published online December 22, 2020

and to a follow-up of 6 years (6). Studies from Australia, Canada, and the United States showed similar patterns but were also restricted to participants of screening colonoscopy (5,8,10,13) or considered any colonoscopy, i.e., screening and diagnostic colonoscopies combined (3,4,7,9,14). Furthermore, all these studies focused on utilization of repeat colonoscopy, whereas information on the frequency of polypectomies conducted at repeat colonoscopy—overall and stratified by time since index colonoscopy—would also be of interest.

To shed further light on this topic, we aimed to describe utilization of repeat colonoscopy within 10 years—stratified by diagnostic vs screening colonoscopy at baseline—and to determine the proportion of persons with polypectomies at first repeat colonoscopy using a large German claims database.

METHODS

Data source

We used the German Pharmacoepidemiological Research Database (GePaRD), which is based on claims data from 4 statutory health insurance providers in Germany, namely AOK Bremen/Bremerhaven, DAK-Gesundheit, Die Techniker, and hkk Krankenkasse and currently includes information on approximately 25 million persons who have been insured with one of the participating providers since 2004 or later. Details about GePaRD have been reported elsewhere (20,21). In addition to demographic data, GePaRD contains information on outpatient and inpatient services and diagnoses and on drug dispensations. Per data year, information on approximately 20% of the general population is available, and all geographical regions of Germany are represented.

In GePaRD, information on colonoscopy, including the date of the procedure, is obtained based on codes of the German Uniform Assessment Standard and the Operations and Procedures Coding System. With these codes, it is possible to distinguish between screening and diagnostic colonoscopy. Furthermore, there are specific codes for snare polypectomy, which is reimbursable for lesions $\geq$5 mm in size, whereas there are no specific codes for forceps polypectomy used to remove smaller lesions. Distinction between polyps removed by snare polypectomy and polyps not removed by snare polypectomy (i.e., removed by forceps polypectomy) thus facilitates rough stratification according to the size of the lesion. Size is an important criterion to distinguish between low- and high-risk adenomas. Diagnoses in GePaRD are coded according to the German modification of the *International Classification of Diseases, 10th Revision*. For inpatient diagnoses, the exact date of the diagnosis is available, whereas outpatient diagnoses are coded on a quarterly basis. All codes used in this analysis are available on request.

Study design and study population

We included persons who underwent at least 1 colonoscopy between 2006 and 2015. The colonoscopy leading to cohort entry was defined as the index colonoscopy. We excluded persons who were not continuously insured for at least 2 years before the index colonoscopy (baseline period) and persons with any code indicating the prevalence or incidence of CRC during the baseline period (including diagnosis codes indicating follow-up care in CRC survivors). We defined 3 subcohorts based on an algorithm that considered procedure/diagnosis codes at index colonoscopy: persons with a code for snare polypectomy (cohort 1), persons with no snare polypectomy but a diagnosis code for polyps in the same quarter, which were classified as persons with forceps polypectomy (cohort 2), and persons without such codes (cohort 3). Although forceps polypectomies are not specifically reimbursable and can therefore not directly be identified in the data by a specific code, the classification of cohort 2 as persons with polyps removed by forceps polypectomy seems plausible given that not removing polyps would be against current guidelines, irrespective of their size (18). Furthermore, this interpretation is supported by comparison with the German colonoscopy registry showing a rather similar proportion of persons with forceps polypectomy (see Supplementary Digital Content 2, http://links.lww.com/CTG/A474). Similar to an algorithm applied in previous studies (9,11), we assumed that polypectomies coded within 6 months after a colonoscopy are related to the previous procedure (e.g., completion of polypectomy or early repeat colonoscopy due to poor bowel cleansing) and therefore combined the information.

The subcohorts were stratified by the type of index colonoscopy (diagnostic vs screening), and persons were followed up until the end of the study period (December 31, 2015), end of insurance, or death, whichever occurred first.

Data analysis

First, we characterized the persons in each subcohort regarding several characteristics, stratified by the type of colonoscopy. We then determined—on a quarterly basis—the proportion of persons undergoing a repeat colonoscopy for the first time since index colonoscopy, considering only persons with a complete follow-up during the respective quarter in the denominator. Based on these proportions, we calculated the cumulative proportion of persons undergoing at least 1 repeat colonoscopy for each time point (quarter) after index colonoscopy. We used this approach instead of Kaplan-Meier analysis as our method gives more weight to the time where persons are typically considered eligible for repeat colonoscopy rather than, for example, on person-time in the end-of-life phase.

To determine the proportion of persons with a snare polypectomy at first repeat colonoscopy, we divided the overall number of persons with a code for a snare polypectomy at first repeat colonoscopy or in the next 6 months (as described previously) by the overall number of persons with a repeat colonoscopy. We calculated this proportion stratified by the type of colonoscopy, age, and sex. We also calculated this proportion on a yearly basis. For example, all persons with a first repeat colonoscopy between years 1 and 2 after index colonoscopy were in the denominator, and of these, persons with a snare polypectomy were in the numerator.

In additional analyses, we assessed potential differences between persons with an early vs a late or no repeat colonoscopy and explored potential reasons for colonoscopies performed earlier than expected (see Supplementary Digital Content 3, http://links.lww.com/CTG/A474).

RESULTS

Overall, 3,076,657 persons with at least 1 colonoscopy between 2006 and 2015 were included (Table 1). Of these, 472,010 persons (15%) had an index colonoscopy with a code for snare polypectomy (cohort 1), 408,380 persons (13%) were assigned to the group "forceps polypectomy" (cohort 2), and the remaining 2,196,267 (71%) had no codes indicating polyp detection (cohort 3). In each cohort, about one-third had an index colonoscopy coded as screening colonoscopy (35%, 34%, and 29% in cohorts 1,

Table 1. Description of the study population stratified by procedure/diagnosis codes at index colonoscopy (cohorts 1–3)[a] and type of index colonoscopy (screening vs diagnostic)

	Cohort 1 (15.2%)			Cohort 2 (13.4%)			Cohort 3 (71.4%)		
	Screening	Diagnostic	Overall	Screening	Diagnostic	Overall	Screening	Diagnostic	Overall
Persons, n (%)	166,969 (35.4)	305,041 (64.6)	472,010 (100)	139,761 (34.2)	268,619 (65.8)	408,380 (100)	628,106 (28.6)	1,568,161 (71.4)	2,196,267 (100)
Age									
Mean (SD)	65.1 (7.3)	63.0 (13.1)	63.8 (11.4)	64.4 (7.0)	61.6 (13.0)	62.6 (11.4)	64.1 (7.1)	55.4 (16.7)	57.9 (15.1)
Median (IQR)	65 (59–70)	64 (53–73)	65 (56–72)	64 (58–70)	63 (52–71)	63 (56–71)	63 (58–69)	55 (45–69)	59 (49–69)
Age groups, n (%)									
<18 yr	4 (0.0)	372 (0.1)	376 (0.08)	0 (0.0)	306 (0.1)	306 (0.07)	1 (0.0)	13,506 (0.9)	13,507 (0.6)
18–49 yr	370 (0.2)	46,284 (15.2)	46,654 (9.9)	2 (0.0)	47,590 (17.7)	47,592 (7.3)	49 (0.0)	554,637 (35.4)	554,686 (25.3)
50–54 yr	227 (0.1)	39,317 (12.9)	39,544 (8.4)	6 (0.0)	35,265 (13.1)	35,271 (8.6)	33 (0.0)	215,693 (13.8)	215,726 (9.8)
55–59 yr	46,300 (27.7)	32,426 (10.6)	78,726 (16.7)	45,036 (32.2)	28,702 (10.7)	73,738 (18.1)	219,211 (34.9)	141,568 (9.0)	360,779 (16.4)
60–69 yr	72,720 (43.6)	79,414 (26.0)	152,134 (32.2)	59,349 (42.5)	74,361 (27.7)	133,710 (32.7)	257,223 (41.0)	278,396 (17.8)	535,619 (24.4)
70–79 yr	42,331 (25.4)	78,839 (25.9)	121,170 (25.7)	32,302 (23.1)	64,249 (23.9)	96,551 (23.6)	136,256 (21.7)	257,002 (16.4)	393,258 (17.9)
80+ yr	5,017 (3.0)	28,389 (9.3)	33,406 (7.1)	3,066 (2.2)	18,146 (6.8)	21,212 (5.2)	15,333 (2.4)	107,359 (6.9)	122,692 (5.6)
% Female	42.4	48.1	46.1	48.4	51.2	50.2	58.0	61.3	60.3
No. of colonoscopies during follow-up, mean (SD)	2.0 (1.4)	2.1 (1.5)	2.0 (1.2)	1.6 (1.0)	1.9 (1.3)	1.8 (1.2)	1.3 (0.8)	1.6 (1.1)	1.5 (1.0)
Persons with colonoscopy before cohort entry[b], n (%)	533 (0.3)	5,989 (2.0)	6,522 (1.4)	426 (0.3)	9,272 (3.5)	9,698 (2.4)	1,739 (0.3)	34,784 (2.2)	36,523 (1.7)
Months of follow-up, median (IQR)	57 (26–90)	46 (20–78)	50 (22–82)	54 (23–86)	52 (23–84)	53 (23–85)	60 (27–92)	50 (22–82)	52 (23–85)

IQR, interquartile range.
[a]Cohort 1: persons with a code for snare polypectomy, cohort 2: persons assigned to the group "forceps polypectomy," and cohort 3: persons without codes indicating polyps/polypectomy.
[b]This refers to the baseline period of 2 years.

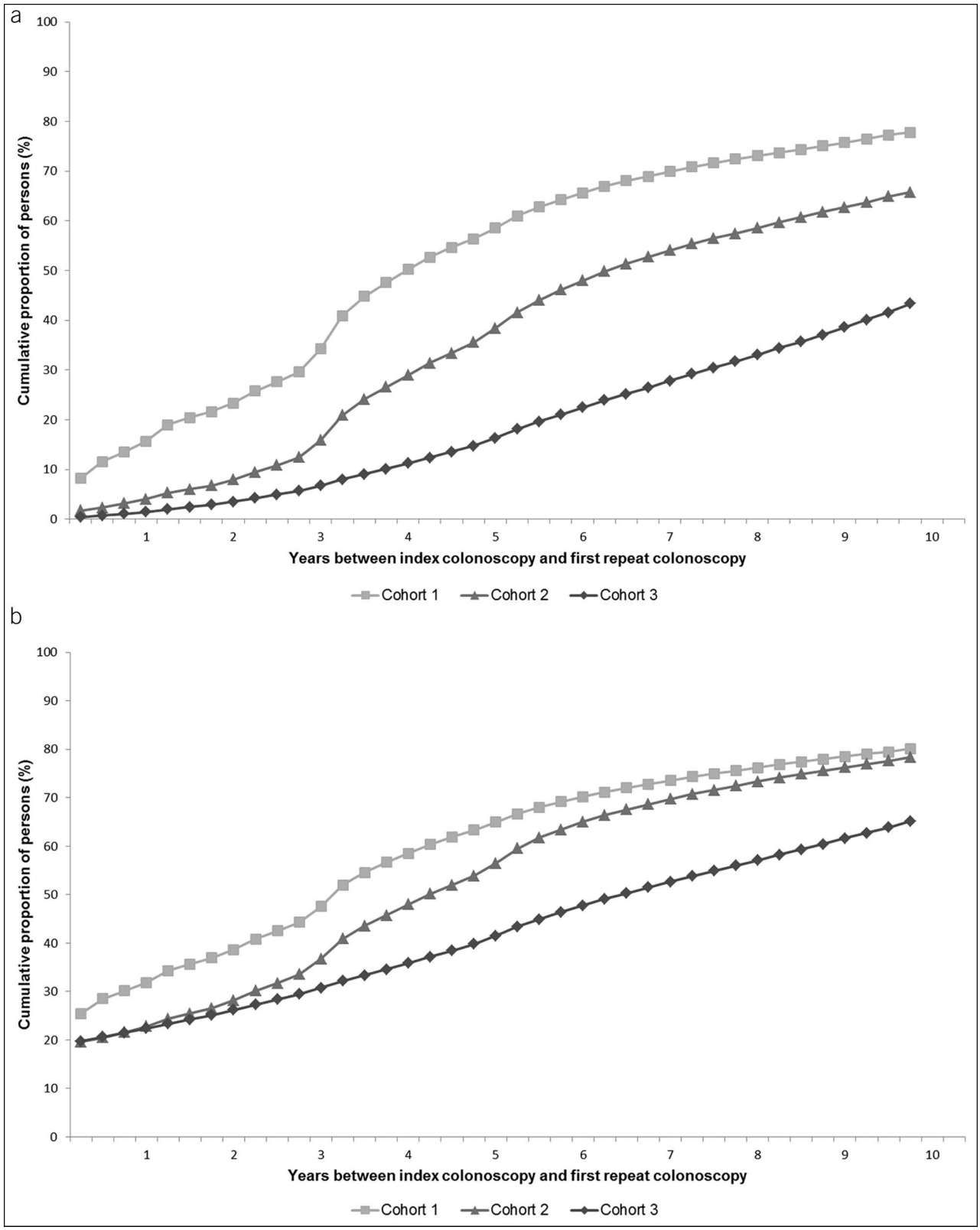

Figure 1. Cumulative proportion of persons with a repeat colonoscopy according to years since index colonoscopy and stratified by cohorts 1–3[1]. (**a**) Persons with a screening index colonoscopy. (**b**) Persons with a diagnostic index colonoscopy. [1]Cohort 1: persons with a code for snare polypectomy, cohort 2: persons assigned to the group "forceps polypectomy," and cohort 3: persons without codes indicating polyps/polypectomy.

Table 2. Snare polypectomies conducted at first repeat colonoscopy[a] in cohorts 1–3,[b] stratified by type of index colonoscopy and by sex and age at repeat colonoscopy

Persons with a snare polypectomy at first repeat colonoscopy, n (%)[c]	Cohort 1		Cohort 2		Cohort 3	
	Screening	Diagnostic	Screening	Diagnostic	Screening	Diagnostic
Overall	16,738 (26.6)	21,229 (26.9)	7,170 (17.2)	13,242 (17.4)	13,036 (12.0)	28,753 (10.2)
Men						
All age groups	10,620 (29.1)	12,049 (29.5)	4,152 (18.7)	7,355 (19.5)	6,584 (13.9)	13,345 (12.1)
<30 yr	0 (0.0)	39 (26.9)	0 (0.0)	17 (11.6)	0 (0.0)	86 (2.5)
30–<50 yr	5 (17.2)	652 (20.0)	0 (0.0)	345 (12.1)	0 (0.0)	1,161 (6.3)
50–<60 yr	982 (27.4)	2,269 (25.9)	267 (15.9)	1,124 (15.8)	276 (10.5)	2,574 (10.5)
60–<70 yr	5,061 (28.8)	3,452 (30.5)	1,984 (18.3)	2,101 (20.3)	2,810 (13.2)	3,265 (13.6)
70–<80 yr	4,042 (29.9)	4,492 (32.9)	1,668 (19.6)	3,028 (21.5)	2,958 (15.1)	4,757 (15.6)
80+ yr	530 (29.3)	1,145 (30.8)	233 (20.4)	740 (23.2)	540 (14.4)	1,502 (15.3)
Women						
All age groups	6,118 (23.1)	9,180 (24.1)	3,018 (15.5)	5,887 (15.3)	6,452 (10.5)	15,408 (9.0)
<30 yr	0 (0.0)	36 (17.7)	0 (0.0)	30 (14.5)	0 (0.0)	108 (2.1)
30–<50 yr	3 (9.4)	586 (16.4)	0 (0.0)	325 (9.9)	0 (0.0)	1,340 (4.7)
50–<60 yr	694 (21.8)	1,837 (21.2)	260 (14.1)	1,045 (13.4)	328 (8.5)	3,091 (7.8)
60–<70 yr	2,949 (23.0)	2,491 (25.2)	1,501 (15.3)	1,692 (15.7)	2,863 (9.8)	3,841 (10.4)
70–<80 yr	2,171 (23.9)	3,260 (26.9)	1,119 (16.1)	2,143 (16.5)	2,724 (11.3)	5,095 (11.6)
80+ yr	301 (23.0)	970 (26.0)	138 (15.9)	652 (19.7)	537 (12.4)	1,933 (11.6)

[a]Excluding those with repeat colonoscopies within the first 6 months as this is already represented in cohort definition.
[b]Cohort 1: persons with a code for snare polypectomy, cohort 2: persons assigned to the group "forceps polypectomy," and cohort 3: persons without codes indicating polyps/polypectomy.
[c]Percentages were calculated using the number of persons with a repeat colonoscopy in the respective subgroup as the denominator.

2, and 3, respectively). The mean age at cohort entry was higher in cohort 1 (64 years) and cohort 2 (63 years) compared with cohort 3 (58 years). Within each cohort, the mean age was higher among those with a screening (index) colonoscopy compared with a diagnostic (index) colonoscopy, with the difference amounting to 2 years, 3 years, and 9 years, in cohorts 1, 2, and 3, respectively. The proportion of females increased from cohort 1 (46%) to cohort 2 (50%) and cohort 3 (60%). Within each cohort, the proportion of females was 3–6 percentage points lower in the screening vs the diagnostic colonoscopy group. The mean number of colonoscopies during follow-up ranged between 1.5 (cohort 3) and 2.0 (cohort 1).

Figure 1 shows the cumulative proportion of persons with a repeat colonoscopy within 10 years in each cohort stratified by the type of index colonoscopy. Among persons with a screening colonoscopy at baseline, the cumulative proportion with a repeat colonoscopy within less than 3 years in cohorts 1, 2, and 3 was 30%, 12%, and 6%, respectively. Within 5 years after baseline, 59%, 38%, and 16% in cohorts 1, 2, and 3, respectively, underwent at least 1 repeat colonoscopy; these proportions increased to 78%, 66%, and 43%, respectively, within 10 years after baseline (Figure 1a). Among persons undergoing a diagnostic colonoscopy at baseline, the overall patterns were similar, but a large proportion underwent a second colonoscopy within the first quarter after the index colonoscopy (25%, 20%, and 20%, respectively), and the cumulative proportions with at least 1 repeat colonoscopy were higher compared with those with a screening colonoscopy at baseline (80%, 78%, and 65% within 10 years, respectively), mainly in cohorts 2 and 3 (Figure 1b). The patterns did not change in sensitivity analyses, where we excluded persons aged 70 years or older at index colonoscopy (see Supplementary Digital Content 4, http://links.lww.com/CTG/A474).

Among males with a screening colonoscopy at baseline, the overall proportion with a code for a snare polypectomy at repeat colonoscopy in cohorts 1, 2, and 3, respectively, was 29% (women: 23%), 19% (women: 16%), and 14% (women: 11%). These proportions were similar among persons with a diagnostic colonoscopy at baseline. Compared with the age group 50–60 years, the proportions in the age group 80+ years were 1–5 percentage points higher among those with a screening colonoscopy (Table 2) and 4–7 percentage points higher among those with a diagnostic colonoscopy at baseline. Figure 2 shows that the point estimates of the proportion of persons with a snare polypectomy at repeat colonoscopy reach a minimum at year 3 and then tended to increase according to the time passed between index and repeat colonoscopies. For example, in screening cohort 1, 32% of persons with a (first) repeat colonoscopy after 9 years had a snare polypectomy compared with 25% in those with a (first) repeat colonoscopy after 3 years. The distribution of age and sex of the persons in the denominator is shown in Supplementary Digital Content 5 (http://links.lww.com/CTG/A474) for each of these time points. The mean age at baseline of persons undergoing their first repeat colonoscopy at year 9 was 2–6 years higher compared with that of persons at year 3. The proportion of males was mostly

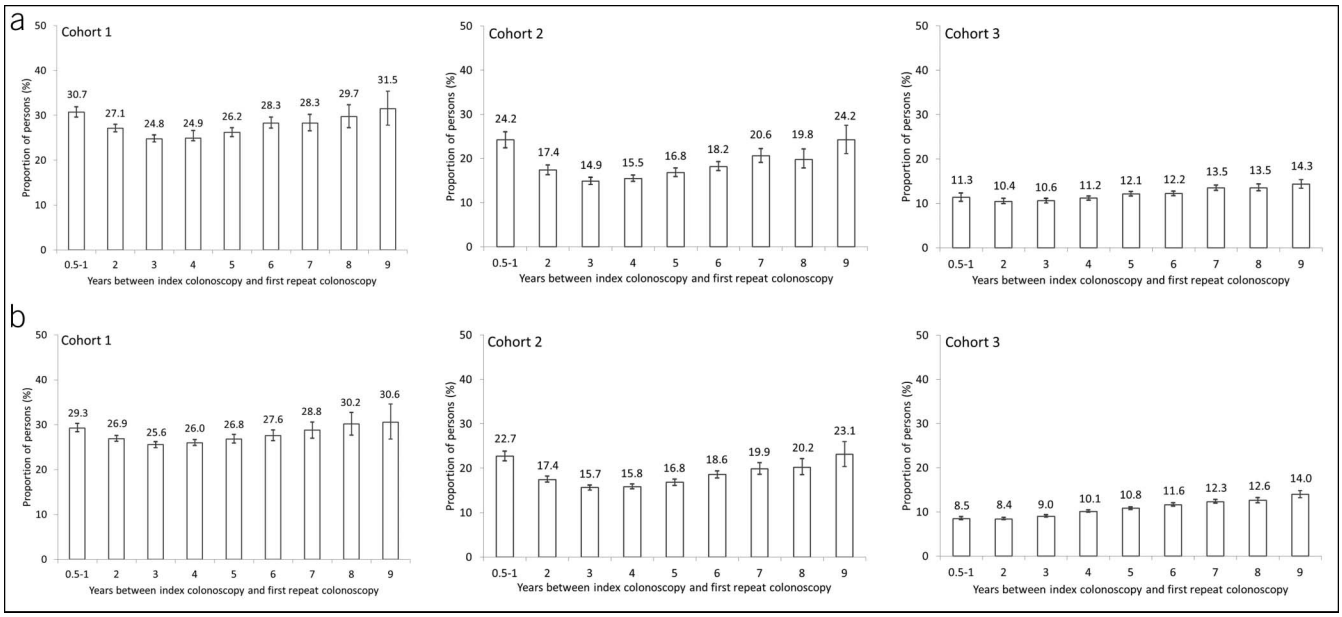

Figure 2. Proportion of persons with a snare polypectomy at first repeat colonoscopy[1] according to years since index colonoscopy and stratified by cohorts 1–3[2]. (**a**) Persons with a screening index colonoscopy. (**b**) Persons with a diagnostic index colonoscopy. [1]Excluding those with repeat colonoscopies within the first 6 months as this is already represented in the cohort definition. [2]Cohort 1: persons with a code for snare polypectomy, cohort 2: persons assigned to the group "forceps polypectomy," and cohort 3: persons without such codes indicating polyps/polypectomy.

the same, except for diagnostic cohort 2 (8 percentage points lower for persons with a repeat colonoscopy at year 9 vs year 3).

Among persons with a repeat colonoscopy earlier than expected, a diagnosis or symptom possibly explaining the procedure was coded in 10%–17% of cohort 1 and in 20%–31% of cohort 3. In both cohorts, more than 50% of these persons had a fecal occult blood test any time during the follow-up and 13%–17% within 6 months before the repeat colonoscopy (see Supplementary Digital Content 3, http://links.lww.com/CTG/A474).

DISCUSSION

Our findings based on the analyses of 3 million persons undergoing colonoscopy and a follow-up of up to 10 years suggest that there is substantial underuse of surveillance colonoscopy among persons with a previous snare polypectomy, i.e., persons at an increased risk of CRC. Approximately 20% of persons with a snare polypectomy at index colonoscopy did not undergo a repeat colonoscopy within 10 years. On the other hand, our data also show that a relevant proportion of persons undergo repeat colonoscopy earlier than expected. Among persons undergoing another colonoscopy, the proportion of persons with a snare polypectomy at the repeat examination markedly differed between the diagnostic subgroups: for example, in persons with a repeat colonoscopy 9 years after a screening colonoscopy, the proportions of persons with a snare polypectomy at repeat colonoscopy were 14% in cohort 3, 24% in cohort 2, and 32% in cohort 1.

Overall, the literature on the utilization of repeat colonoscopies is sparse, and most studies were conducted in the United States (4,5,8–10,13). The results of available studies showing overuse of repeat colonoscopy among persons without adenomas or with low-risk adenomas (3,5,7,8,10,13) and underuse among persons with advanced adenomas (3,4,9,10,12,13) are similar to the patterns observed in our study. In a recent study by Hoffmeister et al. using primary data from 6,407 participants of screening colonoscopy in Germany, 39% of persons with high-risk adenomas at baseline did not undergo a repeat colonoscopy within 6 years. In our study, 34% of persons with a snare polypectomy at screening index colonoscopy did not undergo a repeat colonoscopy within 6 years, i.e., the extent of underuse estimated based on primary data vs claims data is very consistent. The small difference may be due to differences in considering early repeat examinations (more complete information in claims data). The longer follow-up period of our study allowed us to show that even within 10 years after baseline, 22% of persons in this risk group had not undergone a repeat colonoscopy.

Furthermore, the study by Hoffmeister et al. showed that 22% of persons with a negative colonoscopy at baseline underwent a repeat colonoscopy within 6 years. Although this also corresponds well to the proportion observed in our study within 6 years among persons without a snare polypectomy or polyp diagnosis at baseline (21%), we additionally could show that this proportion linearly increases to 43% within 10 years. Regarding persons undergoing a diagnostic colonoscopy at baseline, there is no similar study to which we can compare our findings. We found that the overall patterns were similar to persons with a screening colonoscopy; only the high proportion undergoing an early repeat examination was striking. We can only speculate on the reasons, but given that diagnostic colonoscopies are typically conducted in persons with symptoms or certain diseases, we assume that these special conditions may more often require early repeat examinations compared with asymptomatic persons undergoing screening colonoscopy.

Remarkably, our analysis showed that more than 50% of persons who underwent a repeat colonoscopy earlier than expected had a fecal occult blood test within follow-up and 13%–17% before the repeat colonoscopy, although it is typically

not recommended to perform this test after a colonoscopy (18), i.e., this represents another source of overuse.

Overall, the proportion of persons with a snare polypectomy at first repeat colonoscopy was higher in cohort 1 compared with cohort 2, and higher in cohort 2 compared with cohort 3. These differences between the cohorts are plausible in view of other studies showing a higher rate of adenoma recurrence in persons with larger vs smaller adenomas (22,23) and the lowest risk of adenomas in persons with a negative colonoscopy at baseline (15). In addition, quantitatively, our results are in line with the results of previous studies. For example, Stock et al. reported that in 28% of persons with high-risk adenomas removed at index colonoscopy, further lesions were detected at colonoscopies conducted within 3 years. Cooper et al. reported that 32% of patients with polypectomy at index colonoscopy had another polypectomy at repeat colonoscopy conducted within 5 years after baseline.

In this study, we observed that the proportion of persons with a snare polypectomy at first repeat colonoscopy tended to increase according to the time passed between index and repeat colonoscopies, but this increase was only moderate, and there was no clear time pattern across cohorts. There are at least 2 reasons why we would have expected a clearer pattern. First, the longer the time period between index and repeat colonoscopies, the longer is the time for new lesions to grow, i.e., a clear and steady increase in all cohorts starting some years after the last colonoscopy would seem plausible. Second, the mean age among persons undergoing their first repeat colonoscopy later was slightly higher compared with persons undergoing it earlier, and age is an important risk factor for adenoma occurrence (24). Interestingly, Pinsky et al. (25) using primary data from 2,600 persons undergoing surveillance colonoscopy within 10 years also reported a pattern somewhat other than expected. They did not observe relevant differences in recurrence rates when they stratified them by time since index colonoscopy, neither among persons with advanced adenomas nor among persons with nonadvanced or no adenomas at baseline. The findings of our study and the study by Pinsky et al can be considered complementary in the sense that we also could not show a clear time pattern based on a much larger sample size and stratified by the type of index colonoscopy (screening vs diagnostic); however, Pinsky et al. had detailed information on adenomas. They used these data, for example, to investigate whether an increase in recurrence rates might have been masked because persons at a higher risk of recurrence may have been referred for earlier surveillance, but controlling for baseline adenoma characteristics did not change the observed pattern. Other studies reporting on the probability of polyp recurrence according to time since baseline colonoscopy did not restrict the denominator to persons who actually underwent another colonoscopy, i.e., they analyzed the data differently and can therefore not be used for comparison with our results (9,26). Although the lack of a clear increase in polypectomies according to time since baseline colonoscopy is relevant and requires further attention, caution is warranted when using this as an argument in discussions of optimal intervals for surveillance given that CRC incidence rather than adenoma recurrence is crucial in this regard.

Overall, this study illustrates the urgent need for a monitoring system that ensures adequate allocation and timing of repeat colonoscopies to avoid both underuse and overuse. In Germany, where there is currently no such system; this will play an important role in maximizing the benefit and minimizing the burden of CRC screening and in avoiding unnecessary health care costs. Such a system, however, should not be restricted to the screening setting as we also found strong indicators of both overuse and underuse among persons with a diagnostic colonoscopy at baseline. The optimal solution on how to monitor utilization of surveillance colonoscopies may depend on the health care system and requires implementation research in the respective country. Trials conducted in the United States suggested that simple physician reminders and comprehensive alerting systems (linked to electronic medical records and using an automated step-wise approach for contacting physicians and patients) could be effective tools to increase the use of surveillance colonoscopies among persons with previous adenomas (27,28). These examples predominantly address underuse of colonoscopy. The problem of overuse may require other solutions, e.g., identification and education of physicians conducting unnecessary colonoscopies and possibly their patients or—as also applied to reduce unnecessary drug prescriptions in Germany—claims for recourse by health insurance providers.

When interpreting the results, it should be noted that our study and the database we used have strengths and limitations. To the best of our knowledge, this is the largest study on this subject to date. The sample size of 3 million persons, which could hardly be reached with primary data collection, facilitated analyses stratified by various factors. Furthermore, the longitudinal character of the database allowed a long and continuous follow-up. Finally, recall and volunteer bias are avoided with claims data. Errors due to billing and coding cannot be excluded, but comparison of the distribution of colonoscopies with and without polypectomy with the German screening colonoscopy registry showed very good agreement (see Supplementary Digital Content 2, http://links.lww.com/CTG/A474). Our database (GePaRD) contains all information on colonoscopies performed in the inpatient and outpatient setting except for diagnostic colonoscopies performed in the hospital and billed as outpatient procedures for patients who were not hospitalized. According to estimates of a large health insurance provider in Germany, this kind of billing applied to approximately 18% of all colonoscopies in 2014 (29). Regarding the interpretation of our study, this missing information would mainly be relevant as far as such colonoscopies were performed in persons assigned to cohort 1 in our data after several years of follow-up. In that case, we would overestimate the proportion of persons underusing surveillance colonoscopy. However, we assume that this specific scenario applies only to a minority of such colonoscopies as current guidelines mention clinical reasons for their conduct (18), e.g., if a colonoscopy in the outpatient setting seems generally too risky because of comorbidity or in case a colonoscopy was started in the outpatient setting but turned out to be too risky. Reassuringly, our findings on underuse agree very well with the study by Hoffmeister et al. after a follow-up of 6 years, which also suggests that we do not miss a relevant part of information in this regard. An important limitation of claims data is the lack of information on polyp characteristics such as number, size, and histology. However, in primary data studies in which this information is typically available, the sample sizes are much smaller than that of our study, i.e., both data sources have their specific value. Unlike in other claims databases, we could at least roughly distinguish between smaller and larger polyps. Furthermore, it seems plausible that polyps removed by snare polypectomy typically were adenomas rather than hyperplastic polyps given that most hyperplastic polyps are diminutive (30), and snare polypectomy is reimbursable only for polyps $\geq$5 mm in size. The clear differences in the probability of another snare polypectomy between the cohorts also suggest that the data are suitable

for a relevant distinction of risk groups. Subsequent analyses using information on CRCs as far as it is available in claims data will shed further light on risk differences between the 3 cohorts. To describe the diagnostic yield according to time since index colonoscopy, we focused on snare polypectomies conducted at first repeat colonoscopy in this analysis. We did not consider procedures (e.g., colorectal surgery) indicating the diagnosis of CRC. However, given the small number of CRCs relative to the high number of polyps detected at surveillance colonoscopies (11,15), consideration of these codes is expected to affect the proportions reported in Figure 2 only at the first or second decimal place.

In conclusion, our study suggests a substantial underuse of repeat colonoscopy among persons with a previous snare polypectomy, i.e., persons at an increased risk of CRC, and overuse among lower risk groups in Germany. The former means that the full potential of early detection is not realized, whereas the latter leads to unnecessary burden, harm, and health care costs. A system that facilitates monitoring and controlling of the use of repeat colonoscopy is urgently needed and should not be restricted to the screening setting.

CONFLICTS OF INTEREST

Guarantor of the article: Ulrike Haug, PhD.

Specific author contributions: S.S. and U.H. conceptualized the study and developed the data analysis plan. S.S. and W.S. contributed to data analysis. S.S. drafted the first version of the article. All authors contributed to interpretation of the results and critically revised the manuscript draft. All authors approved the final version of the article. U.H. and D.H.-S. acquired funding for this project, and U.H. supervised the project.

Financial support: This study was supported by a grant (01VSF16037) from the Federal Joint Committee (G-BA).

Potential competing interests: None to report.

Study Highlights

WHAT IS KNOWN

- ✓ Persons with adenomas at index colonoscopy are at increased long-term risk of colorectal cancer.
- ✓ Longitudinal studies on repeat colonoscopy use are sparse.

WHAT IS NEW HERE

- ✓ Approximately 20% of persons with a snare polypectomy did not undergo another colonoscopy within 10 years.
- ✓ In persons without polyps/polypectomy, more than 40% had a repeat colonoscopy earlier than expected.
- ✓ Patterns of overuse and underuse were largely similar in screening and diagnostic colonoscopy.
- ✓ One-quarter of persons had a snare polypectomy both at baseline and at first repeat colonoscopy.

TRANSLATIONAL IMPACT

- ✓ The study suggests that a system monitoring the use of repeat colonoscopy is urgently needed.
- ✓ This may facilitate adequate surveillance and avoid unnecessary burden and health care costs.
- ✓ Such a system should not be restricted to the screening setting.

ACKNOWLEDGMENTS

We thank all statutory health insurance providers, which provided data for this study, namely AOK Bremen/Bremerhaven, DAK-Gesundheit, Die Techniker (TK), and hkk Krankenkasse. We also thank Anja Gabbert, Alina Ludewig, and Inga Schaffer for statistical programming of the datasets and analyses.

REFERENCES

1. Chen C, Läcke E, Stock C, et al. Colonoscopy and sigmoidoscopy use among older adults in different countries: A systematic review. Prev Med 2017;103:33–42.
2. Stock C, Haug U, Brenner H. Population-based prevalence estimates of history of colonoscopy or sigmoidoscopy: Review and analysis of recent trends. Gastrointest Endosc 2010;71:366–81.
3. Bunjo Z, Koh YH, Leopardi L, et al. Surveillance colonoscopies frequently booked earlier than the National Health and Medical Research Council guidelines: Findings of a single centre audit. ANZ J Surg 2019;89:E61–5.
4. Cooper GS, Kou TD, Barnholtz Sloan JS, et al. Use of colonoscopy for polyp surveillance in Medicare beneficiaries. Cancer 2013;119:1800–7.
5. Goodwin JS, Singh A, Reddy N, et al. Overuse of screening colonoscopy in the Medicare population. Arch Intern Med 2011;171:1335–43.
6. Hoffmeister M, Holleczek B, Stock C, et al. Utilization and determinants of follow-up colonoscopies within 6 years after screening colonoscopy: Prospective cohort study. Int J Cancer 2019;144:402–10.
7. Hol L, Sutradhar R, Gu S, et al. Repeat colonoscopy after a colonoscopy with a negative result in Ontario: A population-based cohort study. CMAJ Open 2015;3:E244–50.
8. Kruse GR, Khan SM, Zaslavsky AM, et al. Overuse of colonoscopy for colorectal cancer screening and surveillance. J Gen Intern Med 2015;30:277–83.
9. Lansdorp-Vogelaar I, Fedewa S, Lin CC, et al. Utilization of surveillance after polypectomy in the Medicare population—A cohort study. PLoS One 2014;9:e110937.
10. Murphy CC, Sandler RS, Grubber JM, et al. Underuse and overuse of colonoscopy for repeat screening and surveillance in the Veterans Health Administration. Clin Gastroenterol Hepatol 2016;14:436–44.
11. Stock C, Hoffmeister M, Birkner B, et al. Performance of additional colonoscopies and yield of neoplasms within 3 years after screening colonoscopy: A historical cohort study. Endoscopy 2013;45:537–46.
12. Stock C, Holleczek B, Hoffmeister M, et al. Adherence to physician recommendations for surveillance in opportunistic colorectal cancer screening: The necessity of organized surveillance. PLoS One 2013;8:e82676.
13. Schoen RE, Pinsky PF, Weissfeld JL, et al. Utilization of surveillance colonoscopy in community practice. Gastroenterology 2010;138:73–81.
14. Laiyemo AO, Pinsky PF, Marcus PM, et al. Utilization and yield of surveillance colonoscopy in the continued follow-up study of the polyp prevention trial. Clin Gastroenterol Hepatol 2009;7:562–7.
15. Click B, Pinsky PF, Hickey T, et al. Association of colonoscopy adenoma findings with long-term colorectal cancer incidence. JAMA 2018;319:2021–31.
16. Cottet V, Jooste V, Fournel I, et al. Long-term risk of colorectal cancer after adenoma removal: A population-based cohort study. Gut 2012;61:1180–6.
17. Holme Ø, Bretthauer M, Eide TJ, et al. Long-term risk of colorectal cancer in individuals with serrated polyps. Gut 2015;64:929–36.
18. Pox C, Aretz S, Bischoff SC, et al. S3-guideline colorectal cancer version 1.0 [in German]. Z Gastroenterol 2013;51:753–854.
19. US Preventive Services Task Force. Screening for colorectal cancer: US Preventive Services Task Force recommendation statement. JAMA 2016;315:2564–75.
20. Leibniz Institute for Prevention Research and Epidemiology–BIPS GmbH. The German Pharmacoepidemiological Research Database (GePaRD). (https://www.bips-institut.de/en/research/research-infrastructures/gepard.html). Accessed September 3, 2020.
21. Pigeot I, Ahrens W. Establishment of a pharmacoepidemiological database in Germany: Methodological potential, scientific value and practical limitations. Pharmacoepidemiol Drug Saf 2008;17:215–23.

22. de Jonge V, Sint Nicolaas J, van Leerdam ME, et al. Systematic literature review and pooled analyses of risk factors for finding adenomas at surveillance colonoscopy. Endoscopy 2011;43:560–72.
23. Saini SD, Kim HM, Schoenfeld P. Incidence of advanced adenomas at surveillance colonoscopy in patients with a personal history of colon adenomas: A meta-analysis and systematic review. Gastrointest Endosc 2006;64:614–26.
24. Ferlitsch M, Reinhart K, Pramhas S, et al. Sex-specific prevalence of adenomas, advanced adenomas, and colorectal cancer in individuals undergoing screening colonoscopy. JAMA 2011;306:1352–8.
25. Pinsky PF, Schoen RE, Weissfeld JL, et al. The yield of surveillance colonoscopy by adenoma history and time to examination. Clin Gastroenterol Hepatol 2009;7:86–92.
26. Amonkar MM, Hunt TL, Zhou Z, et al. Surveillance patterns and polyp recurrence following diagnosis and excision of colorectal polyps in a Medicare population. Cancer Epidemiol Biomarkers Prev 2005;14:417–21.
27. Ayanian JZ, Sequist TD, Zaslavsky AM, et al. Physician reminders to promote surveillance colonoscopy for colorectal adenomas: A randomized controlled trial. J Gen Intern Med 2008;23:762–7.
28. Leffler DA, Neeman N, Rabb JM, et al. An alerting system improves adherence to follow-up recommendations from colonoscopy examinations. Gastroenterology 2011;140:1166–73.
29. Friedrich J, Tillmanns H. Ambulante Operationen im Krankenhaus. In: Klauber J, Geraedts M, Friedrich J, et al (eds). Krankenhausreport 2016 Schwerpunkt: Ambulant im Krankenhaus. Schattauer: Stuttgart, Germany, 2016, pp 127–47.
30. Laiyemo AO, Murphy G, Sansbury LB, et al. Hyperplastic polyps and the risk of adenoma recurrence in the polyp prevention trial. Clin Gastroenterol Hepatol 2009;7:192–7.