Gastroenterology 2015;149:356–366

Trends in Adenoma Detection Rates During the First 10 Years of the German Screening Colonoscopy Program

Hermann Brenner,[1,2] Lutz Altenhofen,[3] Jens Kretschmann,[3] Thomas Rösch,[4] Christian Pox,[5] Christian Stock,[6] and Michael Hoffmeister[1]

[1]Division of Clinical Epidemiology and Aging Research, German Cancer Research Center (DKFZ), Heidelberg, Germany; [2]German Cancer Consortium (DKTK), German Cancer Research Center (DKFZ), Heidelberg, Germany; [3]Central Research Institute of Ambulatory Health Care in Germany, Berlin, Germany; [4]Interdisciplinary Endoscopy Department and Clinic, University Clinic Hamburg, Hamburg, Germany; [5]Department of Medicine, Ruhr University Bochum, Knappschaftskrankenhaus, Germany; and [6]Institute of Medical Biometry and Informatics, University of Heidelberg, Heidelberg, Germany

See editorial on page 273.

BACKGROUND & AIMS: The adenoma detection rate (ADR) is an important quality indicator of screening colonoscopy; it is inversely associated with risk of interval cancers and colorectal cancer mortality. We assessed trends in the ADR in the first 10 years of the German screening colonoscopy program. **METHODS:** We calculated age-adjusted and age-specific detection rates of nonadvanced adenomas and advanced adenomas for each calendar year based on 4.4 million screening colonoscopies conducted from 2003 through 2012 and reported to the German screening colonoscopy registry. **RESULTS:** We observed a steady and strong increase in rate of detection of nonadvanced adenomas in both sexes and all age groups. Age-adjusted rates of detection of nonadvanced adenomas increased from 13.3% to 22.3% among men and from 8.4% to 14.9% among women. This increase was mostly due to an increase in detection rates of adenomas <0.5 cm, and it is partly explained by an innovation effect (higher ADRs among incoming colonoscopists than among leaving colonoscopists, and relatively stable ADRs among continuing colonoscopists). Only modest increases were observed in detection rates of advanced adenomas (from 7.4% to 9.0% among men, and from 4.4% to 5.2% among women) and colorectal cancer. In 2012, overall ADR reached 31.3% and 20.1% in men and women, respectively. **CONCLUSIONS:** We observed a strong increase in ADRs from 2003 through 2012 in Germany. Although we cannot exclude the effects of secular trends in colorectal neoplasm prevalence, the observed increase was mainly the result of a steady increase in detection of nonadvanced adenomas (especially adenomas <0.5 cm). Further research should address potential implications for defining screening and surveillance intervals.

Keywords: Colon Cancer; Endoscopy; Colorectal Neoplasms; Prevention.

There is increasing evidence that screening colonoscopy with detection and removal of adenomas is a powerful approach to colorectal cancer (CRC) prevention.[1–5] Effectiveness of CRC prevention obviously depends on the ability of colonoscopists to detect and remove colorectal adenomas, and the adenoma detection rate (ADR), which is related to the level of training,[6] has been suggested to be an important and necessary, albeit not sufficient, indicator of endoscopist performance.[7,8] Recent studies have demonstrated the ADR at screening colonoscopy to show clear inverse associations with the risk of interval cancers[9] and CRC mortality.[10]

ADRs are known to vary by sex and age of patients.[9,11–14] However, previous studies have demonstrated strong interphysician variation and inter-center variation in the ADR, even after adjustment for patient factors.[9,15] To our knowledge, however, no previous study has systematically assessed time trends in ADR on the national level in countries offering screening colonoscopy. In this article, we provide a detailed assessment of such trends according to sex and age of screening colonoscopy participants within the initial 10 years of the German screening colonoscopy program.

Methods

Database

Our analysis is based on data of the German screening colonoscopy registry.[14] Screening colonoscopy has been offered in Germany as a primary screening examination for early detection and prevention of CRC since October 2002. Women and men aged 55 years or older are eligible for a first screening colonoscopy. If this first screening colonoscopy is conducted before 65 years of age, a second screening colonoscopy is offered 10 years later. Certification to conduct screening colonoscopy is tightly regulated on the basis of extensive previous training and experience, and its maintenance is subject to rigorous quality control. In particular, only gastroenterologists, internists, or surgeons who have conducted at least 200 colonoscopies in the preceding 2 years are certified for conducting screening colonoscopies. Maintenance of certification is contingent on conduction of at least 200 colonoscopies per year, the quality and completeness (ie, terminal ileum reached) of which has to be proven by photo or video documentation. These requirements, which do not include a minimum

Abbreviations used in this paper: **ADR, adenoma detection rate; CRC, colorectal cancer.**

0016-5085/$36.00
http://dx.doi.org/10.1053/j.gastro.2015.04.012

ADR limit, did not change over time during the period of investigation. Histopathologic examination is performed decentrally by certified pathology laboratories.

Along with introduction of screening colonoscopy, a national screening colonoscopy registry was built up, including all screening colonoscopies among men and women covered by Statutory Health Insurance (close to 90% of adults in the eligible age range). Details of the registry's operation and data quality have been reported elsewhere.[14,16] Briefly, all screening colonoscopies are reported anonymously on a standardized form. Reporting is virtually complete, as it is a prerequisite for physicians' reimbursement by the health insurance funds. The registry includes primary screening examinations only (ie, it does not include colonoscopies conducted for surveillance, workup of symptoms, or other screening tests). Items reported include basic sociodemographic variables, as well as information on findings at colonoscopy, including number (categories: 1, 2−4, and >4), size (categories: <0.5, 0.5−1 cm, 1−2 cm, and >2 cm), and histologic characteristics of polyps. In case of multiple neoplasms, only characteristics of the most advanced type are recorded. The reporting forms are processed and checked for completeness and plausibility using standardized algorithms at regional data centers before anonymized transfer to the national data center. Approximately 20%−30% of eligible people have had a screening colonoscopy within the initial 10 years from the introduction of this screening offer. For this analysis, we used data from 4,407,971 first-time screening colonoscopies in 2003−2012.

Statistical Analyses

Given the strong differences in adenoma prevalences between men and women, all analyses were conducted separately for men and for women. In addition, given expected differences in detection rates of advanced and nonadvanced adenomas, analyses were conducted separately for both types of adenomas. In the German screening colonoscopy registry, advanced adenomas are defined as at least 1 adenoma ≥1 cm or at least 1 adenoma with villous components or high-grade dysplasia. In additional analyses, adenoma detection rates were stratified by adenoma size, regardless of histologic subtype (<0.5 cm, 0.5−1 cm, and >1 cm).

We first present trends in cumulative numbers of participants in screening colonoscopy up to various ages (60, 65, 70, 75 years, and any age) for each calendar year from 2002 to 2012. Apart from the trends in numbers of participants, these results also indicate changes in age distribution of screening colonoscopy participants over time, which requires careful consideration in the analysis of trends in ADR, due to the dependency of adenoma prevalences on age.

We then present age-adjusted and age-specific detection rates of the various types of colorectal adenomas for each calendar year from 2003 to 2012. Age adjustment was done to the age distribution of screening colonoscopy participants in the total study period (2003−2012). In order to make results comparable between men and women, the same standard population of all 4,407,971 screening colonoscopy participants included in this analysis was used for age adjustment in analyses for both men and women. Age categories used for adjustment and for age-specific analyses were 55−59, 60−64, 65−69, 70−74, 75−79 and 80+ years. For comparison, age-adjusted detection rates are also shown for colorectal cancer, and detection rates are also shown for all neoplasms combined. For clarity of presentation and due to their very small size, we did not include 95% confidence intervals in the graphical presentations of ADRs. Given the very large size of the study population, the width of the confidence intervals was <1%-unit even for the vast majority (173 of 240 [72%]) of the sex-, age-, and calendar-year−specific detection rates of nonadvanced and advanced adenomas, the exceptions were mostly restricted to age groups 75−79 years and 80+ years.

In order to address possible reasons for, and consequences of, trends in ADR, we also assessed trends in age-adjusted cecal intubation rates and in sedation rates, as well as in age-adjusted bleeding and perforation rates for both men and women over time.

The composition and technical equipment of colonoscopists are not constant over time and observed trends in ADR might partly reflect an "innovation effect." To assess the potential role of such an innovation effect, we carried out additional separate analyses for "incoming" colonoscopists (typically younger colonoscopists opening or joining a gastroenterology practice with the most recent technological equipment) and "leaving" colonoscopists (typically older, retiring colonoscopists), as well for "continuously practicing" colonoscopists providing screening colonoscopies throughout the period of investigation. Because unique colonoscopist identifiers were only included in the database from 2008 on, these analyses were restricted to calendar years 2008−2012. Also, the database does not include colonoscopists' age, so the impact of this variable could not be assessed directly. Incoming colonoscopists were defined as colonoscopists not providing any screening colonoscopy in 2008, but providing screening colonoscopies in 2012 and possibly preceding years. Leaving colonoscopists were defined as colonoscopists providing screening colonoscopies in 2008 and possibly subsequent calendar years, but not in 2012. Continuously practicing colonoscopists were defined as colonoscopists providing screening colonoscopies in each calendar year from 2008 to 2012. Age-adjusted, sex-specific detection rates of nonadvanced adenomas and advanced adenomas were calculated for each calendar year and each group.

Finally, in order to assess stability of variation and ranking of overall ADR across colonoscopists over time, we assessed the joint classification of continuously practicing colonoscopists according to sex- and age-adjusted quintiles of overall ADR in 2008 and 2012. In order to limit the role of random variation, this analysis was restricted to colonoscopists who performed at least 50 screening colonoscopies among women and 50 screening colonoscopies among men in each of the 2 calendar years. For this analysis, indirect adjustment by sex and age was performed, using overall sex- and age-specific ADR in 2008 and 2012 to calculate expected ADRs. Agreement of ADR quintile in 2008 and 2012 beyond chance was quantified by a quadratically weighted κ coefficient with weights of 1, 4, 9, and 16 for differences by 1, 2, 3, and 4 quintiles, respectively.

Results

Figure 1 shows the annual cumulative numbers of men and women participating in screening colonoscopy up to various ages. Among men, the total number of screening colonoscopies increased steeply between 2003 and 2004 and reached its peak at 239,970 in 2006. Since then,

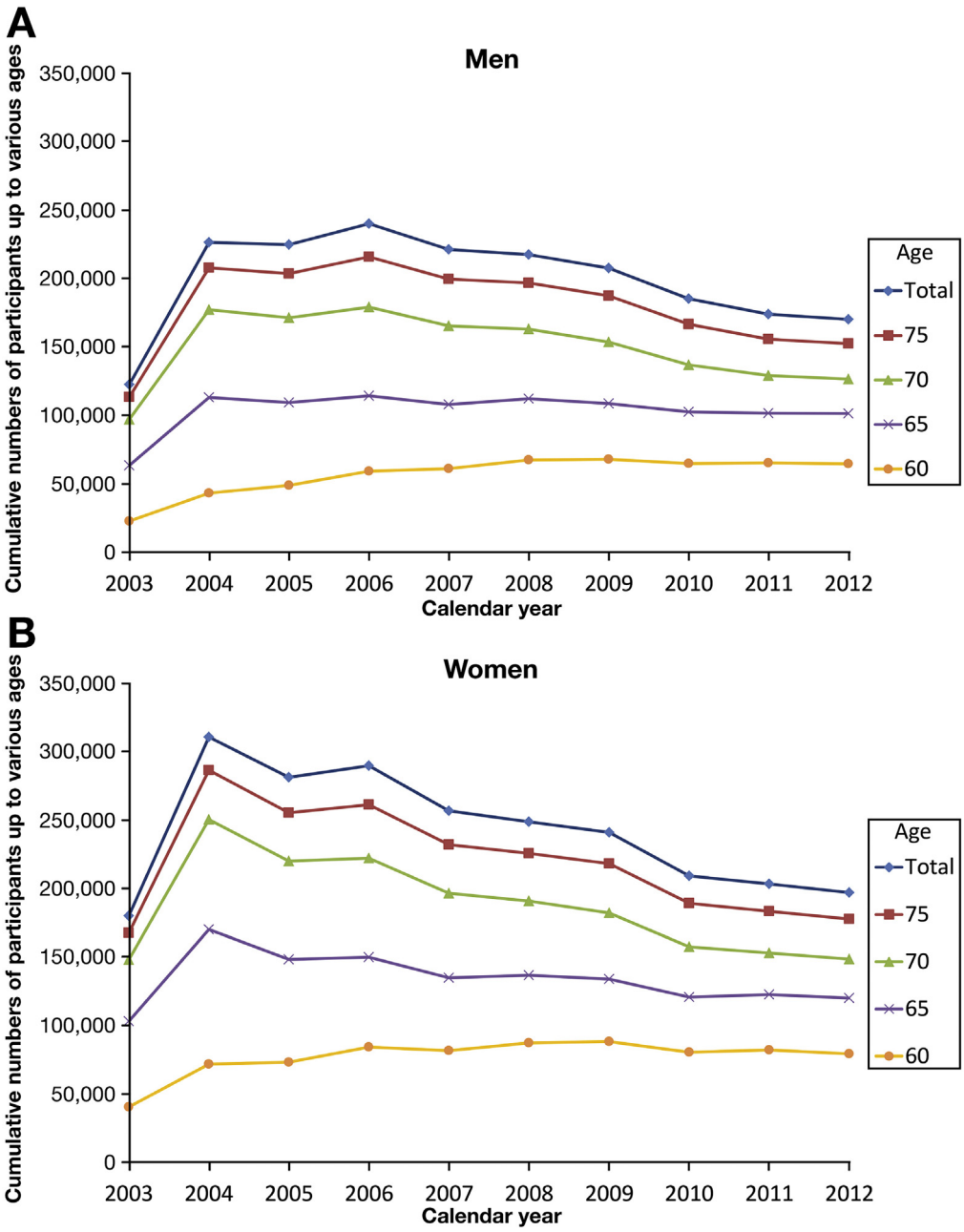


Figure 1. Annual cumulative numbers of (*A*) men and (*B*) women participating in screening colonoscopy up to various ages. German national screening colonoscopy registry, 2003–2012.

numbers of screening colonoscopies gradually declined, except for the youngest age group (55–59 years), in whom the number of screening colonoscopies continued to increase up to 2009 and remained essentially constant thereafter. As a result, the proportion of first time screening colonoscopies conducted in this age group increased from 18.6% in 2003 to 38.1% in 2012.

In all calendar years, more women than men participated in screening colonoscopy. The sex difference was largest in the earlier years of the program, and the decline in numbers of participants in later years was stronger for women than for men. In contrast to other age groups, the numbers of female participants remained approximately constant between 2006 and 2012 for the youngest age group (55–59 years), whose share among the total number of female participants rose from 22.5% in 2003 to 40.2% in 2012.

Age-adjusted detection rates of nonadvanced adenomas, advanced adenomas, and CRC were substantially higher among men than among women (Figure 2). Detection rates of nonadvanced adenomas strongly increased over time in both sexes, from 13.3% in 2003 to 22.3% in 2012 among men, and from 8.4% to 14.9% among women, less pronounced increases were seen (in absolute terms) for advanced adenomas (from 7.4% to 9.0% among men, and from 4.4% to 5.2% among women) and CRC. The steepest increase in detection rates of nonadvanced adenomas was observed between 2006 and 2007 among both men and women. The overall neoplasm detection rate (nonadvanced

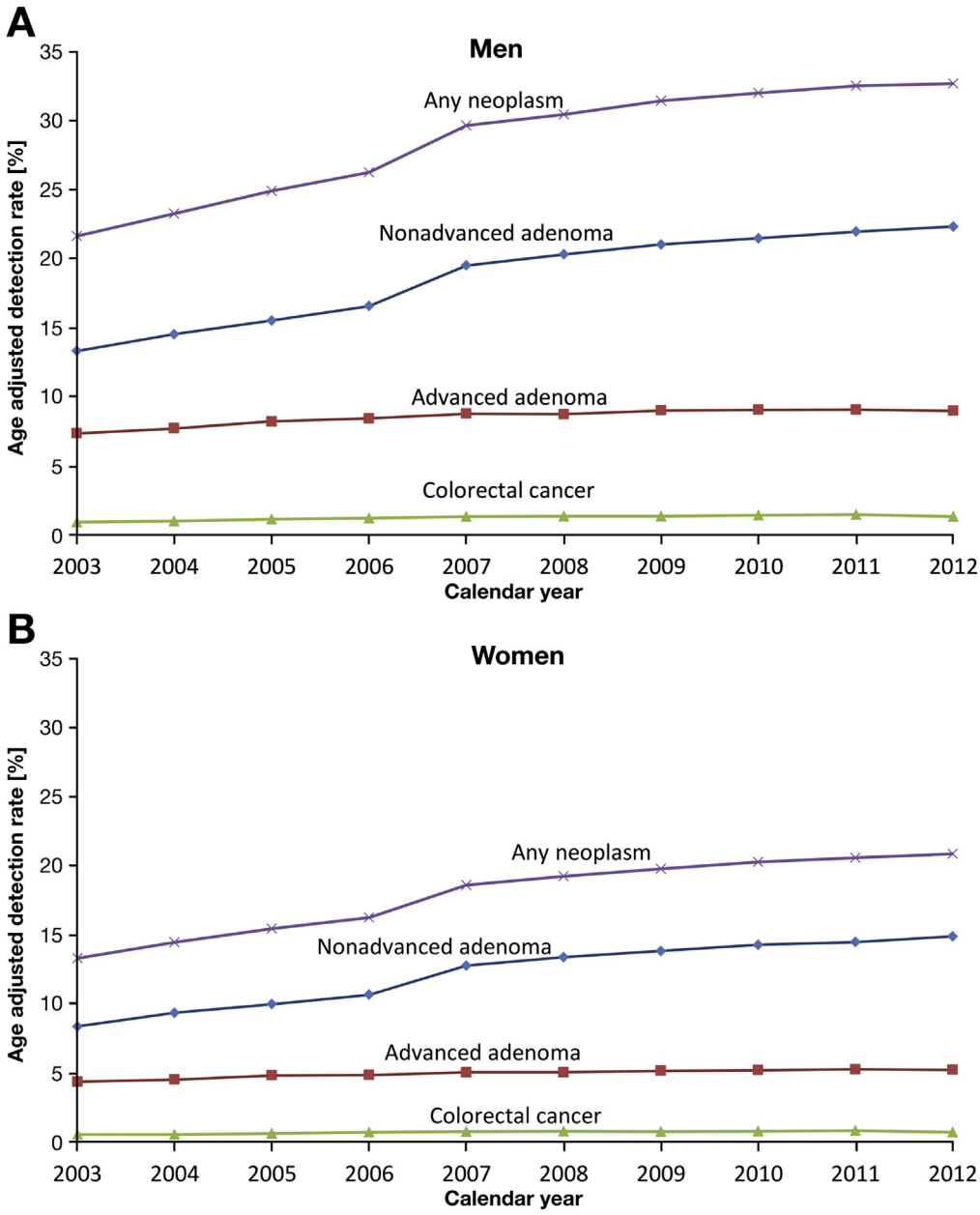


Figure 2. Trends in age-adjusted detection rates of nonadvanced adenomas, advanced adenomas, colorectal cancer, and any neoplasm by sex (*A*, men; *B*, women). German national screening colonoscopy registry, 2003–2012. For the sake of readability, confidence intervals that are very tight (width <0.6%-unit in all cases) are not shown.

adenomas, advanced adenomas and CRC combined) increased from 21.6% in 2003 to 32.7% in 2012 among men, and from 13.3% in 2003 to 20.9% in 2012 among women.

The strong increase in detection rates of nonadvanced adenomas was seen consistently with almost identical temporal patterns in all age groups in both sexes (Figure 3). Likewise, the very modest increase in detection rates of advanced adenomas was very similar in all age groups and both sexes (Figure 4). For advanced adenomas, a clear age gradient was seen with detection rates consistently increasing with age (apart from the oldest age group among men).

As can be seen from Figure 5, the increase in age-adjusted detection rates of nonadvanced adenomas over time was much stronger for adenomas <0.5 cm than for larger adenomas. Therefore, the increases in detection rates of nonadvanced adenomas and of overall ADRs were, to a large extent, due to increased detection rates of small nonadvanced adenomas, which accounted for a clear majority of nonadvanced adenomas detected at the end of the observation period.

Supplementary Figure 1 shows trends in age-adjusted cecal intubation rates and sedation rates over time. Cecal intubation rates were already rather high in 2003 (>98% in both men and women), with little change over time since then. Sedation rates increased over time in both men and women, but the vast majority of screening colonoscopies was conducted under sedation throughout the period of investigation (especially among women). In contrast to the

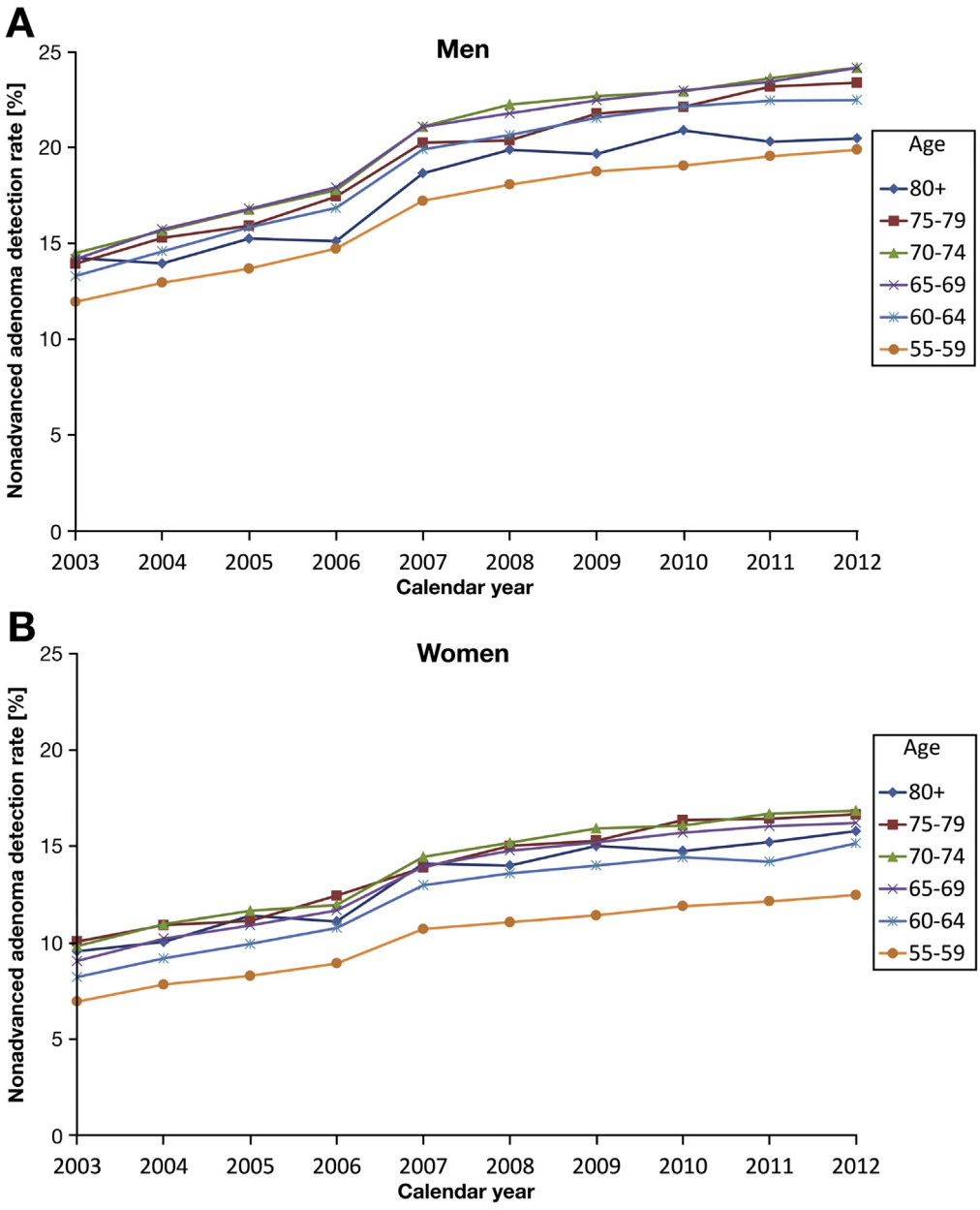


Figure 3. Trends in detection rates of nonadvanced adenomas by sex and age (*A*, men; *B*, women). German national screening colonoscopy registry, 2003–2012. For the sake of readability, confidence intervals that are very tight (width <1%-unit in 78 of 120 cases) are not shown.

increase in ADR, most of the increase was already seen in the early years up to 2006. Consistent recording of bleedings and perforations was restricted to calendar years 2005 to 2012. Age-adjusted bleeding and perforation rates were consistently well below 0.5% and 0.1%, respectively, with decreasing rather than increasing trends over time despite increasing ADR (data not shown).

Of the 1,809,035 screening endoscopies performed from 2008 to 2012, there were 209,937 (11.7%), 1,445,378 (79.9%) and 129,165 (7.1%) performed by 647 incoming, 1597 continuous, and 548 leaving endoscopists (for 1.4% of endoscopies a classification of the endoscopist was missing). As illustrated in Figure 6, the slight increase in ADRs between 2008 and 2012 might be due, at least in part, to an innovation effect, with endoscopists starting to perform screening colonoscopies during the period of investigation showing higher ADRs than endoscopists stopping to perform screening colonoscopies. Intermediate levels of ADRs were seen for the majority of continuously practicing endoscopists performing screening colonoscopies throughout the period of investigation. Overall, ADRs within groups of endoscopists remained rather stable during the 5-year period investigated. In addition, variation and ranking of sex- and age-adjusted ADR across colonoscopists was rather stable over time (Table 1), with a quadratically weighted κ coefficient of agreement between quintile membership in 2008 and 2012 of 0.73.

Discussion

In this study, we observed a strong increase in the detection rate of nonadvanced adenomas within the initial

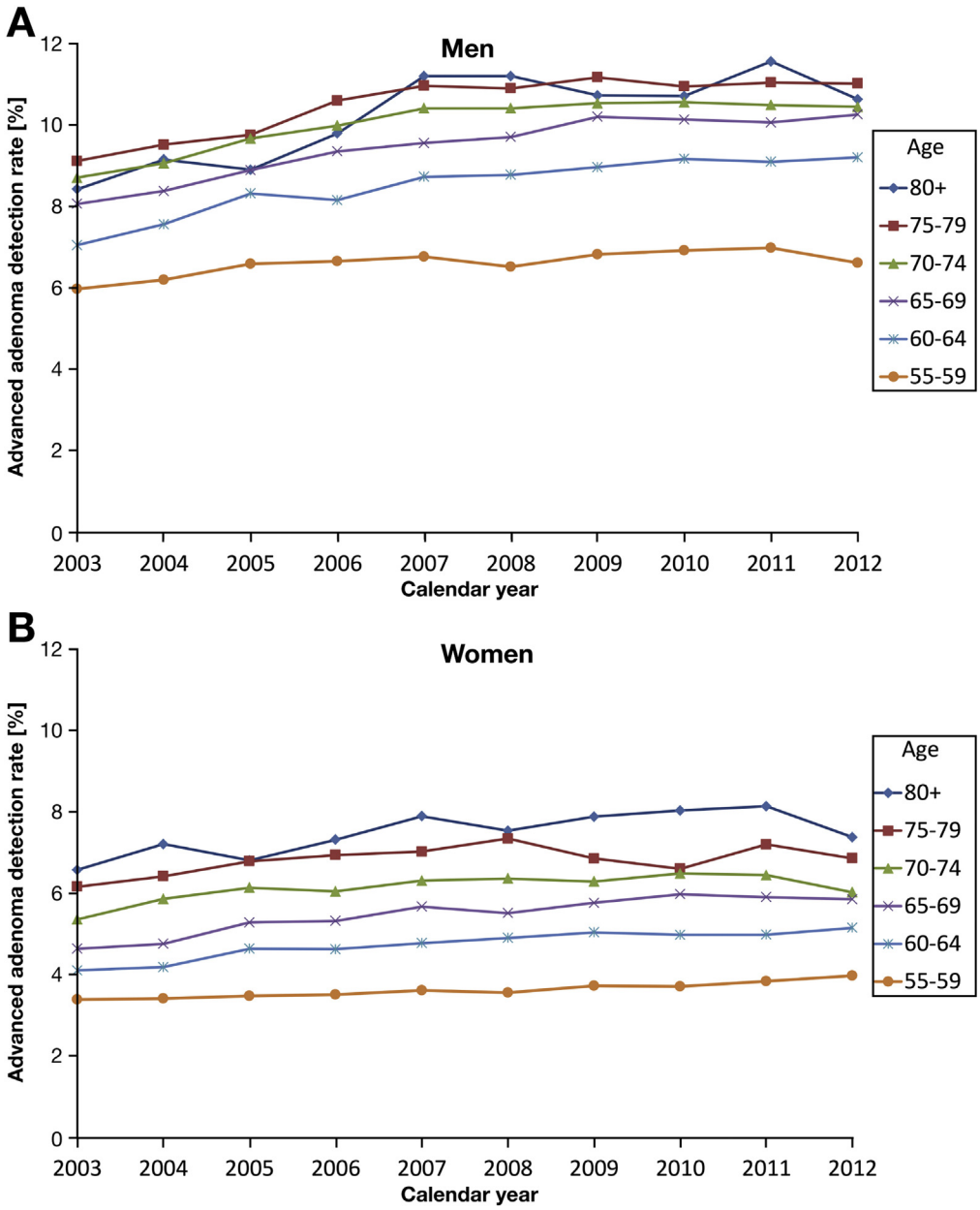


Figure 4. Trends in detection rates of advanced adenomas by sex and age (*A*, men; *B*, women). German national screening colonoscopy registry, 2003–2012. For the sake of readability, confidence intervals that are very tight (width <1%-unit in 95 of 120 cases) are not shown.

10 years of the German screening colonoscopy program. This strong increase was seen consistently in both sexes and all age groups and was, to a large extent, due to a particularly strong increase in detection rates of small adenomas of <0.5 cm. By contrast, only a less pronounced increase was seen (in absolute terms) in detection rates of advanced adenomas and CRC. The increase in ADRs appears to be at least partly explained by an innovation effect.

In theory, the observed increase in detection rates of nonadvanced adenomas might be due to various reasons, including increasing true prevalences of nonadvanced adenomas over time, enhanced detection, or more complete reporting of nonadvanced adenomas. Increasing true prevalences of nonadvanced adenomas could result from changes in risk factor patterns over time or from selection effects (ie, more selective participation of those at higher risk in more recent years). The latter suggestion appears to be supported by the observation that the particularly strong increase in ADR from 2006 to 2007 went along with a particularly strong drop in numbers of participants between those years. It would be very unusual, however, for risk factor changes to occur simultaneously and at the same pace in both sexes and across a broad range of age groups. There also seems to be no obvious reason why risk factor changes or selection effects should have selectively led to substantially increased prevalences of nonadvanced adenomas (especially small nonadvanced adenomas), but not of advanced adenomas or CRC. A more plausible explanation for the selective major increase in detection rates of nonadvanced adenomas, especially small ones, seems to be

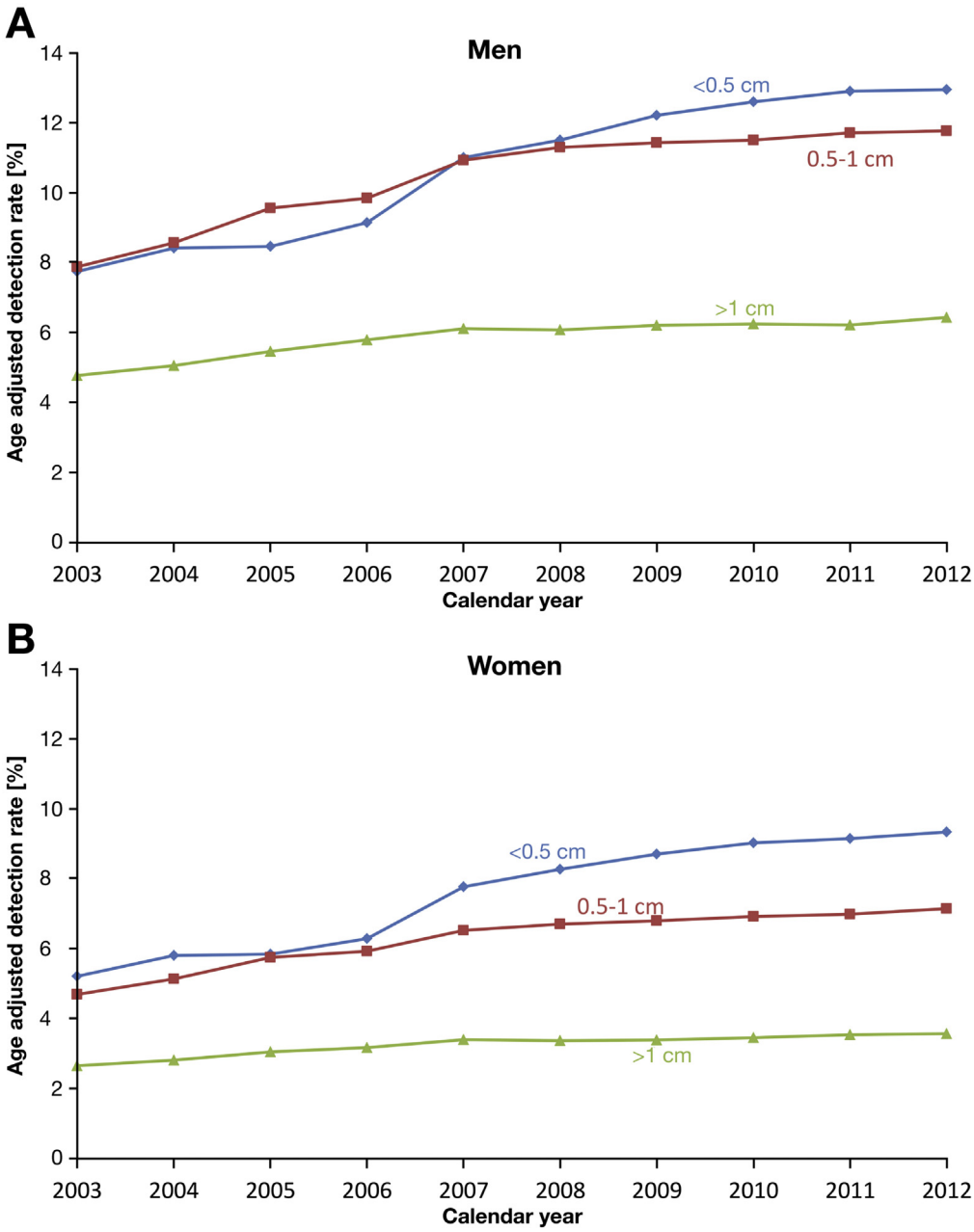


Figure 5. Trends in age-adjusted detection rates of adenomas according to size of largest adenoma (*A*, men; *B*, women). German national screening colonoscopy registry, 2003–2012. For the sake of readability, confidence intervals that are very tight (width <0.4%-unit in all cases) are not shown.

enhanced detection or reporting of such lesions over time. Plausible reasons for enhanced detection rates might include, for example, increasing training and experience and enhanced technical equipment of colonoscopists,[17] enhanced bowel preparation, sustained major efforts of quality assurance in the German screening colonoscopy program, but possibly also increasing awareness of the quality criteria of colonoscopies (including the ADR). Although the German national screening colonoscopy registry does not allow assessment of trends in the quality of bowel preparation, cecum intubation rates were high from the beginning, and trends in completeness of colonoscopy are unlikely to explain the observed trends in the ADR. The same applies to trends in sedation rates, which were high throughout the period of investigation. Even though sedation rates increased over time, the temporal patterns of this increase (which occurred mainly in earlier years) did not match the temporal patterns of the increase in ADR (which occurred mainly after 2006). This is in line with previous evidence that sedation does not have a major impact on ADR.[18]

A possible role of increased awareness of the quality criteria of colonoscopies is supported by the particularly strong increase of detection rates of nonadvanced adenomas from 2006 to 2007, when colonoscopy quality criteria, including the ADR, received increased attention and dissemination.[19,20] An additional factor that might have contributed to the particularly pronounced increase in ADRs from 2006 to 2007 might be the change from paper-based to electronic transmission of colonoscopy records to the

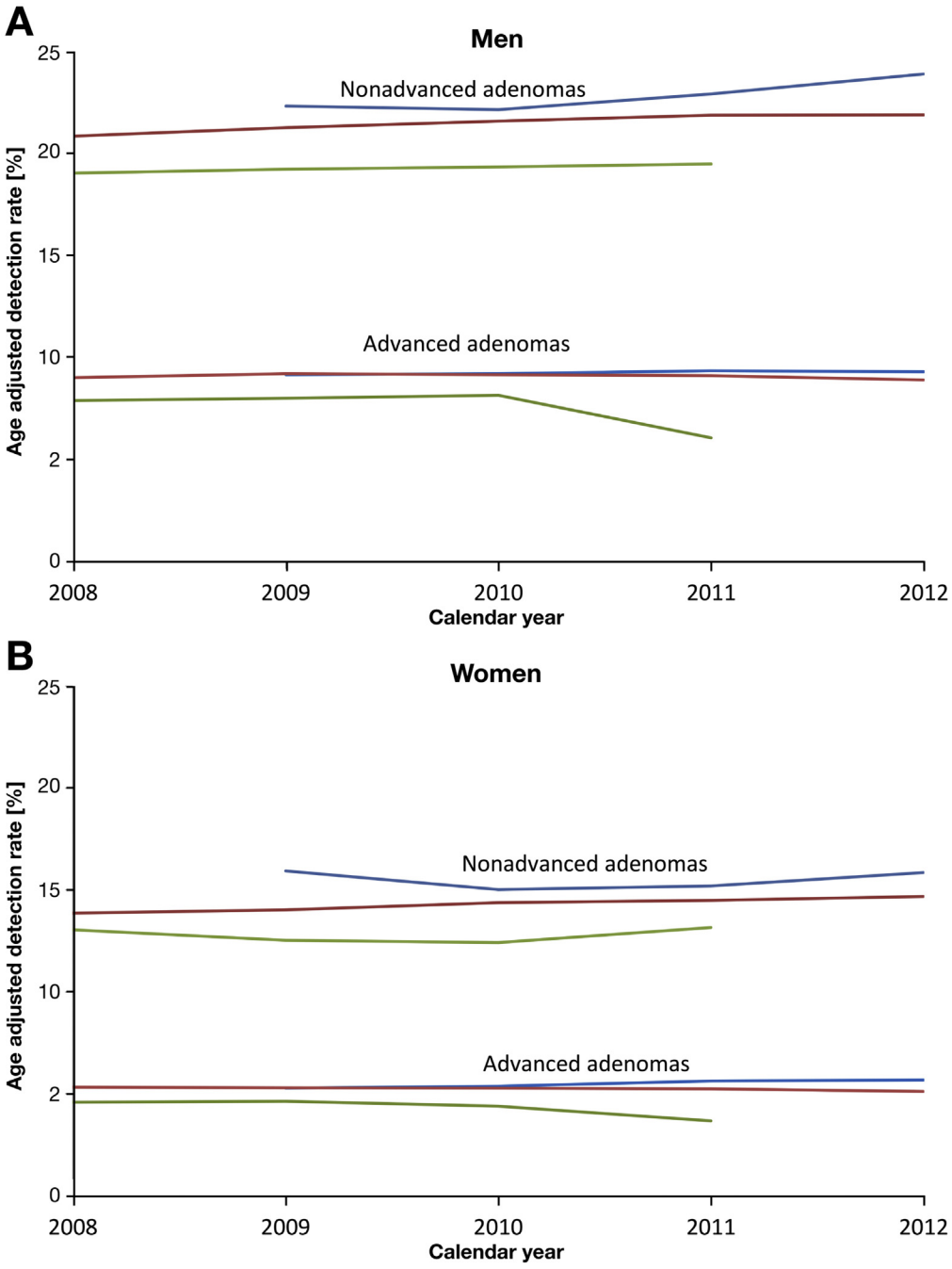


Figure 6. Age-adjusted adenoma detection rates (*A*, men; *B*, women) among incoming colonoscopists with first screening endoscopy in 2009 to 2012 (*blue lines*), among continuously practicing colonoscopists with screening endoscopies throughout 2008 to 2012 (*red lines*), and among leaving colonoscopists with last screening endoscopy in 2008 to 2011 (*green lines*). For the sake of readability, confidence intervals that are very tight (width <1%-unit in 36 of 52 cases) are not shown.

national screening colonoscopy registry, which was introduced in 2006 and became mandatory in 2007. It is possible that enhanced ease of reporting might also have contributed to more complete, enhanced recording of adenomas. Even though there is no direct evidence from validation studies, this possibility appears plausible and should be considered in the interpretation of the results.

Our results also indicate the contribution of an innovation effect to the increase of ADRs, that is, a substantial proportion of the increase might not be due to increasing ADRs of practicing screening colonoscopists over time, but due to higher ADRs among incoming colonoscopists who typically install the latest technological equipment at the time of opening or taking over a practice than among continuously practicing or leaving colonoscopists. Of course, additional factors, such as differences in training or emphasis in withdrawal techniques, could also contribute to observed differences between groups of colonoscopists. Even though the vast majority (approximately 90%) of leaving colonoscopists are leaving on their own initiative (typically due to retirement), the group of leaving colonoscopists also includes a minority of colonoscopists who lose their certification, for which not reaching the required number of colonoscopies was the most commonly reported indication.[21] If the ADR of the latter group of colonoscopists was substantially lower than those of continuing

Table 1. Distribution of Continuously Practicing Colonoscopists According to Quintiles of Sex- and Age-Adjusted Overall Adenoma Detection Rates in 2008 and 2012

Quintile (adjusted ADR) in 2008	Quintile (adjusted ADR) in 2012				
	1 (<17.1%)	2 (17.1% to <22.5%)	3 (22.5% to <28.0%)	4 (28.0% to <34.1%)	5 (≥34.1%)
1 (<16.2%)	63 (60.0)	33 (31.4)	8 (7.6)	1 (1.0)	0 (0.0)
2 (16.2% to <22.3%)	30 (28.3)	37 (34.9)	20 (18.9)	13 (12.3)	6 (5.7)
3 (22.3% to <26.5%)	9 (8.5)	25 (23.6)	35 (33.0)	29 (27.4)	8 (7.5)
4 (26.5% to <33.7%)	2 (1.9)	10 (9.4)	34 (32.1)	34 (32.1)	26 (24.5)
5 (≥33.7%)	1 (1.0)	1 (1.0)	9 (8.6)	29 (27.6)	65 (61.9)

NOTE. Values are n (%).

colonoscopists, this could also explain part of the gap between continuous and leaving colonoscopists. Because the screening colonoscopy registry does not include the reasons why colonoscopists leave, this issue could not be addressed precisely in our analysis.

Although increasing ADRs over time are reassuring with respect to minimization of interval cancers, our results suggest that a non-negligible proportion of adenomas, especially smaller adenomas, may have been missed during the early years of the screening colonoscopy offer. This finding is consistent with results of studies published up to 2006, which had shown substantial miss rates for small adenomas.[22] On the other hand, steadily increasing ADRs, with an increasing share of detection rates of small adenomas, might raise concerns about "overdetection" or "overreporting" of clinically irrelevant findings in more recent years. To our knowledge, no previous study has provided a comparably comprehensive analysis of time trends in a national screening colonoscopy program. Our results are highly consistent, however, with previous studies regarding major variation of ADR according to sex and age.[9,11–14] With respect to overall levels of ADR, the combined detection rates of nonadvanced adenomas and advanced adenomas were below the commonly recommended benchmarks of 25% for men and 15% for women[19,20,23] in the early years of the program, reached the benchmarks in 2006, and continued to increase to overall levels slightly above 30% for men and 20% for women in recent years. Nevertheless, mean nonadvanced and overall ADRs remained below levels of around 50%, which appear to be achievable in screening colonoscopy.[10]

Taken together, the observation of increasing ADR over time might have a number of potentially important clinical implications. First, screening colonoscopies conducted today might provide more complete CRC prevention than suggested in previous studies that were addressing the impact of screening colonoscopies conducted one or more decades ago.[5] Second, interval cancers, which might have mostly resulted from missed adenomas in the past,[24,25] might become increasingly rare, and longer screening and surveillance intervals, especially after increasing detection of very small adenomas, might be better justified in the future than in the early colonoscopy era. So far, the German S3 guideline for colorectal cancers foresees surveillance intervals of 5 years after detection of 1–2 adenomas <1 cm without high-grade neoplasia,[26] and the US Multi-Society Task Force on Colorectal Cancer recommends surveillance intervals of 5–10 years after detection of 1–2 tubular adenomas <1 cm,[27] both without further differentiation by adenoma size.

Such differentiation seems to be particularly important though, because the increase in ADRs, along with the increasing share of very small adenomas, will otherwise increase the burden of surveillance colonoscopies substantially, and the expected disproportional increase of negative surveillance colonoscopies might make surveillance after positive findings less cost-efficient. This issue might become even more relevant in the future, should further advances in imaging technology enable detection of adenomas of even smaller sizes than those detectable with current equipment.[28–30] Additional research, including modeling approaches, should address screening and surveillance intervals that can ensure maximum effectiveness and cost-effectiveness of screening colonoscopy in the era of increased and further increasing ADRs with a growing share of very small adenomas.[31] Finally, our results support suggestions that more differentiated colonoscopy quality criteria might be more meaningful than the overall ADR that is increasingly determined by small, nonadvanced adenomas. In particular, such quality criteria might also take size and other adenoma features into consideration.

Our study has a number of strengths and limitations. Major strengths of the study are national coverage of all screening colonoscopies in the Statutory Health Insurance–covered German population and the very large number of screening colonoscopies included, which allowed estimation of ADRs at very high levels of precision, even in sex- and age-specific analyses. Limitations include the restriction of presentation to average ADRs. Both absolute levels of ADR and their trends show substantial variation between individual colonoscopists.[9,15,32] This also applies to Germany,[33] but variation and ranking of sex- and age-adjusted ADR across colonoscopists was rather stable over time during the 5-year period from 2008 to 2012 for which this information was available. Unfortunately, distinction of colonoscopists by different professional groups was also restricted to the 5-year period from 2008 to 2012, during which very similar increases in ADR were seen in each of

the major groups (data not shown). We were able, however, to illustrate an innovation effect, which contributes to the ongoing increase in ADRs. Although the German screening colonoscopy registry offers unique possibilities for monitoring performance and findings of screening colonoscopy on the national level, confidentiality regulations unfortunately hinder its potentially much more beneficial use for directly assessing the impact of screening colonoscopy and the role of ADR in prevention of CRC incidence and mortality by record linkage with cancer registry and mortality data.

Despite its limitations, our analysis provides important information suggesting favorable developments in the quality of screening colonoscopy in Germany, but, at the same time, raises concerns about "oversurveillance," which can result from detecting an increasing proportion of small adenomas, most of which would carry only a very small risk of developing into clinically manifest CRC during a lifetime. The main challenge for the German screening colonoscopy program remains increasing its utilization in the first place. This might be best achieved by transformation of the screening offer into an organized screening program. A national law was launched in 2013 requesting such a transition, the implementation of which is currently in preparation. Further efforts should be made to enable linkage of screening registry data with cancer incidence and mortality data. The implications of strongly increasing ADRs, with increasing shares of very small adenomas, on the definition of the most suited screening and surveillance intervals should be addressed in future research.

Supplementary Material

Note: To access the supplementary material accompanying this article, visit the online version of *Gastroenterology* at www.gastrojournal.org, and at http://dx.doi.org/10.1053/j.gastro.2015.04.012.

References

1. Zauber AG, Winawer SJ, O'Brien MJ, et al. Colonoscopic polypectomy and long-term prevention of colorectal-cancer deaths. N Engl J Med 2012;366:687–696.
2. Doubeni CA, Weinman S, Adams K, et al. Screening colonoscopy and risk for incident late-stage colorectal cancer diagnosis in average-risk adults. Ann Intern Med 2013;158:312–320.
3. Brenner H, Chang-Claude J, Jansen L, et al. Reduced risk of colorectal cancer up to 10 years after screening, surveillance or diagnostic colonoscopy. Gastroenterology 2014;146:709–717.
4. **Nishihara R, Wu K, Lochhead P**, et al. Long-term colorectal-cancer incidence and mortality after lower endoscopy. N Engl J Med 2013;369:1095–1105.
5. Brenner H, Stock C, Hoffmeister M. Effect of screening sigmoidoscopy and screening colonoscopy on colorectal cancer incidence and mortality: systematic review and meta-analysis of randomised controlled trials and observational studies. BMJ 2014;348:g2467.
6. Peters SL, Hasan AG, Jacobson NB, et al. Level of fellowship training increases adenoma detection rates. Clin Gastroenterol Hepatol 2010;8:439–442.
7. Wang HS, Pisegna J, Modi R, et al. Adenoma detection rate is necessary but insufficient for distinguishing high versus low endoscopist performance. Gastrointest Endosc 2013;77:71–78.
8. Calderwood AH, Jacobson BC. Colonoscopy quality: metrics and implementation. Gastroenterol Clin North Am 2013;42:599–618.
9. Kaminski MF, Regula J, Kraszewska E, et al. Quality indicators for colonoscopy and the risk of interval cancer. N Engl J Med 2010;362:1795–1803.
10. Corley DA, Jensen CD, Marks AR, et al. Adenoma detection rate and risk of colorectal cancer and death. N Engl J Med 2014;370:1298–1306.
11. Regula J, Rupinski M, Kraszewska E, et al. Colonoscopy in colorectal-cancer screening for detection of advanced neoplasia. N Engl J Med 2006;355:1863–1872.
12. Brenner H, Altenhofen L, Hoffmeister M. Sex, age and birth cohort effects in colorectal neoplasms: a cohort analysis. Ann Intern Med 2010;102:1411–1414.
13. 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;306:1352–1358.
14. Pox C, Altenhofen L, Brenner H, et al. Efficacy of a nationwide screening colonoscopy program for colorectal cancer. Gastroenterology 2012;142:1460–1467.
15. Ricci E, Hassan C, Petruzziello L, et al. Inter-centre variability of the adenoma detection rate: a prospective, multicentre study. Dig Liver Dis 2013;45:1022–1027.
16. Adler A, Lieberman D, Aminalai A, et al. Data quality of the German screening colonoscopy registry. Endoscopy 2013;45:813–818.
17. Adler A, Wegscheider K, Lieberman D, et al. Factors determining the quality of screening colonoscopy: a prospective study on adenoma detection rates, from 12,134 examinations (Berlin colonoscopy project 3, BECOP-3). Gut 2013;62:236–241.
18. Jover R, Zapater P, Polania E, et al. Modifiable endoscopic factors that influence the adenoma detection rate in colorectal cancer screening colonoscopies. Gastrointest Endosc 2013;77:381–389.
19. Rex DK, Petrini JL, Baron TH, et al. Quality indicators for colonoscopy. Gastrointest Endosc 2006;63(Suppl):S16–S28.
20. Lieberman D, Nadel M, Smith RA, et al. Standardized colonoscopy reporting and data system: report of the Quality Assurance Task Group of the National Colorectal Cancer Roundtable. Gastrointest Endosc 2007;65:757–766.
21. KBV Qualitätsbericht Ausgabe 2013 [in German]. Available at: http://www.sindbad-mds.de/infomed/sindbad.nsf/0/c9d7fdb248319ee1c1257c71003ef121/$FILE/KBV_QualBericht_2013.pdf. Accessed December 19, 2014.
22. Van Rijn JC, Reitsma JB, Stoker J, et al. Polyp miss rate determined by tandem colonoscopy: a systematic review. Am J Gastroenterol 2006;101:343–350.

23. Rex DK, Bond JH, Winawer S, et al. Quality in the technical performance of colonoscopy and the continuous quality improvement process for colonoscopy: recommendations of the U.S. Multi-Society Task Force on Colorectal Cancer. Am J Gastroenterol 2002;97:1296–1308.
24. Pohl H, Robertson DJ. Colorectal cancers detected after colonoscopy frequently result from missed lesions. Clin Gastroenterol Hepatol 2010;8:858–864.
25. Brenner H, Chang-Claude J, Seiler CM, et al. Interval cancers after negative colonoscopy: population-based case-control study. Gut 2012;61:1576–1582.
26. Leitlinienprogramm Onkologie (Deutsche Krebsgesellschaft, Deutsche Krebshilfe, AWMF): S3-Leitlinie Kolorektales Karzinom, Langversion 1.0, AWMF Registrierungsnummer: 021-0070L. Available at: http://leitlinienprogramm-onkologie.de/Leitlinien.7.0.html. Accessed October 11, 2014.
27. Lieberman DA, Rex DK, Winawer SJ, et al. Guidelines for colonoscopy surveillance after screening and polypectomy: a consensus update by the US Multi-Society Task Force on Colorectal Cancer. Gastroenterology 2012;143:844–857.
28. Dik VK, Moons LM, Siersema PD. Endoscopic innovations to increase the adenoma detection rate during colonoscopy. World J Gastroenterol 2014;20:2200–2211.
29. Gómez V, Wallace MB. Advances in diagnostic and therapeutic colonoscopy. Curr Opin Gastroenterol 2014;30:63–68.
30. **Gralnek IM, Sieresma PD**, Halpern Z, et al. Standard forward-viewing colonoscopy versus full-spectrum endoscopy: an international, multicenter, randomised tandem colonoscopy trial. Lancet Oncol 2014;15:353–360.
31. Lansdorp-Vogelaar I, Knudsen A, Brenner H. Cost-effectiveness of colorectal cancer screening. Epidemiol Rev 2011;33:88–100.
32. Greenspan M, Rajan KB, Baig A, et al. Advanced adenoma detection rate is independent of nonadvanced adenoma detection rate. Am J Gastroenterol 2013;108:1286–1292.
33. Stock C, Uhlmann L, Hoffmeister M, et al. Identification of physicians with unusual performance in screening colonoscopy databases: a Bayesian approach. Gastrointest Endosc 2015;81:646–654.e1.

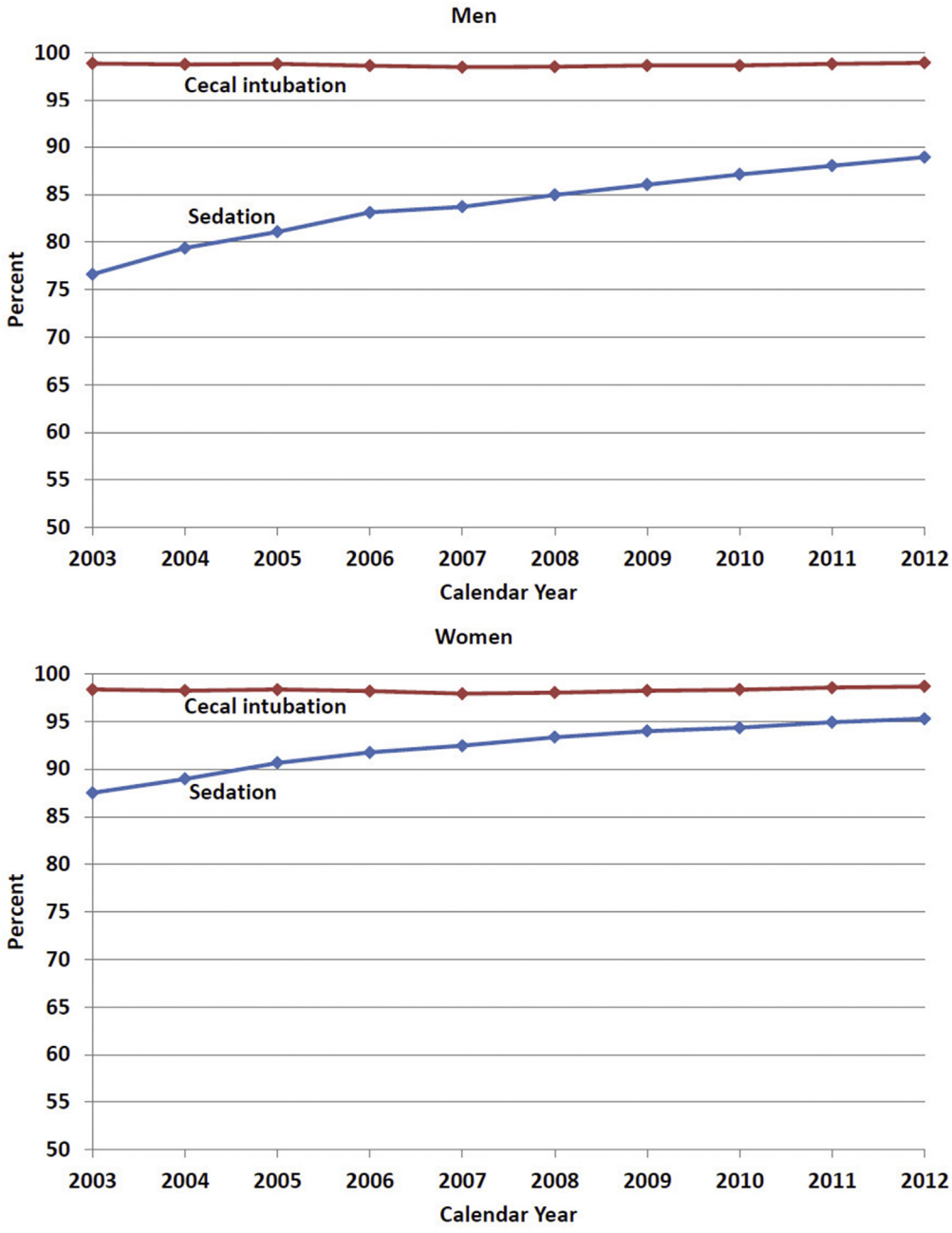
Author names in bold designate shared co-first authorship.

Received November 17, 2014. Accepted April 14, 2015.

Reprint requests
Address requests for reprints to: Hermann Brenner, MD, MPH, Division of Clinical Epidemiology and Aging Research, German Cancer Research Center, Im Neuenheimer Feld 581, D-69120 Heidelberg, Germany. e-mail: h.brenner@dkfz.de; fax: +49-6221-421302.

Conflicts of interest
The authors disclose no conflicts.

Funding
The German screening colonoscopy registry is funded by the National Association of Statutory Health Insurance Physicians and the National Association of Statutory Health Insurance Funds. This study was further supported in part by grants from the German Research Council (Deutsche Forschungsgemeinschaft, grant number BR 1704/6-4) and the German Federal Ministry of Education and Research (grant number 01KH0404, 01ER0814). The sponsors did not have any role in this study.



Supplementary Figure 1. Trends in age-adjusted cecal intubation and sedation rates. German national screening colonoscopy registry, 2003–2012. For the sake of readability, confidence intervals that are very tight (width <1%-unit in 39 of 40 cases) are not shown.