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Original Research

Expected long-term impact of the German screening colonoscopy programme on colorectal cancer prevention: Analyses based on 4,407,971 screening colonoscopies

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Abstract ***Aim:*** Endoscopy based screening programmes for colorectal cancer (CRC) are being implemented in an increasing number of countries. In Germany, screening colonoscopy at age 55 or older has been offered since the end of 2002. We aimed to estimate the long-term impact of this offer on CRC prevention.
Methods: We estimated numbers of prevented CRC cases by expected age and year of their (prevented) occurrence over four decades (2005–2045) by four state Markov models (non-advanced adenoma, advanced adenoma, preclinical CRC, clinically manifest CRC). Estimates are based on screening colonoscopies reported to the German screening colonoscopy registry in 2003–2012 ($N = 4{,}407{,}971$), transition rates between the four states and general population mortality rates.
Results: Numbers of prevented clinically manifest CRC cases are projected to increase from <100 in 2005 to approximately 6500 in 2015, 12,600 in 2025, 15,400 in 2035 and 16,000 in 2045, compared to approximately 58,000 incident cases observed in 2003. The annual number of prevented cases is expected to be higher among men than among women and to strongly vary by age. The vast majority of prevented cases would have occurred at age 75 or older.
Conclusions: Despite modest participation rates, the German screening colonoscopy programme will lead to substantial reductions in the CRC burden. The reductions will be fully

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disclosed in the long run only and predominantly affect numbers of incident cases above 75 years of age. Screening offers would need to start at younger ages in order to achieve more effective CRC prevention at younger ages.

1. Introduction

Several randomised trials have demonstrated major reduction of distal colorectal cancer (CRC) incidence by screening with flexible sigmoidoscopy [1–4], and observational studies suggest a large potential for even stronger reduction of (proximal and distal) CRC incidence by screening colonoscopy [5–7]. The trials also indicate, however, that it may often take many years until screening effects become fully manifest.

Screening programmes for CRC based on faecal occult blood testing (FOBT), sigmoidoscopy or colonoscopy are being implemented in an increasing number of countries [8]. Germany was one of the first countries introducing colonoscopy as a primary screening offer in October 2002, and it will be of utmost interest to monitor development of CRC incidence in the screening colonoscopy era. It is unclear, however, when to expect which effects of screening colonoscopy on CRC incidence in various age groups. In this article, we aim to estimate and project the numbers of CRC cases prevented (through detection and removal of adenomas) by the German screening colonoscopy programme according to expected age and year of their (prevented) occurrence.

2. Methods

2.1. Data

Our analysis is based on data of the German national screening colonoscopy registry. Details on the German screening colonoscopy programme and the registry have been reported elsewhere [9]. Briefly, men and women aged 55 years or older are entitled to have colonoscopy as a primary screening examination. If the first screening colonoscopy is conducted before 65 years of age, a second screening colonoscopy is offered 10 years later.

Along with introduction of screening colonoscopy in October 2002, a national screening colonoscopy registry was launched to which all screening colonoscopies among members of statutory health insurance (SHI) in Germany (85% of all men and 92% of all women aged 55+ years in Germany) are reported anonymously on a standardised form. Reporting is a prerequisite for physicians' reimbursement by the SHI and is assumed to be close to complete. The registry includes only primary screening examinations (i.e. colonoscopies conducted for surveillance, work-up of symptoms or other screening tests are not included). Findings at colonoscopy are reported, including number, size and histological characteristics of polyps. In case of multiple neoplasms, participants are classified according to the most advanced finding (non-advanced adenoma, advanced adenoma, or cancer). Advanced adenomas are defined as at least one adenoma $\geqslant 1$ cm or at least one adenoma with villous components or high-grade dysplasia.

Approximately 2–3% of eligible people have had a screening colonoscopy each year since the introduction of this screening offer, which corresponds to a cumulative participation rate of approximately 20–30% within the initial 10 years of the screening colonoscopy programme. For this analysis, we used data from 4,408,571 first time screening colonoscopies in 2003–2012 among participants aged 55 years or older. We assumed the same sex and age specific screening participation rates and the same sex and age specific prevalences of neoplasms among non-members of SHI (approximately 15% of men and 8% of women in Germany in the age groups included), the overwhelming majority of whom have private health insurance which provides equivalent (or less restricted) screening offers.

2.2. Statistical analysis

We estimated the numbers of clinically manifest CRCs, by age and year of occurrence, that are expected to be prevented by detection and removal of adenomas at screening colonoscopy. For 2003–2012, the first 10 years of the German screening colonoscopy programme, numbers of participants in whom adenomas were detected were directly available from reported numbers and extrapolated to the total German population as outlined above. For subsequent calendar years, we assumed age and sex specific numbers of participants in whom adenomas are detected to remain at the level observed in 2012.

Prevented case numbers were obtained from four-state Markov models with annual iterations starting at the individual ages of colonoscopy as illustrated in Fig. 1. An overview of input parameters for the models is given in Tables 1 and 2. At each iteration, progression between states was modelled based on previously derived sex and age specific annual transition rates (Table 2) [10,11], accounting for mortality which was obtained from general population life tables for the period 2009/2011. In the base case analysis, age and sex