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Estimating health benefits and cost-savings for achieving the Healthy People 2020 objective of reducing invasive colorectal cancer☆

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ABSTRACT

This study aims to quantify the aggregate potential life-years (LYs) saved and healthcare cost-savings if the Healthy People 2020 objective were met to reduce invasive colorectal cancer (CRC) incidence by 15%. We identified patients (n = 886,380) diagnosed with invasive CRC between 2001 and 2011 from a nationally representative cancer dataset. We stratified these patients by sex, race/ethnicity, and age. Using these data and data from the 2001–2011 U.S. life tables, we estimated a survival function for each CRC group and the corresponding reference group and computed per-person LYs saved. We estimated per-person annual healthcare cost-savings using the 2008–2012 Medical Expenditure Panel Survey. We calculated aggregate LYs saved and cost-savings by multiplying the reduced number of CRC patients by the per-person LYs saved and lifetime healthcare cost-savings, respectively. We estimated an aggregate of 84,569 and 64,924 LYs saved for men and women, respectively, accounting for healthcare cost-savings of $329.3 and $294.2 million (in 2013$), respectively. Per person, we estimated 6.3 potential LYs saved related to those who developed CRC for both men and women, and healthcare cost-savings of $24,000 for men and $28,000 for women. Non-Hispanic whites and those aged 60–64 had the highest aggregate potential LYs saved and cost-savings. Achieving the HP2020 objective of reducing invasive CRC incidence by 15% by year 2020 would potentially save nearly 150,000 life-years and $624 million on healthcare costs.

1. Introduction

Of cancers that affect both men and women, colorectal cancer (CRC) is the second leading cause of cancer-related deaths in the United States and the third most common cancer in men and in women (CDC, 2017a,b). The Healthy People 2020 (HP2020) agenda for improving the health of all Americans established the following objectives for colorectal cancer: 1) reduce the CRC death rate, 2) reduce the rate of invasive CRC, and 3) increase the proportion of adults who receive CRC screening based on current recommendations (HP2020, 2014).

A recent study from the Centers for Disease Control and Prevention (CDC) showed that while overall CRC test use increased from 2000 to 2015, the nation still had not reached the HP2020 target for increasing CRC screening (White et al., 2017). Weir and colleagues used mortality data from the CDC's National Vital Statistics System (NVSS, 2016) to predict a reduction of 22.5% in CRC death rate from 2007 to 2020 and that the HP2020 target for reducing the CRC death rate would be met in 2013 (Weir et al., 2015). The target for the United States was met in 2014 (HP2020, 2014) and when examined by state, 30 states had achieved the HP2020 target to reduce invasive CRC incidence rates (Henley et al., 2017).

Given the mixed progress in meeting HP2020 CRC objectives for increasing CRC screening and reducing CRC death rates, we aim to focus on the HP2020 CRC objective of reducing the invasive CRC incidence rate from a baseline (year 2007) of 46.9/100,000 population to a target of 39.9/100,000 population in 2020 (HP2020, 2014), representing a 15% reduction over 10 years. We estimate the potential life-years (LYs) saved (health benefit) and lifetime healthcare cost-savings if this objective of reducing 15% of the invasive CRC incidence rate in 2007 were met by 2020. The purpose of this study is to provide

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federal, state, and local health policy-makers with potential quantifiable benefits that could occur if effective evidence-based interventions are implemented to achieve this objective. To our knowledge, this study is the first to quantify the health and economic benefits of achieving the HP2020 CRC objective for reducing invasive CRC incidence rates.

2. Methods

2.1. Dataset for the estimation of the survival functions for CRC patients

We used the United States Cancer Statistics (USCS) data from the CDC's National Program of Cancer Registries (NPCR) and the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program, which together cover the cancer incidence for the entire U.S. population (CDC, 2016a,b; NCI, 2014). Both NPCR and SEER registries collect detailed patient information, including sex, race/ethnicity, year of diagnosis, age of diagnosis, cancer site, stage, survival months, histology, and vital status (CDC, 2016a,b; NCI, 2014). In 2014, the USCS provided data on survival for 62.8% of the U.S. population (32 central cancer registries). From USCS, we identified a total of 886,380 patients who had been diagnosed with primary invasive CRC between 2001 and 2011, according to the International Classification of Disease for Oncology, 3rd Edition (ICD-O-3) site codes of C180–189, C209, and C260, with exclusion of patients with mesothelioma (histology codes of 9050–9055), kaposi sarcoma (9140), and lymphomas and leukemia (9590–9992). The CRC patients were followed through December 31, 2012 with a follow-up between 12 and 144 months. Patients who had not died on this date were censored. The CRC patients were stratified by sex, race/ethnicity, and age.

2.2. Per-person potential LYs saved

For each group of the CRC patients, we used the Kaplan-Meier method to estimate a survival function for the 144 months following diagnosis (the longest follow-up with available data). We then extrapolated the survival function up to 600 months, using a semi-parametric method (Hwang and Wang, 1999) (Fig. 1). 600 months was chosen, because these CRC patients' survival probability approximates to zero at 600 months. The technical details for the extrapolation process has been described elsewhere (Chu et al., 2008; Fang et al., 2007; Hung et al., 2014; Liu et al., 2013). Briefly, this method used the data from the 2001–2011 U.S. life tables of the general population (CDC, 2015) as a reference population. Using the same stratification as the stratification in CRC patients, we generated a survival function for each reference group corresponding to each group of the CRC patients. For each CRC-reference group, we fitted a linear regression to the logit transformed survival ratios (survival probabilities of the CRC group to those of the corresponding reference group) for the last 24 months of the 144 months of follow-up. Assuming a constant excess hazard (Andersson et al., 2013; Fang et al., 2007), we extrapolated the logit transformed survival ratios to 600 months and thus the survival function for each CRC group beyond the 144 months to 600 months.

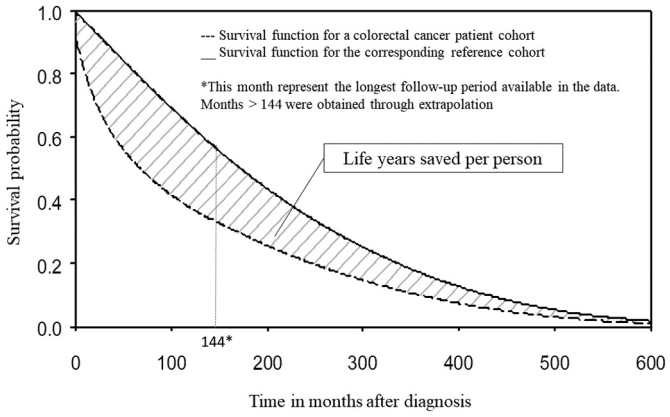

Fig. 1. A graphical illustration of per-person potential life years saved.
Dashed curve: survival function for a colorectal cancer (CRC) patient cohort.
Solid curve: survival function for the corresponding reference group.
Shaded area: the difference in life expectancies between a CRC group and the corresponding reference group.

Based on the estimated survival functions for the CRC and the reference groups, we derived life expectancies (LEs) for each CRC group and the corresponding reference group. We then computed per-person potential LYs saved by subtracting LE for each reference group from that for the corresponding CRC group (Fig. 1).

2.3. Dataset for the estimation of the annual healthcare costs associated with CRC

We used data from the Medical Expenditure Panel Survey (MEPS) Household Component to estimate costs associated with CRC. The MEPS is a nationally representative survey that estimates healthcare use, expenditures, sources of payment, and insurance coverage for the U.S. civilian non-institutionalized population (AHRQ, 2015a,b). We pooled data from 2008 to 2012, which comprised 177,054 people, including 587 individuals who reported that they were ever diagnosed with CRC. Annual healthcare expenditures in the MEPS are defined by the sum of the total annual healthcare costs paid via any type of payment (out-of-pocket, private insurance, Medicare, Medicaid, and other sources) for any service (ambulatory care, inpatient care, prescription medications, home health care, nursing home care, and other services) in a year (AHRQ, 2015a,b). We adjusted all costs to the 2013 price level using the Personal Health Care Expenditure Price Index (AHQR, 2015a,b).

2.4. Per-person annual healthcare cost associated with CRC

We used a two-part model to estimate per-person annual healthcare cost associated with CRC, because the distribution of the cost data was right-skewed with 22% of the individuals with zero expenditure (Manning and Mullahy, 2001). In the first part, we used a logit model to predict the probability of any healthcare utilization; in the second part, we estimated utilization among those with positive expenditures using a generalized linear model with log-link and gamma-variance function. The covariates in this two-part model included CRC diagnosis (yes/no), sex, race/ethnicity, age, education, marital status, number of comorbid conditions, health insurance, and U.S. Census region. Based on the results, we predicted the average per-person annual healthcare costs associated with CRC for each of the sex, racial/ethnic, and age groups.

2.5. Per-person lifetime healthcare cost-savings

For each group, we defined per-person lifetime cost-savings as the total cost saved, had a CRC patient not developed CRC. We used the following equation to calculate the mean per-person lifetime cost-savings (E).

$$E = \int_0^\infty S(t)C(t)dt$$

where t is time following CRC diagnosis, $S(t)$ is the survival function for CRC patients (previously derived in Section 2.2), and $C(t)$ is a smoothed function of healthcare cost associated with CRC in present value, based on the predicted annual healthcare costs associated with CRC (Section 2.4). Present values were calculated using an annual rate of 3% (Gold et al., 1996) (Fig. 2).