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Review article

Recent diagnostic procedures for colorectal cancer screening: Are they cost-effective?

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ABSTRACT

Colorectal cancer (CRC) is the third most common cancer worldwide and the fourth most common cause of death. Reduction in mortality rates in some countries worldwide are most likely ascribed to CRC screening and/or improved treatments. We reviewed the most relevant articles which discuss the cost-effectiveness of colorectal cancer screening procedures, in particular, the recent ones through the last eight years. The effectiveness of screening estimated by discounted life years gained (LYGs) compared to no screening, differed considerably between the studies. Despite these differences, all studies consistently emphasized that screening for CRC was cost-effective compared with no screening for each of the recognized screening strategies. Newer technologies for colorectal cancer screening, including computed tomographic colonography (CTC), faecal DNA test, and Pillcam Colon are less invasive and accurate, however, they are not cost-effective, as their cost was higher than all other established screening strategies. When compliance and adherence to such new techniques are increased more than the established strategies they would be more cost-effective particularly CTC.

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Introduction

Colorectal cancer (CRC) is one of the main causes of morbidity and mortality throughout the world. It accounts for more than 9% of all cancer incidence and it is the third most common incident cancer worldwide and the fourth most common cause of death. The highest increases in the colorectal cancer incidence are in Asia (Japan, Kuwait) and Eastern Europe (Czech Republic, Slovakia, and Slovenia) [1]. In fact, rates amongst males in the Czech Republic, Slovakia, and Japan have not only surpassed the peak rates witnessed in long-lasting developed countries such as the United States, Canada, and Australia but they continue to increase [2]. The decrease in colorectal cancer incidence in the USA partially mirrors the improvement in discovery and removal of precancerous lesions; whilst the increase in many Asian and Eastern Euro-

pean countries may reflect variations in risk factors for colorectal cancer that are associated with westernization such as raised obesity and smoking prevalence. In contrast to incidence trends, decreasing CRC mortality rates which have been detected in USA in the last years is most likely ascribed to CRC screening and/or improved treatments [2]. However, mortality rates are still increasing in countries that have more limited resources, including Mexico and Brazil, Romania and Russia in Eastern Europe [1–4].

The incidence of colorectal cancer can be abridged with growing efforts focused on a mass screening of average-risk individuals, 50 years and older [5]. The study conducted by researchers who simulated the 1980 through 2030 US adult population aged 50 years and over using micro simulation modelling, indicated that increasing CRC screening rates to 80% by 2018 would reduce CRC mortality rates by 19% and incidence rates by 17% during short-term follow-up and by 22% and 33%, respectively, during extended follow-up [6].

The aim of this study was to review the most relevant articles that discuss the cost-effectiveness of colorectal cancer screening procedures, in particular, the recent ones through the last eight years.

Abbreviations: AAA, abdominal aortic aneurism; CTC, colonography; CS, colonoscopy; CRC, colorectal cancer; CEA, cost-effective analysis; CER, cost-effectiveness ratios; FAP, familial polyposis; FOBT, faecal-occult-blood tests; GDP, gross-domestic product; HNPCC, hereditary non-polyposis colon cancer; ICER, incremental cost-effectiveness ratio; LYS, life-year saved; NHS, National health System; OC, optical-colonoscopy; USPSTF, United States Preventive Services Task Force; WTP, willingness to pay.

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Who are at increased risk of CRC?

Many risk factors have been incriminated in the occurrence and increased risk of colorectal cancer, amongst them; physical inactivity, obesity, smoking, a diet that is high in red meats (beef, pork, lamb, or liver) and processed meats (some luncheon meats and hot dogs), heavy alcohol consumption, inflammatory bowel syndrome in addition to family history of CRC. The risk is almost two-folds in those with only one affected first-degree relative and it is even higher if there are more than one relative is affected or if that relative was diagnosed with CRC cancer when they were younger than 45 years [7–10].

American Cancer Society, CDC and U.S preventive services recommended to start screening for both men and women at average risk of developing colorectal cancer at the age of 50, however for people at an increased risk, for example, history of colorectal cancer and/or adenomatous polyp, history of inflammatory bowel syndrome, a family history of a hereditary CRC syndrome such as familial polyposis (FAP), hereditary non-polyposis colon cancer (HNPCC), they should start their screening at the age of 45 or less [11–13].

Cost-effectiveness analysis

Cost-effectiveness analysis is a tool for assessing the gains in health relative to the costs of multiple health interventions. It helps identify neglected chances and opportunities by highlighting interventions that are moderately inexpensive, yet have the potential to decrease the disease burden significantly. It identifies ways to redirect resources and to reveal not only the utility of allotting resources from ineffective to effective interventions, but also the utility of allotting resources from less to more cost-effective interventions [14]. WHO defined a “cost-effective intervention” as cost per quality adjusted life years (QALY) gained or saved as a result of the intervention which is lower than or equal to three times the per-capita gross-domestic product (GDP) (personal income) in a given country or setting [15].

Model-based cost-effective analysis (CEA) is a tool which can be used to consider the probable impacts of various policy options and medical interventions on forthcoming program welfares and costs. CEA permits estimation of costs per outcome measured in natural units such as life-year saved (LYS) compared to the local willingness to pay (WTP) threshold. It addresses the following questions: How much the intervention costs? What are the costs compared to alternatives? Is it worth the cost? [16,17]

Cost-effectiveness ratios (CER)

Two types of CER ratios are described; CER comparing each intervention strategy with the no intervention scenario or the standard of care, and incremental cost-effectiveness ratio (ICER) comparing each strategy with the most effective substitute which may or may not be a “no intervention” scenario. ICERs are then calculated for strategies which are effective or economically rational, which denotes that no further strategy or a combination of strategies offers more life-years for the same or lower costs [16].

Deciding the balance between costs and benefits

Screening may be applied if there is a good balance between costs and benefits, such good balance has no universal definition but when an intervention provides an additional year of life at an incremental cost of \$50,000 or less, it is considered acceptable in many industrialized countries [16,17].

Methods

Medline was searched for articles which discuss the different aspects of CRC screening cost-effectiveness. The search was limited to the last eight years. Most of the studies were conducted in North America, European countries and few in Asia and Australia. The current review was carried out to review the most relevant articles, published in MEDLINE database, and science direct that discuss the cost-effectiveness of colorectal cancer screening procedures, in particular, the recent ones.

Cost-effectiveness of new CRC diagnostic and screening strategies

It has been established that CRC screening is cost-effective in comparison with no screening for each of the recognized screening strategies, where CRC screening could save 18,800 lives per year [18,19]. In several studies, almost all screening strategies, except stool DNA showed incremental cost-effectiveness ratios (ICERs) below \$20,000/LYG when a comparison is made with no screening [20–27].

There is developing evidence on recent technologies for colorectal cancer screening, including computed tomographic colonography (CTC), faecal DNA test, and Pillcam Colon or capsule endoscopy. They are less invasive and accurate, however, several issues should be discussed before applying these procedures for population-based screening programs. The most important is the cost-effectiveness of such procedures, particularly after they have been deemed acceptable by United States Preventive Services Task Force (USPSTF) [13] as an option for CRC screening in 2002 (but not capsule endoscopy).

In the last decades, CTC or virtual colonoscopy has emerged as an alternative to conventional colonoscopy for colorectal carcinoma screening, and has recently been adopted by several medical societies [28]. Given the fact that CTC technique is standardized, easy to perform and less invasive than colonoscopy (CS) [20,29], yet, the existing data on the cost-effectiveness of CTC for screening based on mathematical models are conflicting. The current review addressed the results of the recent studies discussing the cost-effectiveness of CTC, within the time range used in this review, where different screening strategies were compared: faecal-occult-blood tests (FOBT), CTC, optical-colonoscopy (OC) and flexible sigmoidoscopy. Some models evaluated 5-yearly CTC and others evaluated 10-yearly and 15-yearly CTC. All studies [20,29,30–38] established that CTC is cost-effective compared with no screening. Contradicting results have emerged from two different studies which used ten-year simulation modelling to assess asymptomatic, average-risk population 50–74 years old; the first one was in UK [30] which found that CTC has the potential to bear a cost-effective choice for CRC screening in the UK, National health System (NHS) and may be cost saving compared with the existing program of biennial FOBT depending on the adherence rate and also yielded better health benefits in terms of QALYs and life-years. The second study was in France and concluded that CTC is the most effective but not the most cost-effective in contrary to FOB which is the least effective but the most cost-effective [31].

For USA Medicare population, CTC would likely be cost-effective and highly efficacious and decreasing the Medicare expenditure [20,32], where three strategies were found to be highly cost-effective compared with no screening, with an incremental cost-effectiveness ratio (ICER) of \$6088, \$1251, and \$1104 per life-year gained for 5-year CTC, 10-year CTC, and 10-year optical colonoscopy strategies, respectively [20].

Lansdorp-Vogelaar I et al. [38] estimated the threshold costs for which CTC screening would be a cost-effective substitute to colo-

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