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Life expectancy and the value of early detection

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Abstract

This paper presents a model of the benefits and costs of early detection of asymptomatic disease as they vary by age. The benefits of early detection tend toward zero as the risk of death from competing causes increases. Costs per detected case also decline with age, assuming that disease incidence rises with age, but are always strictly positive. On balance, there is always an age limit beyond which the costs associated with early detection outweigh the benefits. Application of the model to prostate cancer screening suggests that early detection above age 70 or so is not cost-effective.

JEL classification: I10

Keywords: Screening; Cost-effectiveness; Prognosis; Life expectancy; Cancer

1. Introduction

Aggressive screening for asymptomatic disease is a bedrock of public health policy in the US. Cancer screening guidelines are generally of the form "Perform screening tests starting at age *x*". However, the benefits of early detection and treatment decline sharply with age because older persons are more likely to die from comorbid conditions or "competing risks". Although the limitations of early detection of asymptomatic tumors in the elderly are widely recognized, they have not been given the same degree of attention as

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other factors (for example, age of initiation and frequency) that influence the benefits from screening.

Consider the U.S. Preventive Services Task Force (2002a) guideline on mammography. The guideline states very specifically that women aged 40 and older ought to receive screening mammography every 1–2 years. Yet, with respect to the upper age limit for screening, the Task Force guideline contains the fairly imprecise recommendation: "the evidence is also generalizable to women aged 70 and older (who face a higher absolute risk for breast cancer) if their life expectancy is not compromised by comorbid disease". The guideline continues, "The absolute probability of benefits of regular mammography increase along a continuum with age . . . The balance of benefits and potential harms, therefore, grows more favorable as women age", implying that remaining life expectancy should play a small role, if any, in screening decisions. To be fair, the Task Force recognizes this limitation and has called for more research on the benefits of screening in the elderly (Mandelblatt et al., 2003). In general, however, cancer screening guidelines and guidelines for the treatment of early stage disease devote relatively little attention to prognostic issues,[1] possibly reflecting a neglect of prognosis as a factor in decision-making throughout modern medicine (Christakis and Sachs, 1996).

The purpose of this paper is to characterize theoretically the relationship between age and the cost-effectiveness of early detection and treatment. The main result is that there always exists an age beyond which the costs of early detection outweigh the benefits. In some cases, this age level will be of no practical consequence, since it exceeds the maximum human lifespan. In others, it will fall well within the population survival distribution and imply that screening performed without regards to age and life expectancy results in over-diagnosis and over-treatment.

Previously, Picone et al. (2004) presented a two-period model in which the value of early detection rises with life expectancy. However, their result depends entirely on risk aversion, and a different but equally valid method of modeling the way in which disease affects utility under risk aversion produces the opposite conclusion (Bleichrodt et al., 2003).[2] Wu (2003), in an empirical study of the factors affecting receipt of screens, hypothesizes that sicker people are less likely to be screened because the anxiety resulting from a positive screen is amplified by poor initial health. While psychological considerations are undoubtedly important in understanding screening behaviors,[3] they are not essential for explaining the result.

The model in this paper assumes risk neutrality and abstracts away from psychological considerations to show how the value of screening varies positively with life expectancy. The result follows from the simple but dismal epidemiology of competing risks; having asymptomatic disease does not affect well-being so long as one dies of another cause before

[1] An exception is guidelines for cervical cancer screening, which generally state an explicit age limit beyond which routine screening should be discontinued.

[2] Picone et al. (2004) assume that health status if ill declines from X to Y, where Y is independent of X. With concave utility, this implies that individuals who start off with low levels of health X have less to lose from developing illness. By contrast, in Bleichrodt et al. (2003), perfect health is represented by X and health if sick by $X - M$, so that health if sick and health if healthy have a common term, X. With concave utility, this formulation implies that persons who start off with low levels of health X have *more* to lose from developing illness.

[3] Byrne and Thompson (2001), for example, evaluate the implications of myopia for receipt of screenings.