Likelihood That a Woman With Screen-Detected Breast Cancer Has Had Her "Life Saved" by That Screening

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Background: Perhaps the most persuasive messages promoting screening mammography come from women who argue that the test "saved my life." Because other possibilities exist, we sought to determine how often lives were actually saved by mammography screening.

Methods: We created a simple method to estimate the probability that a woman with screen-detected breast cancer has had her life saved because of screening. We used DevCan, the National Cancer Institute's software for analyzing Surveillance Epidemiology and End Results (SEER) data, to estimate the 10-year risk of diagnosis and the 20-year risk of death—a time horizon long enough to capture the downstream benefits of screening. Using a range of estimates on the ability of screening mammography to reduce breast cancer mortality (relative risk reduction [RRR], 5%-25%), we estimated the risk of dying from breast cancer in the presence and absence of mammography in women of various ages (ages 40, 50, 60, and 70 years).

Results: We found that for a 50-year-old woman, the estimated risk of having a screen-detected breast cancer in the next 10 years is 1910 per 100 000. Her observed 20-year risk of breast cancer death is 990 per 100 000. Assuming that mammography has already reduced this risk by 20%, the risk of death in the absence of screening would be 1240 per 100 000, which suggests that the mortality benefit accrued to 250 per 100 000. Thus, the probability that a woman with screen-detected breast cancer avoids a breast cancer death because of mammography is 13% (250/1910). This number falls to 3% if screening mammography reduces breast cancer mortality by 5%. Similar analyses of women of different ages all yield probability estimates below 25%.

Conclusions: Most women with screen-detected breast cancer have not had their life saved by screening. They are instead either diagnosed early (with no effect on their mortality) or overdiagnosed.

CANCER SURVIVOR STORIES are important motivators for screening. They are common—a 4-month sample of 18 daily newspapers and magazines in 2005 found that, on average, each periodical published a new cancer survivor story at least once a month.[1] Narratives such as survivor stories also are

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more powerful than strictly didactic information. They are easier to understand,[2] more persuasive,[3] and more likely to impact viewers' and readers' behaviors, specifically by increasing screening behavior.[4] Celebrity survivor stories are particularly influential,[5] and in 1 case,[6] they were shown to double mammography rates. One explanation of this phenomenon—particularly in breast cancer—may be the general public's presumption that every survivor whose cancer was detected by screening has had her life saved because of screening.

Other outcomes, however, are possible. A woman may have had her breast cancer detected early yet not benefit from early detection because her cancer would have been equally treatable had it presented clinically. This possibility becomes more likely as treatment for early breast cancer improves.[7] Alternatively, a woman may have been overdiagnosed—diagnosed with a cancer not destined to cause symptoms or death.[8] Because it is important to acknowledge that these alternatives exist, in this article, we estimate the probability that a woman with screen-detected breast cancer—that is, one detected by screening mammography—has, in fact, had her life saved because of screening.

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Table. Simple Method Used to Calculate the Probability That a Breast Cancer Death Was Avoided Because of Screening

Measure	Source	Notation and Calculation	Base Case Data[a]
Probability of screen detection			
Observed risk of developing breast cancer in next 10 y	DevCan[9]	a	2990 per 100 000
Proportion of breast cancers found by mammography	Breen et al[10]	b	64%
Estimated risk of having screen-detected breast cancer in the next 10 y	Calculated	$c = a \times b$	1910 per 100 000
Probability of death			
Observed risk of death in the next 20 y	DevCan[9]	d	990 per 100 000
Estimated risk of death in the absence of mammography	Calculated	$e = d/(1.0 - 0.2)$	1240 per 100 000
Probability of benefit			
Among all women			
Absolute risk reduction in mortality due to mammography	Calculated	$f = e - d$	250 per 100 000
Among all women with screen-detected breast cancer			
Probability that breast cancer death was avoided because of screening	Calculated	$g = f/c$	13%

[a] The base case example is for a 50-year-old woman and 20% relative risk reduction with mammography.

METHODS

OVERVIEW

To determine this probability, we wanted to devise a simple and transparent method. Our approach depends on 2 readily estimable probabilities for a woman in the general population of the United States: (1) the probability of having breast cancer detected by screening and (2) the probability of avoiding breast cancer death because of the screening. Both estimates are strongly related to age, and the second is also clearly related to the estimated relative risk reduction (RRR) in breast cancer mortality attributable to mammography. Consequently, we vary both inputs (ages, 40, 50, 60, and 70 years; RRRs, 5%, 10%, 15%, 20%, and 25%).

PROBABILITY OF SCREEN DETECTION

We used DevCan 6.5.0 to estimate the 10-year risk of developing breast cancer (both invasive cancer and ductal carcinoma in situ) in American women aged 40, 50, 60 and 70 years. DevCan was developed by the National Cancer Institute[9] to compute the risk of developing (or dying from) cancer, conditional on a specified age using cross-sectional data of incident cases from the standard areas of the Surveillance, Epidemiology, and End Results (SEER) Program.

The DevCan estimates, however, cannot distinguish between clinically detected and screen-detected cancer. Thus, we sought an alternative data source for the proportion of breast cancers detected by screening. We found a data source using the 2003 National Health Interview Survey[10] showing that in the 2001-2003 period, approximately 60% of all breast cancers were detected by screening mammograms. We contacted the authors, who shared the data stratified by our age groups (age ranges, 40-49 years, 63%; 50-59 years, 64%; 60-69 years, 61%; and 70-79 years, 52%).

The risk of having screen-detected cancer was estimated simply as the product of the risk of developing breast cancer and the proportion of breast cancers found by mammography.

PROBABILITY OF DEATH

We also used DevCan to estimate the 20-year risk of breast cancer death in American women aged 40, 50, 60, and 70 years. To capture the downstream benefit of screening, we made the optimistic assumption that a 10-year course of screening would influence mortality over a 20-year period. In other words, we assumed that the mortality benefit for screened women accrues for an additional 10 years after the 10-year screening period.

We then made another optimistic assumption: that the 20-year risk of breast cancer death currently observed has already been lowered by the population-wide use of mammography (ie, 100% penetration of mammography). To reflect this, we inflated the risk of death to estimate what it would have been in the absence of screening mammography. The magnitude of the inflation is directly related to the magnitude of the estimated relative risk reduction in breast cancer mortality attributable to mammography. If the observed risk of breast cancer death was 1000 per 100 000 and the estimated relative risk reduction was 20%, for example, we would estimate that the risk of breast cancer death without mammography would have been 1250 per 100 000 (=1000/[1.0-0.2]). We repeat these estimates for both inputs: each age group and 5 estimates about the RRR of mammography.

PROBABILITY OF BENEFIT

The absolute risk reduction in mortality due to mammography, or mortality benefit, was calculated as the difference between the estimated 20-year risk of death without mammography and the 20-year risk of death observed currently. The probability that a woman with screen-detected breast cancer has avoided breast cancer death because of screening was the ratio of the mortality benefit and the probability of having screen-detected breast cancer.

RESULTS

The **Table** details our method for a 50-year-old woman under the assumption that screening mammography reduces the risk of breast cancer death by 20%. Her observed risk of developing breast cancer in the next 10 years is 2990 per 100 000. In this age group, 64% of breast cancers are found by mammography, suggesting that her risk of having a screen-detected breast cancer during this period is 1910 per 100 000. Her observed 20-year probability of breast cancer death is 990 per 100 000. Assuming that screening has already reduced this risk by 20%, her risk of death in the absence of screening would be 1240 per 100 000, which suggests that the mortality benefit accrued to 250 per 100 000. Thus, the probability that a 50-year-old woman with screen-detected breast cancer avoids a breast cancer death because of mammography is 13% (250/1910).
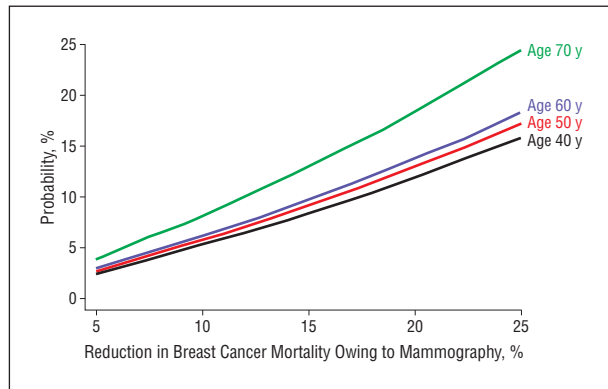
Figure. Probability that a woman with screen-detected breast cancer has her life saved because of the screening (using various ages and reductions in breast cancer mortality owing to mammography).

The **Figure** shows that for a 50-year-old woman, this number rises to 17% if screening mammography reduces breast cancer mortality by 25% and falls to 3% if screening mammography reduces breast cancer mortality by 5%. The figure also shows a similar relationship for women of other ages: the probability that a woman with screen-detected breast cancer has her life saved because of screening increases as the RRR of mammography increases. This probability also rises with age. The effect is most dramatic for a 70-year-old woman because the proportion of screen-detected cancers in this age group is relatively low (52%). Regardless, all analyses yield probability estimates below 25%.

COMMENT

We devised a simple and transparent method to estimate the probability that a woman with screen-detected breast cancer benefited from screening. Using a variety of plausible estimates about the RRR attributable to mammography, we found that this probability is always less than 25%.

There are a number of limitations to our approach. First, it assumes that the underlying disease burden of breast cancer is stable over time. If the burden of disease is rising, then our approach would underestimate the probability of benefit; if it is falling, then our approach would overestimate benefit. Second, our data on the risk of having screen-detected breast cancer are dependent on the accuracy of the estimated proportion of breast cancers found by screening mammography. While our data come from a widely recognized national survey (the National Health Interview Survey of the Centers for Disease Control and Prevention),[10] they are based on patient self-report. It is reassuring, however, that we found similar estimates from a cohort study at a single cancer center, based on medical records.[11] Had we assumed instead that only 50% of breast cancers were screen detected, the base case shown in the Table would shift from 13% to 17% (and the range across ages and various risk reductions depicted in the Figure would shift from 2.5%-24.0% to 3.2%-25.0%).

Third, we were forced to make an assumption to capture the downstream benefit of screening: namely, that the mortality benefit for screened women accrues for an additional 10 years after the 10-year screening period. Long-term follow-up of the Swedish randomized trials of mammography found that mortality benefit for all women (aged 40 to 74 years) was maximal 3.5 years following the cessation of the trials[12] and 5.8 years for women in their 40s.[13] Thus, we are confident that this additional 10-year assumption was adequate to capture downstream benefits.

Finally, there are a number of reasons to believe that we have overestimated the probability that a woman with screen-detected breast cancer has benefited from screening. The additional 10-year assumption is likely excessive, leading us to overestimate the probability. Were we to have used only an additional 5 years (ie, a 15-year probability of breast cancer death), for example, the base case shown in the Table would shift from 13% to 9% (and the range depicted in the Figure would shift from 2.5%-24.0% to 1.5%-19.0%). Furthermore, the assumption of 100% penetration of mammography is also likely to be too generous. If so, our inflated estimate of mortality in the absence of mammography has been overinflated, also leading us to overestimate benefit.

Yet the most consequential variable in our analysis, by far, is the one we allowed to vary—the RRR attributable to mammography. We considered a range of values: namely, that screening mammography reduces breast cancer mortality anywhere from 5% to 25%. The values toward the high end (20%-25%) reflect the randomized trial data from more than a quarter century ago. Readers should be aware, however, that there are both theoretical and empirical reasons to believe that this mortality benefit has declined over time. As women with new breast lumps now present earlier for evaluation[14] (there is no debate about the value of diagnostic mammography), the benefit of screening would be expected to be less. As treatment of clinically detected breast cancer (that detected by means other than screening) has improved,[7] the benefit of screening would be expected to be less. Recent empirical data from European nations, in which the initiation of screening mammography has been a relatively discrete event, confirm that the current benefit of screening mammography is disappointingly small.[15,16] Consequently, we believe that readers should focus on the values toward the low end (5%-10%) and recognize that the probability that a woman with screen-detected breast cancer has, in fact, avoided a breast cancer death because of screening mammography is now likely to be well below 10%.

Against this backdrop of declining benefit is the increasing recognition of the problem of mammography overdiagnosis—the detection of cancers not destined to cause symptoms or death. It is a problem that is notoriously difficult to quantify: estimates of the ratio of the overdiagnosis harm to the mortality benefit range from 2:1 to 10:1.[17,18] Nevertheless, there is little doubt that the problem is only aggravated by the increasing resolution of mammographic imaging.

Today, more people are likely to know a cancer survivor than ever before. Between 1971 and 2007, the number of cancer survivors in the United States more than doubled, from 1.5% to 4.0% of the population.[19] Breast cancer survivors are particularly common: they now rep-

resent approximately 2.5 million, or one-fifth of the current survivor population.[20]

Earlier diagnosis (either via enhanced awareness or screening) and better treatment are clearly part of the explanation for this large survivor population. But so too is the enthusiasm for screening and the resulting overdiagnosis. And, ironically, this enthusiasm may, in turn, be the product of a large number of survivors. This self-reinforcing cycle (the more detection, the more enthusiasm—the so-called popularity paradox of screening)[21] is driven, in part, by the presumption that every screen-detected breast cancer survivor has had her "life saved" because of screening. Our analyses suggest this is an exaggeration. In fact, a woman with screen-detected cancer is considerably more likely not to have benefited from screening. We believe that this information is important to put cancer survivor stories in their proper context.

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INVITED COMMENTARY

Screening

Simple Messages . . . Sometimes

In their article appearing in this issue of the *Archives*, Welch and Frankel[1] critically evaluate the common claim among cancer survivors that their "life was saved" by screening. After providing convincing evidence that this claim is markedly exaggerated, the authors express concerns that overly inflated perceptions of the benefits of mammography may lead to a self-perpetuating cycle of unwarranted demand for screening, overdiagnosis, overtreatment, and a continually growing population of breast cancer survivors who advocate mammography. The demographics of survivorship suggest that their concern is legitimate.

According to the National Cancer Institute,[2] there were an estimated 11.9 million cancer survivors (approxi-