# COMMENTARY

## Risk Charts: Putting Cancer in Context

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Whether people respond to a given health threat depends in part on how large they perceive their personal risk to be. Typical presentations of health risks (e.g., in the news, in public service announcements, and in direct-to-consumer advertisements) may do little to inform these perceptions. For example, efforts to describe various diseases to the public often take the following form: "This year, approximately 182 800 women in the United States will be diagnosed with invasive breast cancer, and approximately 40 800 women will die from breast cancer" *(1)*. Similar messages can be found for most well-known diseases [and increasingly, over the Internet, for less well-known diseases, such as hemochromatosis *(2)*]. What is missing from these messages is context: How does the chance of dying from breast cancer—or any other single disease—compare with the chance of dying from another disease? What is an individual's chance of dying from any cause? Without some context, it is impossible to gauge the magnitude of a disease risk.

To provide this context, we have created simple charts with age-, sex-, and smoking-specific data about the chance of dying from various common causes. In this article, we describe the method for creating these charts and make the charts publicly available.

### METHODS

#### Overview

The risk charts are designed to be simple, low-tech tools that can be used anywhere (e.g., posted in a clinic office). Our goal was to create charts that put disease risk in context by placing the 10-year chance of dying from various causes side by side. The risk charts include data for a range of ages on a single page to facilitate their use in a clinical setting.

#### Data

Information about deaths came from the National Center for Health Statistics (NCHS) Multiple Cause of Death Public Use File for 1998 *(3)*. The file contains information on all deaths of persons residing in the United States in 1998 and is based on death certificates completed by each state [all states require the reporting of all deaths; it is believed that more than 99% of all deaths in the United States are registered by the states *(4)*]. A death certificate may list multiple causes of death, which are translated at NCHS into codes enumerated in the International Classification of Diseases, 9$^{th}$ Revision (ICD-9) *(5)*. A computer program at NCHS assigns the underlying cause of death from the multiple causes listed on each certificate *(4)*. The risk charts we developed are based on these underlying causes of death.

#### Disease Categories

We included in the risk charts both the most common causes of death (e.g., heart attack, lung cancer) and causes that have received particular attention in the media (e.g., AIDS, ovarian cancer). The charts present 11 causes of death for women and nine for men. Eight causes apply to both sexes: accidents, heart attack, cerebrovascular disease, pneumonia, influenza, AIDS, lung cancer, and colon cancer. Sex-specific causes are prostate cancer (for men) and breast, cervical, and ovarian cancer (for women).

We grouped individual causes of death into disease categories using standard NCHS groupings [i.e., based on a list of the 282 most common causes of death *(6)*; *see* supplemental Table 1 on the Journal's Web site at http://jncicancerspectrum.oupjournals.org/jnci/content/vol94/issue11/index.shtml]. Our only departure from the NCHS groupings was the creation of the category "heart attack," which includes deaths from acute and chronic ischemic heart disease and associated complications (e.g., congestive heart failure and arrhythmia); the heart attack category does not include other heart disease deaths (e.g., endocarditis, valvular disease, pericarditis).

#### Calculations

**Age-specific death rates.** We calculated the 10-year chance of dying from selected causes and from any cause as follows. We used the NCHS Multiple Cause of Death File to count the number of deaths in 1998 for individuals 20 years old and older from each selected cause (and from any cause). Because this file includes all U.S. deaths, there are sufficient data to generate death rates for every year of age. We generated these rates by dividing the number of deaths at each year of age by the estimated midyear (July 1, 1998) U.S. resident population by using data from the U.S. Census *(7)*. (For example, we generated the annual death rate from lung cancer for 20-year-old women, 21-year-old women, and 22-year-old women). Thus, we calculated the annual death rate for every year of age for each disease category.

**Ten-year probability of death.** We determined the 10-year probability of death for each age represented in the risk chart (i.e., age 20 years to age 90 years, in 5-year increments) by creating a theoretical cohort of 100 000 individuals. For example, we applied the age-specific all-cause death rate for a 20-year-old man to calculate total number of deaths after 1 year in a cohort of 100 000 20-year-old men. We then subtracted this number from 100 000 to obtain the number of survivors (i.e., of the original 100 000 20-year-old men, how many reached age 21?). These survivors made up the population at risk for death in the subsequent year. We then applied the all-cause death rate

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*See* "Notes" following "References."

**Table 1.** Example of risk chart calculation: calculation of the 10-year probability of accidental death for a 20-year-old man

| | No. alive at start of year* (A) | Annual rate of accidental deaths (B) | No. of accidental deaths (A × B) |
|---|---|---|---|
| Year 1 | 100 000 | 0.00059 | 59 |
| Year 2 | 99 864 | 0.00066 | 66 |
| Year 3 | 99 717 | 0.00059 | 59 |
| Year 4 | 99 573 | 0.00056 | 56 |
| Year 5 | 99 432 | 0.00055 | 55 |
| Year 6 | 99 290 | 0.00052 | 52 |
| Year 7 | 99 150 | 0.0005 | 50 |
| Year 8 | 99 015 | 0.0005 | 49 |
| Year 9 | 98 873 | 0.00046 | 46 |
| Year 10 | 98 732 | 0.00044 | 43 |
| Total | | | 535 per 100 000 |

*Number alive at the start of year (i.e., the population at risk) = number alive at start of previous year − number of all-cause deaths during the previous year.

calculated for 21-year-old men to determine the number of deaths over the next year and repeated the process through the 10th year. In this way, we defined the population at risk for death at the beginning of each of 10 years. We then applied the age-specific death rate for each individual cause of death to the population at risk at the beginning of each year and obtained the 10-year chance of death from each cause by adding the number of deaths in each of the 10 years. Table 1 illustrates this calculation for the 10-year chance of accidental death for a 20-year-old man.

**Adjusting risk estimates for smoking.** After age and sex, smoking is the most important risk factor for a variety of specific causes of death (e.g., lung cancer and heart disease) as well as for all-cause mortality. Thus, we created two sets of charts: one for current smokers and one for never smokers. We used the Centers for Disease Control and Prevention's definitions of smoking status *(8,9)*: current smokers are people who currently smoke and have smoked at least 100 cigarettes in their lifetime, and never smokers are people who have smoked fewer than 100 cigarettes in their lifetime. (We did not create charts for former smokers, i.e., people who do not smoke now but smoked at least 100 cigarettes in the past). To calculate the chance of dying according to smoking status, we needed the following information: the age-specific prevalence of smoking and the relative risk of death (from various causes and all causes) associated with smoking. We assumed that the risk of dying in the general population is the weighted average of the risk for smokers and nonsmokers, and that the risk for smokers is equal to the risk for nonsmokers multiplied by the relative risk of death associated with smoking.

We obtained the prevalence of smoking by age from the Behavioral Risk Factor Surveillance System of the Centers for Disease Control and Prevention *(8)*. The relative risks of death for diseases with well-established associations with smoking (heart disease, stroke, lung cancer, pneumonia, and influenza)

**Risk chart for women who have never smoked***

**Find the line with your age. The numbers next to your age tell how many of 1000 women will die in the next 10 years from each cause of death.**

| | Vascular disease | | Cancer type | | | | | Infection | | | Accidents | Any cause |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age, y | Heart attack | Stroke | Lung | Breast | Colon | Ovarian | Cervical | Pneumonia | Influenza | AIDS | | |
| 20 | | | | | | | | | | | 2 | **4** |
| 25 | | | | | | Fewer than 1 death | | | | 1 | 1 | **5** |
| 30 | | | | 1 | | | | | | 2 | 2 | **7** |
| 35 | | | | 1 | | | | | | 2 | 2 | **11** |
| 40 | 1 | 1 | | 2 | 1 | | | | | 2 | 2 | **17** |
| 45 | 2 | 1 | 1 | 4 | 1 | 1 | 1 | | | 1 | 2 | **26** |
| 50 | 4 | 2 | 2 | 5 | 2 | 1 | 1 | 1 | | 1 | 2 | **42** |
| 55 | 7 | 2 | 3 | 6 | 3 | 2 | 1 | 1 | | 1 | 2 | **66** |
| 60 | 14 | 4 | 5 | 7 | 4 | 3 | 1 | 2 | | | 2 | **105** |
| 65 | 30 | 10 | 7 | 9 | 6 | 3 | 1 | 4 | | | 3 | **158** |
| 70 | 52 | 19 | 10 | 10 | 8 | 4 | 1 | 7 | | | 5 | **247** |
| 75 | 90 | 36 | 11 | 11 | 11 | 4 | 1 | 15 | | | 7 | **381** |
| 80 | 153 | 62 | 11 | 12 | 14 | 4 | 1 | 30 | 1 | | 11 | **581** |
| 85 | 221 | 86 | 8 | 12 | 15 | 3 | 1 | 48 | 3 | | 14 | **771** |
| 90 | 272 | 96 | 5 | 10 | 14 | 2 | 1 | 64 | 5 | | 15 | **879** |

*The numbers in each row do not add up to the chance of dying from any reason because there are many other causes of death in addition to the ones listed here.
AIDS = acquired immunodeficiency syndrome.

**Fig. 1.** Risk chart for women who have never smoked. The chart indicates the number of women per 1000 who will die from various diseases and for any reason during the next 10 years, beginning at the indicated age. Shaded area indicates age group and disease combinations with fewer than 1 death per 1000.

and for death from any cause were derived from the Cancer Prevention Study used in the U.S. Surgeon General's Report on the health consequences of smoking *(9)*. Recently, Thun et al. *(10)* developed an adjusted model to account for possible confounding of the relative risks in the Surgeon General's report by various behavioral and demographic factors; they found that adjustment made little difference in the relative risks. We used the adjusted relative risk estimates where available (i.e., for each specific cause of death); otherwise, we used unadjusted values (i.e., for all-cause mortality).

### Chart Format

To make the charts simple to understand, we limited the amount of data presented and paid particular attention to their format. The charts present data on the 10-year chance of dying to provide a reasonable window into the future; to avoid data overload, they use a starting age of every 5th year (i.e., age 20 years, 25 years, 30 years, and so on) rather than every year. Mortality data can be represented as counts, proportions, or rates; we used counts with a stable denominator (e.g., 3 in 1000, 10 in 1000) because there is some evidence suggesting that people find this format easiest to understand *(11–14)*. The data in the risk charts are given as the number of deaths per 1000 rather than per 100 000 people because many people have trouble imagining such a large group (i.e., 100 000 is outside of common experience) *(15)*. To further simplify the appearance of the charts, we rounded the number of deaths to the nearest whole number and shaded cells in which the death rate was less than 1 per 1000. Finally, to help clarify how much each individual disease category contributes to all-cause mortality, the charts include the overall chance of dying.

## Results

### Risk Chart for Never Smokers

Fig. 1 displays the 10-year disease-specific mortality and all-cause mortality in 5-year increments for women who never smoked. The first row shows that, for 20-year-old women, death is uncommon (only four of 1000 women who are 20 years old will die in the next 10 years) and that accidents are responsible for half of the deaths that do occur. By the time a woman reaches 40 years of age, heart attack, stroke, colon cancer, breast cancer, AIDS, and accidents are about equally common causes of death, although death is still quite infrequent (17 of 1000 women who are 40 years old will die in the next 10 years). After age 50, heart attack becomes the single largest cause of death for women. Breast cancer is the leading cause of cancer death until about age 65, when lung and colon cancer reach about the same magnitude (although by age 80, lung cancer deaths drop off and colon cancer deaths exceed breast cancer deaths). By age 75, a woman's chance of dying from pneumonia exceeds her chance of dying from any one cancer.

The risk chart for nonsmoking men appears in Fig. 2. A comparison of Fig. 1 and 2 shows that, until age 80, a man's

**Risk chart for men who have never smoked***

**Find the line with your age. The numbers next to your age tell how many of 1000 men will die in the next 10 years from each cause of death.**

| | Vascular disease | | Cancer type | | | Infection | | | Accidents | Any cause |
|---|---|---|---|---|---|---|---|---|---|---|
| Age, y | Heart attack | Stroke | Lung | Colon | Prostate | Pneumonia | Influenza | AIDS | | |
| 20 | | | | | | | | | 5 | **10** |
| 25 | | | | | | Fewer than 1 death | | 1 | 5 | **11** |
| 30 | 1 | | | | | | | 2 | 4 | **13** |
| 35 | 2 | | | | | | | 2 | 5 | **18** |
| 40 | 4 | 1 | | 1 | | | | 2 | 5 | **27** |
| 45 | 7 | 1 | 1 | 1 | | 1 | | 1 | 5 | **39** |
| 50 | 12 | 2 | 2 | 2 | 1 | 1 | | 1 | 4 | **62** |
| 55 | 20 | 4 | 3 | 4 | 2 | 2 | | 1 | 4 | **93** |
| 60 | 32 | 6 | 5 | 6 | 4 | 3 | | | 5 | **146** |
| 65 | 61 | 12 | 7 | 9 | 8 | 6 | | | 6 | **221** |
| 70 | 93 | 21 | 12 | 11 | 14 | 11 | | | 7 | **336** |
| 75 | 142 | 36 | 15 | 14 | 23 | 22 | 1 | | 11 | **494** |
| 80 | 196 | 53 | 13 | 16 | 32 | 38 | 1 | | 15 | **652** |
| 85 | 241 | 67 | 10 | 16 | 37 | 56 | 1 | | 19 | **770** |
| 90 | 223 | 73 | 6 | 14 | 36 | 74 | 1 | | 21 | **828** |

*The numbers in each row do not add up to the chance of dying from any reason because there are many other causes of death in addition to the ones listed here.
AIDS = acquired immunodeficiency syndrome.

**Fig. 2.** Risk chart for men who have never smoked. The chart indicates the number of men per 1000 who will die from various diseases and for any reason during the next 10 years, beginning at the indicated age. Shaded area indicates age group and disease combinations with fewer than 1 death per 1000.

overall chance of dying in the next 10 years is greater than that of a woman. Similarly, a man's chance of death from accidents always exceeds a woman's chance; until age 70, a man's chance of accidental death is twice that of women. The overall patterns of death, however, are similar. From age 40 on, heart attack is the most common single cause of death for men. Until about age 70, a man's chances of dying from lung, colon, or prostate cancer are all similar; from age 70 on, however, death from prostate cancer becomes much more common than death from the other cancers. After age 80, the chance of dying from pneumonia exceeds the chance of dying from any one cancer.

### Risk Chart for Current Smokers

A current smoker refers to someone who currently smokes and who has smoked at least 100 cigarettes in his or her lifetime. At all ages, a smoker's chance of dying in the next 10 years is greater than that of a never-smoker. Fig. 3 shows that, for female smokers, lung cancer is the leading cause of death from about age 40 until age 75; the chance of death from lung cancer is substantially greater than the chance of death from breast cancer from age 35 on. After age 75, the chance of dying from a heart attack exceeds the chance of dying from any of the major cancers. Fig. 4 shows that, for men who smoke, heart attack is the leading cause of death until age 50. Thereafter, the chance of dying from lung cancer is higher than the chance of dying from heart attack until about age 80, after which the chance of dying from heart attack exceeds the chance of dying from lung cancer. At every age, a man's chance of dying from lung cancer substantially exceeds his chance of dying from prostate cancer.

## Discussion

We created simple charts with age-, sex-, and smoking-specific data about the chances of dying from various common causes in the next 10 years. The charts are designed to put the chance of dying from a given disease in the context of the chances of dying from other diseases and of dying from any cause.

Several limitations of the charts merit comment. First, the charts are only as accurate as the data on which they are based. We used the 1998 Multiple Cause of Death Public Use File from the NCHS, the best available national source of mortality data. Nevertheless, these data are derived from death certificates. The accuracy of cause-of-death statistics is determined by the ability of the certifier (usually a physician, medical examiner, or coroner) to properly diagnose the cause of death *(4).* Although valid questions have been raised about the reliability of death certificates *(16),* they remain the standard source of data about causes of death in the United States. Second, the charts present data only about mortality, not about disease incidence. Many people may be concerned about their chances of developing a disease, not just their chances of dying from it. Developing incidence charts will be very challenging, however, because judgments

**Risk chart for women who currently smoke***

**Find the line with your age. The numbers next to your age tell how many of 1000 women will die in the next 10 years from each cause of death.**

| | Vascular disease | | Cancer | | | | | Infection | | | Accidents | Any cause† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age, y | Heart attack | Stroke | Lung | Breast | Colon | Ovarian | Cervical | Pneumonia | Influenza | AIDS | | |
| 20 | | | | | | | | | | | 2 | **8** |
| 25 | | | | | | **Fewer than 1 death** | | | | 1 | 1 | **10** |
| 30 | 1 | 1 | 1 | 1 | | | | | | 2 | 2 | **14** |
| 35 | 1 | 1 | 2 | 1 | | | | | | 2 | 2 | **22** |
| 40 | 3 | 2 | 4 | 2 | 1 | | | 1 | | 2 | 2 | **32** |
| 45 | 6 | 4 | 10 | 4 | 1 | 1 | 1 | 1 | | 1 | 2 | **50** |
| 50 | 13 | 6 | 21 | 5 | 2 | 1 | 1 | 1 | | 1 | 2 | **80** |
| 55 | 24 | 9 | 36 | 6 | 3 | 2 | 1 | 2 | | 1 | 2 | **125** |
| 60 | 45 | 16 | 65 | 7 | 4 | 3 | 1 | 4 | | | 2 | **199** |
| 65 | 50 | 16 | 85 | 9 | 6 | 3 | 1 | 8 | | | 3 | **301** |
| 70 | 88 | 30 | 124 | 10 | 8 | 4 | 1 | 16 | | | 5 | **470** |
| 75 | 153 | 58 | 137 | 11 | 11 | 4 | 1 | 33 | 1 | | 7 | **725** |
| 80 | 261 | 99 | 136 | 12 | 14 | 4 | 1 | 66 | 3 | | 11 | **>950** |
| 85 | 375 | 137 | 103 | 12 | 15 | 3 | 1 | 105 | 6 | | 14 | **>950** |
| 90 | 462 | 154 | 64 | 10 | 14 | 2 | 1 | 140 | 12 | | 15 | **>950** |

*Calculations for this chart are based on data that use the standard Centers for Disease Control and Prevention (CDC) definition of a smoker: someone who has smoked at least 100 cigarettes in her lifetime and smokes any amount now. The numbers in each row do not add up to the chance of dying from any reason because there are many other causes of death in addition to the ones listed here. AIDS = acquired immunodeficiency syndrome.

**Fig. 3.** Risk chart for women who currently smoke. The chart indicates the number of women smokers per 1000 who will die from various diseases and for any reason during the next 10 years, beginning at the indicated age. Shaded area indicates age group and disease combinations with fewer than 1 death per 1000.

## Risk chart for men who currently smoke*

**Find the line with your age. The numbers next to your age tell how many of 1000 men will die in the next 10 years from each cause of death.**

| | Vascular disease | | Cancer | | | Infection | | | Accidents | Any cause |
|---|---|---|---|---|---|---|---|---|---|---|
| Age, y | Heart attack | Stroke | Lung | Colon | Prostate | Pneumonia | Influenza | AIDS | | |
| 20 | | | | | | | | | 5 | **23** |
| 25 | 1 | | | | | | | 1 | 5 | **26** |
| 30 | 2 | 1 | 1 | | | | | 2 | 4 | **30** |
| 35 | 4 | 1 | 2 | | | 1 | | 2 | 5 | **43** |
| 40 | 9 | 2 | 6 | 1 | | 1 | | 2 | 5 | **64** |
| 45 | 17 | 3 | 13 | 1 | | 1 | | 1 | 5 | **91** |
| 50 | 32 | 5 | 33 | 2 | 1 | 2 | | 1 | 4 | **145** |
| 55 | 51 | 8 | 55 | 4 | 2 | 3 | | 1 | 4 | **217** |
| 60 | 84 | 14 | 98 | 6 | 4 | 6 | | | 5 | **341** |
| 65 | 91 | 18 | 152 | 9 | 8 | 11 | | | 6 | **516** |
| 70 | 140 | 31 | 249 | 11 | 14 | 23 | | | 7 | **786** |
| 75 | 213 | 54 | 330 | 14 | 23 | 44 | 1 | | 11 | **> 950** |
| 80 | 295 | 80 | 275 | 16 | 32 | 76 | 1 | | 15 | **> 950** |
| 85 | 361 | 100 | 211 | 16 | 37 | 113 | 2 | | 19 | **> 950** |
| 90 | 335 | 109 | 133 | 14 | 36 | 147 | 2 | | 21 | **> 950** |

Fewer than 1 death

*Calculations for this chart are based on data that use the standard Centers for Disease Control and Prevention (CDC) definition of a smoker: someone who has smoked at least 100 cigarettes in his lifetime and smokes any amount now. The numbers in each row do not add up to the chance of dying from any reason because there are many other causes of death in addition to the ones listed here. AIDS = acquired immunodeficiency syndrome.

**Fig. 4.** Risk chart for men who currently smoke. The chart indicates the number of men smokers per 1000 who will die from various diseases and for any reason during the next 10 years, beginning at the indicated age. Shaded area indicates age group and disease combinations with fewer than 1 death per 1000.

about incidence are far more ambiguous than judgments about death. For example, a myocardial infarction can be defined as a small rise in a serum troponin level or as a substantial creatine kinase elevation in the context of typical symptoms and EKG changes. Because reporting on mortality is far less subjective than defining incident cases, the charts present only the chance of dying. Similarly, the charts do not present information about quality of life with different diseases, information that might be helpful for patients making decisions. Such quality-of-life information, however, is not readily available.

Third, our risk estimates are not completely individualized. Patients with important disease risk factors, such as a strong family history of a certain disease, might be able to obtain more precise estimates of their risk of dying from that disease from a customized assessment *(17)*. We have, however, made an effort to account for what are arguably the three most important risk factors for death: age, sex, and smoking. We did not create a set of charts for former smokers because their risk estimates will vary according to a variety of factors [e.g., length of time since stopping smoking, extent of prior smoke exposure, and age of initiation of regular smoking *(9)*]. It is reasonable to assume that the risks for former smokers are intermediate between those of current smokers and never smokers (and that the longer the time since the last cigarette, the closer the former smoker's risk approximates that of a never smoker) *(9,10)*. It should be noted that our charts do have several distinct advantages over interactive computer applications: they are inexpensive, they can be used anywhere, and they require no special hardware or trained personnel.

We believe that our risk charts will help people better understand and compare the important health threats they face. The charts could be posted in clinic offices or distributed to patients for easy reference when decisions (e.g., about cancer screening) are being made. Because the charts give people a sense of how much smoking adds to their chance of dying at every age, they may also be useful in smoking prevention and cessation efforts. We believe that the risk charts are a good first step at helping physicians and their patients put cancer and other disease risks in context.

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## NOTES

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