INFERENCE ABOUT POPULATION ATTRIBUTABLE
RISK FROM CROSS-SECTIONAL STUDIES

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STUDY ON STATISTICS AND ENVIRONMENTAL
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The population attributable risk (PAR) is defined as the fraction of all cases of a disease in a population due to exposure to a given risk factor. Letting P_e denote the proportion of the population exposed to the risk factor and R the relative risk, PAR may be defined (see 1) as

$$PAR = \frac{P_e (R-1)}{P_e (R-1) + 1}.$$

Both Levin (1) and more recent students of PAR (2,3,4) have considered its estimation from case-control studies, when it may be assumed that the odds ratio closely approximates R and that the rate of exposure in the control group closely approximates P_e . Under these assumptions, Walter (3) derived an expression for the approximate standard error of $\ln(1-\hat{PAR})$, where $\hat{PAR}$ denotes the estimated PAR and $\ln$ denotes the natural logarithm.

Little attention seems to have been paid to the problem of drawing inferences about PAR when the data are collected in cross-sectional surveys (such as those conducted by the National Center for Health Statistics) or as part of routine registration (such as the recording of number of live births and numbers of infant deaths in a city). Walter (5) considered this problem, and derived a complicated expression for the standard error of $\hat{PAR}$. Below, a relatively simple expression for the standard error of $\ln(1-\hat{PAR})$ is presented.

Suppose the results of a cross-sectional study are tabulated as follows:

	Outcome Condition		Total
	Present	Absent	
Exposed	a	b	a + b
Not Exposed	c	d	c + d
Total	a+c	b+d	n

Because the estimate of R is $a(c+d)/c(a+b)$ and the estimate of P_0 is $(a+b)/n$, the estimate of PAR for this kind of study becomes, after simplification,

$$\hat{PAR} = \frac{ad - bc}{(a+c)(c+d)}.$$

Using standard methods appropriate for large samples (6), it may be shown that $\ln(1-\hat{PAR})$ is approximately normally distributed with mean $\ln(1-\hat{PAR})$ and standard error

$$s = \text{s.e.}(\ln(1-\hat{PAR})) = \sqrt{\frac{b + (a+d)\hat{PAR}}{nc}}.$$

This formula is related to Walter's (see, e.g., formula 2 in (7)) by $s = \text{s.e.}(\hat{PAR})/(1-\hat{PAR})$. An approximate 95% confidence interval for PAR is $(\hat{PAR}_L, \hat{PAR}_U)$, where

$$\hat{PAR}_L = 1 - \exp(\ln(1-\hat{PAR}) + 1.96s)$$

and

$$\hat{PAR}_U = 1 - \exp(\ln(1-\hat{PAR}) - 1.96s).$$

As an example, consider the following data from Erie County, N.Y. on levels of suspended particulates and mortality over a three year period (1959-1961) from cancer of the prostate (8). The individuals were all white males aged 50-69 years residing in areas with a median family income between approximately \$6,000 and \$12,00 per year.

Mean Daily Level of Suspended Particulates	Died due to Prostatic Cancer	Alive, or Died of Other Causes	Total
$> 100 \mu\text{g}/\text{m}^3$	9	8,456	8,465
$\leq 100 \mu\text{g}/\text{m}^3$	22	34,897	34,919
Total	31	43,353	43,384

The estimated PAR is

$$\hat{PAR} = \frac{9 \times 34,897 - 8,456 \times 22}{31 \times 34,919} = 0.118,$$

indicating that about 12% of deaths due to prostatic cancer in the study group may have been due to residence in areas with high levels of suspended particulates.

The estimated standard error of $\ln(1-\hat{PAR})$ is

$$s = \sqrt{\frac{8,456 + (9 + 34,897) \times 0.118}{43,353 \times 22}} = 0.115.$$

The lower 95% confidence bound on PAR is therefore

$$\begin{aligned} PAR_L &= 1 - \exp(-0.126 + 1.96 \times 0.115) \\ &= 1 - 1.105 = -0.105, \end{aligned}$$

and the upper 95% bound is

$$\begin{aligned} PAR_U &= 1 - \exp(-0.126 - 1.96 \times 0.115) \\ &= 1 - 0.704 = 0.296. \end{aligned}$$

The interval includes the value 0, which is consistent with the absence of a statistically significant association between level of suspended particulates (as dichotomized here) and death due to prostatic cancer. Also consistent with the data, however, is the possibility that as many as 30% of all deaths due to prostatic cancer could have been eliminated if daily levels of suspended particulates had been reduced below 100 $\mu\text{g}/\text{m}^3$.

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