## Risk from Exposure to Asbestos

In the light of the Environmental Protection Agency's proposed ban on the remaining uses of asbestos, it should be of interest to *Science* readers that there is a significant error in certain risk estimates of low-level asbestos exposure.

We report a mistake we discovered in the mesothelioma risk assessment portion of the National Research Council (NRC) report *Asbestiform Fibers: Nonoccupational Health Risks* (*1*). The report's authors proposed, on the basis of the analysis of Peto, Seidman, and Selikoff (*2*), a cumulative incidence function, $I(t,d) = cd(t - t_0)^k$, for equation 7 (p. 209) of the report, where $t$ is age; $t - t_0$ is the time since first exposure at age $t_0$; $cd$ is $b$, a constant depending on the type of asbestos exposure for workers exposed at dose level $d$; and $k$ is a constant.

The values of the constants $k$ and $b$ (and hence $c$) were intended to be chosen from those calculated by Peto *et al.* by using maximum likelihood fitting to several data sets, including Selikoff's 1979 data (*3*) on insulation workers.

Unfortunately, the analysis of Peto *et al.* seems to have been misread, and as a consequence the lifetime risk of mesothelioma has been consistently underestimated by a factor approaching 20. Peto *et al.* fit observed death rates to the function $b(t - t_0)^k$ and found, for example, that when $k$ is 3.2 and $b$ is $4.37 \times 10^{-8}$, the Selikoff data are represented. The NRC chose these values of $k$ and $b$ for direct insertion in equation 7 to illustrate the cumulative incidence function, despite the fact that the Peto *et al.* death rate is the time derivative of the function $I(t,d)$. If the values of $b$ and $k$ are as determined by Peto *et al.*, then the resulting cumulative incidence function (cumulative death rate in the absence of competing causes) becomes $I(t,d)$, which is equal to $(t - t_0)^{k+1}\ cd/(k + 1)$ or $(t - t_0)^{k+1}\ b/(k + 1)$, rather than equation 7.

To grasp the magnitude of this correction, we observe that lifetime risk of mesothelioma, calculated (presumably incorrectly) on page 221 of (*1*) for an admittedly hazardous exposure profile, is as follows: school risk, $21 \times 10^{-6}$; background risk, $46 \times 10^{-6}$; and total risk, $67 \times 10^{-6}$. These become, after correction, school risk, $399 \times 10^{-6}$; background risk, $800 \times 10^{-6}$; and total risk, $1199 \times 10^{-6}$.

A major implication of this correction is that estimated lifetime mesothelioma risks are nearly 20 times larger than those shown in the NRC report. Therefore, mesothelioma risks would appear to dominate those of lung cancer for the exposure profiles illustrated in chapter 7.

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2. V. Peto, H. Seidman, I. Selikoff, *Br. J. Cancer* **45**, 124 (1982).
3. I. J. Selikoff, E. C. Hammond, H. Seidman, *Ann. N.Y. Acad. Sci.* **330**, 91 (1979).

Table 7.2 Estimated individual lifetime risks from a continuous exposure to asbestos at 0.0004 fiber/cm$^3$ (a median dose) or 0.002 fiber/cm$^3$ (a high dose).

| Disease | Exposure group | Estimated individual lifetime risk ($\times 10^6$) | |
|---|---|---|---|
| | | Median exposure (0.0004 fiber/cm$^3$) | High exposure (0.002 fiber/cm$^3$) |
| Lung cancer | Male smoker | 292 | 1459 |
| Lung cancer | Female smoker | 105 | 524 |
| Lung cancer | Male nonsmoker | 27 | 132 |
| Lung cancer | Female nonsmoker | 14 | 68 |
| Mesothelioma | All groups | 156 | 780 |

*Response*: Aroesty and Wolf are correct in pointing out an error in the calculation of mesothelioma risk due to asbestos exposures in the National Research Council (NRC) report *Asbestiform Fibers: Nonoccupational Health Risks* (*1*). The error was in using the simple (annual) incidence function for risk rather than the cumulative incidence function. As a result, equation 11 on page 216 of the NRC report should have read:

$$L = c(0.004)\ (73)^{k+1}/(k + 1)$$

rather than

$$L = c(0.0004)\ (73)^k$$

Using the correct function increases the estimated lifetime risks for mesothelioma by a factor of 17.4. Aroesty and Wolf mention that the corrected mesothelioma risks would now dominate those of lung cancer in the environmental estimates made in the NRC report (table 7.2). This, however, is not the case because the published lung cancer risks were also understated. A multiplier of 4.56 was used to adjust risks for mesothelioma arising from occupational exposures of 1920 hours per year to risks from general environmental exposures of 8760 hours per year. This was not done for lung cancer. Using this same multiplier to estimate lifetime risks for lung cancer resulting from asbestos exposure increases the estimated projections by a factor of 4.5.

Incorporating these corrections increases the estimated risks of both lung cancer and mesothelioma (*2*). The table above is a correction for table 7.2 in the NRC report.

It should also be pointed out that when values of $k$ and $c$ are used which reflect the correlation between their measures, the range of risk estimates in table 7.2 of the NRC report is greatly reduced.

The NRC regrets these errors and urges persons working with the risk estimates to note the new values in the table above. We thank Aroesty and Wolf for calling attention to this matter.

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## The Vinogradov Expedition: Why Did the United States Miss the Boat?

As mentioned by Charles Petit in his article "Red tape snarls Soviet research ship" (News & Comment, 10 Oct., p. 145), I was the sole foreign scientist aboard the Soviet research vessel *Akademik Aleksandr Vinogradov* on the leg from Hilo to San Francisco (Bill Siapno, of Deepsea Ventures, Inc., came aboard at San Francisco at the last minute). Petit's article is accurate but tends to obscure the basic question: "Why was only one American on board?" The answer goes far beyond the fact that the Soviets had difficulties scheduling periods of "R & R" in American ports and in Japan. The story