

Anatomy of the healthy worker effect – A critique of summary statistics employed in occupational epidemiology

by Chi Pang Wen, MD, Shan Pou Tsai, MS¹

WEN CP, TSAI SP. Anatomy of the healthy worker effect – A critique of summary statistics employed in occupational epidemiology. *Scand j work environ health* 8 (1982): suppl 1, 48–52. The “healthy worker effect,” perhaps more accurately termed the “active worker effect,” has been acknowledged by numerous investigators who have disregarded its significance. The healthy worker effect is expressed by SMRs (standardized mortality ratios) and influenced by the following three factors: (i) selection bias, (ii) improved socioeconomic status, and (iii) the conventional way of calculating SMRs. An examination of these three factors shows that selection for “employability” is probably the most significant factor for the healthy worker effect. For example, the shorter the observation, the smaller the SMR, and the stronger the healthy worker effect. Secondly, improved socioeconomic status as a result of employment has been shown to lower mortality. Last, although the SMR has the advantage of estimating relative risk in a small sample, it suffers many methodological pitfalls. It is recommended that at least three parameters be used to summarize mortality experience among the employed: (i) relative risk, (ii) attributable risk, and (iii) life expectancy.

Key terms: active worker effect, attributable risk, life expectancy, relative risk, selection, social economic status, standardized mortality ratio (SMR).

The overall mortality experience of an employed population is usually more favorable than that of the general population. This phenomenon is often referred to as the “healthy worker effect” and is expressed by a summary statistic, the standardized mortality ratio (SMR), with values lower than one. While many investigators have recognized the healthy worker effect (3, 8, 10, 15, 20, 25, 27, 31), many have dismissed its significance in reaching final conclusions.

The phenomenon is not only limited to lower mortality. It is also reflected in lower morbidity (frequency and severity rates of illness) and possible longer life

expectancy. Furthermore, it is more characteristic of “active” workers and would be more accurately addressed as the “active worker effect.”

Although its quantitative contribution depends on the nature of employment, selection for “employability” (selection by the employer or self-selection by the employee) is probably the most significant factor for the healthy worker effect (7, 23, 26). The impact of selection is greatest in a short-term observation. In other words, the shorter the observation, the smaller the SMR and the stronger the healthy worker effect. For the first 5 a of entry into industry, an overall SMR as low as 0.37 has been observed (3). The nonwhite worker has a stronger effect than the white (17), and the white-collar worker, a stronger effect than the blue-collar worker (32), because the selection process tends to result in larger class differentials between the

¹ The University of Texas Health Science Center at Houston, School of Public Health, Houston, Texas, United States.

Reprint requests to: Dr CP Wen, 17611 Butte Creek, Houston, TX 77090, USA.

nonwhite employed and the nonwhite unemployed.

Another kind of selection is separation from the workforce for various reasons, ie, selecting out versus selecting in. Fox & Collier (3) studied a group of chemical workers and found that the separated group had higher SMRs than those who remained employed. Survival in industry by the healthier worker was cited as the reason for this effect (3). However, such a "selecting out" process does not necessarily lead to a healthier workforce since health is usually not the main reason for leaving one's job. Furthermore, a conventional study design for SMR analysis calls for follow-up of all the separated employees, and separation from industry or "selecting out" does not affect the total SMR nor the healthy worker effect in a retrospective cohort study (19).

It would be presumptuous to assume that the healthy worker effect is the exclusive result of selection. Thus, it is the purpose of this paper to examine factors other than selection in detail, ie, changes in life accompanying employment and methodological characteristics of the SMR.

Changes in life accompanying employment

Selection into the job market is accompanied by substantial changes in one's life, among others, improved economic status, better access to medical care, and changes in life-style.

Improved economic status

Economic gains are the immediate result of one's employment, and the employed achieves a different socioeconomic status than the unemployed. For different economic status, mortality has been known to be different (1, 12, 13, 21, 22). Varying populations, at different time periods, have shown that the higher the socioeconomic class, the lower the general overall mortality (1, 5, 6, 9, 13, 22, 27, 30). Consequently, socioeconomic class is a powerful determinant of mortality. Furthermore, status upgrading of the employed from the unemployed has led significantly to the "healthy worker effect."

Better access to medical care

Medical insurance benefits are routinely provided by employers and accepted by employees. There are reasons to believe that better access to medical care will, in most instances, prolong survival time in a life-shortening event (14). This advantage is translated into lower overall mortality, which results in the "healthy worker effect." However, for specific causes, such as cancer, better medical care with a more thorough medical workup can result in more accurate diagnoses and paradoxical results. Under such circumstances, the healthy worker effect could be counterbalanced and either diminish or disappear. This may be part of the reason for frequent observations, eg, of workers with higher SMRs for certain cancers than for hourly workers or an overall SMR of 0.80 and a cancer SMR of 1.00. An alternative and conventional interpretation for the latter is that the selection factor only applies more to noncancer causes and less to cancer causes if at all. The selectivity of specific causes for the healthy worker effect, therefore, could be a combination of factors operating before and after employment.

Changes in life-style

Employment may bring about changes in one's schedules, habits, and relationships. These changes may be indirectly or directly related to health. For example, the socialization process may indirectly produce reductions in substance abuse, while health education materials, referral services, and professional counseling received during employment may produce a direct favorable effect on health.

Data from a US Household Interview Survey conducted by the National Center for Health Statistics (29) showed that there were more young smokers (aged 17—24 a) among the employed (41 %) than among the unemployed (29 %). However, as age increased there were less smokers among the employed than among the unemployed. Indeed 47 % of the employed and 55 % of the unemployed smoke at the age of 45—54 a. These data can be inter-

preted as evidence of a positive health effect from employment rather than as selection.

Job security or job enjoyment tends to promote one's mental health and contributes to a stable family life. Many diseases or conditions, including but not limited to suicide or homicide, are known to be higher among the unemployed or the single than among the employed or the married (13). Despite the varying amounts of job stress experienced among the employed, the unemployed tend to suffer far more stress. Last, while illnesses and poverty run in vicious cycles, health and employment potentiate each other.

Methodological characteristics of the standardized mortality ratio

The relationships of SMR with a number of factors have been discussed elsewhere (1, 2, 4, 11, 32, & "A review of methodological issues of SMR in occupational epidemiology" by Wen & Tsai, submitted for publication). These factors are relative risk, life expectancy, length of observation, study design, study analysis, and comparisons of SMRs. These factors have significant implications regarding the healthy worker effect.

The healthy worker effect is exaggerated by the way the SMR is calculated. For example, a retrospective cohort study at the beginning of a study includes a cohort of active workers but excludes retirees. The result is the active worker effect. SMRs for the younger cohort are much lower than those for the older cohort, which would contribute substantially to the number of observed deaths and, therefore, to the age-adjusted SMR.

With respect to analysis, the published mortality rates, and the computer program used to calculate the SMR, are based on 5-a groupings by age (18). Although mortality rates increase rapidly with age, those who leave the study before the completion of the 5-a interval are assigned a fraction of the expected rates as if they had fully experienced the 5-a risk. Consequently, the expected value will be overestimated for the older ages, and the overall SMR underestimated.

With respect to the underascertainment

of deaths, a more complete follow-up of deaths would yield a higher SMR (28), particularly if those lost to the follow-up have higher mortality rates than those observed. The underascertainment of deaths would create lower than actual SMRs and would be dismissed as the "healthy worker effect." Shindell et al (28) questioned the existence of the healthy worker effect and considered it as an artifact of underascertainment. However, with a better means of death ascertainment, and after 25—30 a of follow-up, Shindell's study still yielded an overall SMR of less than one, 0.92 (28). This SMR is not much different from those reported by others with more conventional means of follow-up.

Increases of SMR with a longer follow-up are, in part, the result of SMR characteristics. The reasons for such increases in SMR include:

(a) The lack of comparability of SMRs: SMR calculations are based on indirect standardization and are internally standardized with weights derived from age distributions of each study group. If the age distribution of the two groups is grossly dissimilar, the two groups should not be compared directly.

(b) A compensatory increase in SMR: If the study cohort has a life expectancy similar to that of the general population cohort, the low SMRs at the early stage of observation will increase in later years.

(c) Diminishing number of active workers: With an increasing observation period, a proportionate decrease in the number of active workers and a concomitant increase in the number of older workers will both contribute to an increase in the SMR.

The concept of latency for cancer may need revision in light of the characteristics of the SMR. After a long follow-up of 20 or 30 a, increased SMRs for certain cancers have been interpreted as evidence for latency. (Latency is defined as the time lapse from the time of exposure until disease or death.) However, such a conclusion should be reached with caution due to the lack of direct comparability of SMRs and

the lack of knowledge on the proportionate increase of cause-specific SMRs.

Recommendation: The need for more summary statistics

At least three parameters are needed to summarize the mortality experience of an employed population: (i) relative risk, (ii) attributable risks, and (iii) life expectancy — or the expected age at death.

In most epidemiologic studies, summary statistics are limited to the SMR or relative risk. Although relative risk is traditionally the most interesting and it has an important virtue, it can be misleading in some instances if not accompanied by other parameters. Confidence intervals are needed for an assessment of the statistical significance of relative risk. A relative risk of five can be very alarming for a disease with a mortality rate of 10 per 1,000, but it is much less significant if the same relative risk is found for a disease with a mortality rate of 10 per million. The corresponding attributable risk for a population of 100,000 in this example is 4,000 excess deaths for the former and four deaths for the latter. If all of these excesses occurred in a period of 40 a, the attributable risk is 100 deaths and 0.1 deaths per year, respectively. Thus, the same relative risk could have entirely different public health connotations.

Life expectancy is important at the personal level because, to the individual, the age of death is as important as the cause of death (16). For example, one may prefer to die at age 95 with cancer or any cause than to die at age 40 from heart disease. As life expectancy increases, competing risk makes the mortality pattern different. Again relative risk addresses the particular cause of death but not the time of death.

The SMR has been mainly used to reflect relative risk and, as previously mentioned, the two can be equivalent to each other in special circumstances. SMR can also be used to reflect attributable risk by the following formula: number of attributable deaths = $(1 - \text{SMR}) \times \text{mortality rate} \times \text{population at risk}$. It is useful to calculate the study cohort life expectancy

and compare it to a population cohort life expectancy. While life expectancy has been shown to be related to SMR under certain assumptions, it is helpful to express the total "loss in years" as the result of the increased relative risk.

To complete the summary statistic, one would also be interested in the converse of relative risk, attributable risk and loss in years, ie, (i) relative benefit, (ii) attributable benefit, and (iii) gain in years. Theoretically, if the relative risk of a certain cause is significantly less than one, which could easily be found, a similar calculation can be made to describe the overall favorable impact of employment.

Caution is needed before the healthy worker effect can be considered in an evaluation of the overall SMR, which has limitations, as discussed. Since not all of the effect is due to selection, it should not be dismissed outright without its intensity, the proportion of active workers, the calculation method, data completeness, length of follow-up, life expectancy, and attributable risk or benefits being considered. Most of the changes in life that accompany employment are not merely the result of survival selection but are important changes induced by the acceptance of employment. The intensity and duration of the healthy worker effect should be examined, and certain portions should be credited to work benefit in contrast to work hazard.

As much can be learned from the favorable experience of a study population as from an unfavorable experience. To ignore such information is to make use of only one-half of the data collected. The researcher should give the reader a more complete picture by using more summary statistics, especially when lay readers or consumers are apt to be involved.

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