

of the introduction of lightweight headsets in the Japanese epidemic may have been due to a placebo effect, since these headsets were already in use in Australia before this epidemic, and suggests caution before any interventions are accepted as preventive.

One particular intervention that warrants further discussion is education. Education about the symptoms of "RSI" in 1984 was quite specific in the description of the stages of "RSI" according to the findings of Browne et al.⁴ However, during 1985, the emphasis changed to discussion, mainly of the workstation, and less attention was given to symptoms, because a view developed that such education was counterproductive and tended to educate staff members into prolonged sick roles as the stages of "RSI" implied an inevitable progression of the condition.²¹ However, the Worksafe Australia education manual continues to teach the stages of "RSI".²²

Further aspects of the epidemic are discussed elsewhere.²³

Conclusions

The contribution of ergonomics to "RSI", at least to type-I "RSI", has been overstated within this industry. There is little evidence of a consistent dose-response relationship of "RSI" in occupational groupings to keystroke rate, age and job duration, and other authors have questioned the importance of posture. The lack of a relationship to the keystroke rate supports the view that "repetition strain injury" is a misnomer, at least for type-II "RSI", and that the terminology should be reviewed. The condition is not related uniquely to new technology, as is shown by its occurrence with old equipment, and by the large epidemic in Japanese telephonists with a previous system, as well as in other occupations.

Future studies should examine the operator and the workstation jointly, and should also include a control group. Various aspects of susceptibility factors in operators should be sought and evaluated critically, and more attention given to factors in job design which

may cause stress. It is desirable that a review of its educational package²² on "RSI" be undertaken to provide lines for the treatment of "RSI".

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PLAINTIFF'S
EXHIBIT

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Current mortality in the Australian petroleum industry: the healthy-worker effect and the influence of life-style factors

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ABSTRACT A surveillance system, to monitor mortality and cancer morbidity on a continuing basis, has been established in the Australian petroleum industry. A baseline survey of 11 573 employees, by personal interview, was carried out in 1981-1983. By the end of June 1986, 33 712 person-years of observation in men had accrued, with 109 deaths. Standardized mortality ratios, with the Australian national death rates as reference, indicate that in terms of mortality from all causes and in mortality from the more common diseases, the death rates in this population are substantially lower than in the national population. Standardization was also carried out in the case of employed men, with data from contributors to the Commonwealth superannuation fund as reference, in order to provide a more appropriate contrast. The risks of tobacco smoking are demonstrated, as is the probable protective effect of mild-to-moderate alcohol consumption. The advantages to the occupational physician in being able to describe current mortality patterns, and in being able to delineate "at-risk" groups are discussed, particularly in the context of health promotion and other interventions. (*Med J Aust* 1987; 147: 222-225)

Practical expressions of interest in the health of a workforce involve the development of programmes which will not only meet employee and community concerns, but will also provide a data base that is capable of answering health queries. In addition, there exists a need to meet the potential demands of regulatory agencies by the establishment of systems which have been tailored to the needs of the particular industry.

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A national surveillance system was established by the Australian petroleum industry in 1980, to monitor mortality and cancer morbidity in all persons who were working in Australian refineries and marketing terminals. Known as "Health Watch", this system is a prospective epidemiological study, with the capacity to test specific hypotheses that concern the possible health consequences of occupationally-determined exposures to hydrocarbon and other chemical substances.

The present report is intended to demonstrate how the application of epidemiological methods in an occupational health setting allows not only the description of current mortality patterns in an industry, but also an assessment of the healthy-worker effect and the contribution of life-style factors to mortality within that industry;

Methods

The methods of the programme, and the results of the baseline survey, have been described fully elsewhere.¹ In general, the target population of this programme consists of all employees of the petroleum industry in Australia, who are working on sites other than head offices, with at least 10 employees; analyses are carried out on data that cover employees who have completed at least five years' continuous employment. Employees of some smaller companies, that are mainly involved in exploration, are excluded from the programme. The study base is updated periodically in that new employees enter at five-yearly resurveys. Employees who resign or retire, remain in the programme, and remain under observation by way of annual mail contact, death-register searches and annual matching with population-based cancer registries.

Data that relate to probable confounding variables such as cigarette smoking are essential, and must be both reliable and acquired in a standard manner, a requirement which may not be met in medical records that are

collected primarily for clinical purposes. For this reason, and because a precise and personally-verified job description was deemed necessary (with the use of the classification system that was developed for the American Petroleum Institute³), a baseline survey by personal interview was carried out in 1981-1983. Eleven thousand, five hundred and seventy-three such interviews were carried out, which represents a response rate of 92% of the defined population. In order to update information, and to incorporate new employees, this survey has been repeated in 1986-1987.

Notifications of deaths among current workers are supplied by the employer; in the case of those who retire or resign, annual mail contact is maintained. Every five years, a list of those with whom contact has been lost is supplied to all Australian state government statisticians, and death records are searched for the appropriate years. Currently, 20% of those in the study population have left the industry and, of these, 4% have been lost to mail contact. Each state of Australia now runs a population-based cancer incidence registry and, annually, the files of the study population are matched against those of the registries, thus producing reliable cancer incidence data.

The death rates, both due to all causes and cause-specific, that occurred in the male study population were standardized for age against the Australian national statistics of the appropriate calendar years. In addition, the all-cause death rates of the employed population, as distinct from those who had left the industry due to retirement or resignation, were also standardized in this manner.

In order to examine the possible contributions of the well-known "healthy-worker effect" to the results, a comparative population was found in the 217 000 male Commonwealth Government employees who are contributors to the Commonwealth superannuation fund. Death rates in this population are reported by the Commissioner for Superannuation,⁴ and these reports were supplemented by special tabulations which were supplied by the Commissioner. Deaths by cause are not available, nor is there any information on deaths that occurred after retirement in those men who had chosen to retire with a lump sum. As a consequence, all retirees have been excluded, and the data that are presented here relate only to deaths which occurred in current contributors — a comparable situation to the deaths among employed petroleum workers.

Statistical inferences on standardized mortality ratios were carried out by means of a Poisson model,⁵ and internal comparisons were made with the person-years method, with essentially a proportional hazards model.⁶ Calculations were carried out with GLIM.⁶

Results

Mortality

By the end of June 1986, the male study population had contributed 33 712 person-years at risk, and 109 deaths had occurred. Table 1 shows the numbers of deaths that were observed both for all causes and for specific causes. The death rates have been standardized for age against the Australian national vital statistics; over all, and for each of the specific causes, the standardized mortality ratio is substantially below 100.

"Healthy-worker effect"

Eighty per cent of the study population's person-years have accrued during employment and, as a consequence, the most likely explanation of the low standardized mortality ratio (SMR) is to be found in the "healthy-worker effect". All employed groups contain only those individuals who are able to carry out productive work, and this is ensured by selective entry to, and retirement from, the workforce on health and other grounds. This selection process ensures that in a comparison with the general population, any workforce will appear "healthier". Employment in the petroleum industry demands both responsibility and maturity, which may explain the lower than expected death rate from accidents, which are related largely to road trauma.

Adjustment for the "healthy-worker effect" requires that the reference population be subject to similar selection pressures as is the study population, in other words, employed. Australian Government employees, who are contributors to the Commonwealth superannuation scheme, provide such a comparative population, and all-cause death rates are available³ in those who die in service. When the death rates of the employed study population were standardized for age against the appropriate national death rates, the resultant SMR was 51 (95% confidence interval [CI], 39-65). When the Government employees' data were used as standard, the SMR rose

TABLE 1: Standardized mortality ratios (SMRs) by cause, Australian national population as standard

Underlying cause	ICD-9*	No. of deaths		SMR	95% Confidence interval
		Observed	Expected		
Ischaemic heart disease	410-414	36	53.19	68	46-92
Cancer	140-239	44	48.97	90	65-121
Stroke	430-438	3	9.18	33	7-96
Respiratory disease	460-519	0	8.31	0	0-44
Accidents, poisoning, violence	800-999	11	24.77	44	22-79
Other		15	29.44	51	29-04
All causes		109	173.86	63	51-76

*International Classification of Diseases (ninth revision) coding.

Test of constant cause-specific SMR $\chi^2 = 19.46$ (cf χ^2 ; $P < 0.002$).

TABLE 2: Relative all-cause mortality rates (RMRs) by smoking category, adjusted for age

Smoking category	No. of deaths	RMR	95% Confidence interval
Never	24	1.0	Baseline
Current, cigarettes only, 1-19 per day	8	1.45	0.65-3.24
Current, cigarettes only, 20-29 per day	26	2.09	1.20-3.65
Current, cigarettes only, 30 and over per day	16	2.10	1.12-3.96
Cigar, pipe, or mixed with cigarette smoking	7	1.43	0.62-3.32
Ex-smoker, ceased over 5 years before survey	17	0.93	0.50-1.74
Ex-smoker, ceased 5 years or less before survey	11	1.59	0.78-3.24

to 84 (95% CI, 65-107). This SMR is still lower than the "expected" 100, although not markedly so; the difference may well reflect the added requirement for the study population to be able to work actively in a manufacturing industry.

Tobacco smoking

Table 2 shows all-cause mortality by smoking status at the initial survey, relative to the "never-smoked" group as base. There is a stepwise increase in the relative mortality rate (RMR) within the current cigarette-smoking group, with the latter rising to 2.10 (95% CI, 1.12-3.96) in the heaviest smoking category. A statistical test for trend among the current cigarette smokers is significant ($\chi^2 = 8.12$; cf χ^2 ; $P < 0.01$). Those subjects who smoke a pipe and/or cigars only, or also smoke cigarettes, have an RMR that is approximately equal to that of those who smoke one to 19 cigarettes a day. Ex-smokers who ceased smoking fewer than five years before the survey, have an RMR that is marginally higher than the lowest category of current smokers, doubtless because this group contains persons who have ceased smoking for health reasons that are related to the habit. Those ex-smokers who had ceased smoking more than five years before

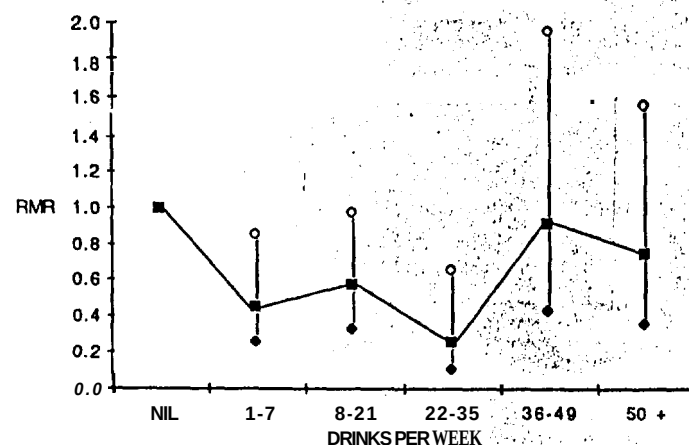


FIGURE: Relative all-cause mortality rate (RMR; age and smoking adjusted) by average drinks per week, nondrinkers as base.

the survey, did not have a discernibly different risk from those who had never smoked.

Alcohol consumption

At the baseline survey, each respondent was asked: "In an average week, on how many days would you have a drink?", and "How many drinks would you usually have on those days?". A drink was defined as a standard measure as served in a hotel or bar. From this information a characteristic of average drinks per week was derived and, in the Figure, the relationship of this measure to subsequent all-cause mortality, relative to non-drinkers and adjusted for smoking habit, is shown. As would have been expected, the relationship is less clear-cut than with smoking, but a non-linear relationship appears to be present with a protective effect for mild-to-moderate drinking.

A statistical test for a quadratic (U-shaped) effect (after adjustment for a linear effect) was carried out, giving $\chi^2 = 7.5$ (cf χ^2 ; $P < 0.01$). The variation in relative mortality rate that remained, once the quadratic model was fitted, was not significant ($\chi^2 = 6.5$; cf χ^2 ; $P = 0.09$).

Discussion

Numerous retrospective cohort studies of mortality experience in the petroleum industry have been reported.⁷ Difficulties in the design of such studies are that data are rarely available on other than basic demographic and job descriptions, and that suitable control populations are quite difficult to assemble for past historic experiences. Against this is the fact that, in the prospective design, it takes years to accumulate a reasonable amount of data and, in the present study, after five years only 109 male deaths are available for analysis. Nevertheless, we believe that the advantages of concurrent data collection are sufficient to warrant an examination of some aspects at this stage.

The "healthy-worker effect", a term that was coined by McMichael et al.,⁹ has a long history; its recognition extends at least as far back as Ramazzini.¹⁰ Even though Miettinen describes comparisons of occupational cohorts with national populations as "a monument to habitual malpractice in the formation of contrasts",¹¹ the fact remains that seeking an appropriate control population in occupational studies is not easy. Comparisons, as presented here, of SMRs that are computed on national rates and SMRs that are computed on contemporary employed populations are helpful in the assessment of the degree of such an effect.

Few, if any, direct comparisons between currently employed populations are available, even though the literature to compare the mortality of such a population with a national population is becoming extensive. In one of the largest of such comparisons on a population of US veterans, Sterling and Weinkam estimated the difference in terms of all-cause mortality to be 27%.¹² In a nationally-based Finnish study, Vinni and Hakama showed it to be 30%.¹³ This emphasizes the importance of the development of a referent population system for occupational studies in Australia. In the United States, such a development is being proposed currently by the National Cancer Institute,¹⁴ and, in Australia, the National Occupational Health and Safety Commission might well consider the problem.

Tobacco smoking is perhaps the most firmly established risk factor of all and, in spite of the fact that in the present population the prevalence of smoking has been shown to be falling steadily in successive birth cohorts,¹⁵ the over-all smoking prevalence of 32%, and our mortality data by smoking category, indicate a need for programmes of intervention. An interesting feature of the smoking-related mortality data is that the average risk to an ex-smoker of more than five years' duration, is no different from that run by a man who

has never smoked.

The apparent protective effect of mild-to-moderate alcohol drinking has been demonstrated previously for ischaemic heart disease¹⁶ and in relation to all-cause mortality.¹⁷ The non-linear relationship of the amount of alcohol that is consumed to the risk and its quadratic shape, as described here, is remarkably similar to that reported by Marmot et al. in a prospective study of British civil servants.¹⁸ Part of the relatively higher risk that is carried by non-drinkers is undoubtedly due to the fact that a proportion of them has given up alcohol for health reasons; another possible explanation is "misclassification bias", particularly if heavy drinkers call themselves non-drinkers. However, neither of these explanations would seem to account completely for the apparently protective effect of mild-to-moderate drinking in terms of all-cause mortality.

Behavioural and personal characteristics account for a major part of the mortality and morbidity of any population, industrial or otherwise.¹⁸ Programmes of health promotion that are delivered by occupational-health personnel have not only the potential of the health improvement of employees, but also that of cost-saving to the enterprise. Although the primary purpose of a study such as "Health Watch" may be directed towards monitoring occupational risks — and the primary interest of the funders may be to gain knowledge of the level of protection that needs to be built into operations — the demonstration of other large health effects is important. Acquisition of this knowledge by all parties in industry poses new questions and challenges. Clearly, everyone gains from the reduction of health risks,¹⁹ of whatever origin.

Within the petroleum industry, as in most large companies, a health service infrastructure exists; occupational physicians and nurses are employed, and communication and other mechanisms exist that link all members of the population. The possibilities for programmes of health promotion clearly exist and the ability to describe current mortality, and its associations, makes it more likely that such programmes would succeed.

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