It is obvious that industrial risks vary considerably in the type and severity of injuries or diseases associated with different occupations and in their average frequencies. It is equally obvious that no single numerical index can express the frequency of minor, major and fatal accidents, accidents causing partial or total disability, and illnesses that may involve periods off work, permanent incapacity, or premature death. To make valid comparisons between industries, any estimate of the harm in each should also include such unquantifiable factors as the worker's anxiety or that of his family about the type of injury or illness that is liable to occur or to recur after treatment.

ACCIDENTAL DEATH RATE
The frequency of accidental death attributable to the occupation, reckoned as the number of such deaths per year per million employed and at risk is, however, a simple, limited but easily measurable and important index by which different industries can be compared. Such an index is valuable in showing in a quantitative way the relative hazard of different major industries and the level of risk that separates those normally regarded as 'safe' from those of recognised hazard.

Since 1959, H.M. Chief Inspector of Factories, and now the Health and Safety Executive (1975), have published annually the number of accidental deaths in various occupations, and the corresponding numbers of workers at risk. From the ratio of these values (Table 1) it is immediately obvious that the accidental death rate attributable to the occupation may differ considerably in different industries, although remaining relatively constant and characteristic of any one industry.

The large differences between such rates is indicated (Table 2) by the average values for the period 1959-75 in those industries reported regularly by the Chief Inspector of Factories. About half of these have average values between 23 and 34 deaths per million per year (D/M/Y), although the values range down to 3.5 for the manufacture of clothing and footwear, and up to 154 for shipbuilding.

A similar wide range was shown in fatal occupational accident rates in 'fuel industries' as reported by the Secretary of State for Energy (Central Office of Information, 1977). For the period 1967-76, during which data were available in
Table 1. UK fatal occupational accident rates per million employed per year (Deaths per million per year – D/M/Y). (means ± S.E.)

| Years     | Metal goods | Textiles | Clothing and footwear |
|-----------|-------------|----------|-----------------------|
| 1959-60   | 149 ± 12    | 22 ± 4   | 1.0                   |
| 1961-62   | 156 ± 12    | 28 ± 5   | 6.0                   |
| 1963-64   | 112 ± 10    | 28 ± 5   | 2.1                   |
| 1965-66   | 136 ± 11    | 23 ± 4   | 4.2                   |
| 1967-68   | 130 ± 11    | 20 ± 4   | 4.5                   |
| 1969-70   | 135 ± 12    | 20 ± 4   | 0.0                   |
| 1971-72   | 128 ± 13    | 26 ± 5   | 1.2                   |
| 1973-74   | 167 ± 15    | 30 ± 6   | 6.4                   |
| 1975      | 100 ± 16    | 17 ± 6   | 9.2                   |
| Mean      | 137         | 24       | 3.5                   |

Table 2. UK fatal occupational accident rates. Mean of rates, 1959-75

| Industry                                         | D/M/Y |
|--------------------------------------------------|-------|
| Shipbuilding and marine engineering              | 154   |
| Metal manufacture                                 | 137   |
| Chemical and allied industries                    | 87    |
| Bricks, pottery, glass, cement, etc.              | 80    |
| Timber furniture, etc.                           | 58    |
| Leather, leather goods and fur                   | 34    |
| Food, drink and tobacco                          | 33    |
| Metal goods not elsewhere specified              | 30    |
| Paper, printing and publishing                   | 26    |
| Vehicles                                         | 25    |
| Textiles                                         | 24    |
| Engineering and electrical goods                 | 23    |
| Clothing and footwear                            | 3.5   |

In some occupations, substantially higher rates occur. It was shown by Schilling (1971) that the fatality rate from accidents at sea in deep sea fishing had varied from year to year between 1959 and 1968, with an average rate of 2,800 D/M/Y, which would reach about 3,000 D/M/Y if deaths ashore were included also. The
recent statement from the Department of Energy (Central Office of Information, 1977) quotes a similar rate (2,800 D/M/Y) for 1975.

For aircrews, the rates are likely to be considerably lower, depending upon the hours flown per year, since the present mean level of risk, at least for passengers, is now only about one per million flying hours (Flight International, 1974, 1976).

In construction work as a whole in the UK, the risk has been in the region of 200 D/M/Y for a number of years, averaging 188 from 1971 to 1975 (Health and Safety Executive, 1975). In some types and conditions of construction work, however, it is likely to be considerably higher; for example, in construction of major dams. Thus, it was said of the Nile High Dam that over 100 deaths had occurred in a workforce of 35,000 (Sunday Times, 1965); and of the Cabora Bassa Dam in Mozambique that 50 deaths had occurred in 5 years among 3,000 workers (The Times, 1974); both statements suggest a rate in the region of 3,000 D/M/Y.

Rates in different groups of occupations in the USA are published annually in

Table 4. US fatal occupational accident rates D/M/Y

| Industry               | 1955 | 1958 | 1961 | 1964 | 1968 | 1971 | 1975 | Mean  |
|------------------------|------|------|------|------|------|------|------|-------|
| Trade                  | 120  | 90   | 90   | 80   | 70   | 70   | 60   | 83    |
| Manufacturing          | 120  | 120  | 110  | 100  | 90   | 100  | 80   | 103   |
| Service and government | 150  | 140  | 130  | 130  | 125  | 125  | 115  | 131   |
| Transport and public utilities | 340  | 330  | 430  | 440  | 380  | 360  | 330  | 373   |
| Agriculture            | 550  | 570  | 600  | 670  | 650  | 670  | 580  | 613   |
| Construction           | 750  | 740  | 740  | 730  | 740  | 710  | 610  | 717   |
| Mining and quarrying   | 1,040| 960  | 1,080| 1,080| 1,170| 1,000| 630  | 994   |
| All (these) industries | 240  | 220  | 210  | 210  | 190  | 180  | 150  | 200   |
the survey *Accident Facts*, and show accidental death rates, as averaged between the years 1955 and 1975, of from 80 D/M/Y in ‘Trade’ to about 1,000 D/M/Y in mining and quarrying (Table 4), with a mean rate of 200 D/M/Y in the occupations reviewed. In the same way, data for French and German (FGR) workers show widely differing rates in different industries (Pochin, 1974), although the hazards of comparable industries in different countries tend to be broadly similar, or similar in relation to industrial hazards as a whole in these countries. For example, the fatality rate in chemical industries was 103 D/M/Y in Germany (FGR, 1970), 169 in France (1968-70) and 80 in the UK (1968-70), despite the likelihood of differences of registration or attribution in different countries.

**DECREASES IN ACCIDENTAL DEATH RATES**

The rates recorded for UK factories appear to be relatively constant from year to year (see Table 1), although on analysis the mean value for all these industries is found to be falling by about 0.5 per cent per year. Within this group, however, the risk in shipbuilding has been falling rather faster — by 1.9 ± 0.8 per cent a year; and that in chemical industries by 1.6 ± 1.0 per cent a year, if the disaster at Flixborough in 1974 is omitted from the analysis. The accidental death rate for face workers in coal mining in the UK has fallen by a factor of about 2.5 over the last 15 years, corresponding to an (exponential) decrease of about 6.5 per cent per year. For air crews, also, the decrease is likely to have been rapid — if the risks per flying hour are similar for passengers and crew — since the latter rate has been falling exponentially by 4.5 to 5 per cent a year for 25 years on scheduled air services, while the risk per mile has been falling by about 8 per cent a year (*Flight International*, 1974, 1976).

In US industries, the risk rates appear to be rather higher than in comparable UK industries but to have been falling faster (DHSS, 1969-70; US Department of Labor, 1974), the rates for individual groups of occupations falling by up to 3 per cent a year (Table 5; linear regressions of rate on time for the data recorded in

| Industry                          | Rate of change |
|-----------------------------------|----------------|
| Trade                             | $-3.1 \pm 0.6$ |
| Manufacturing                     | $-1.9 \pm 0.3$ |
| Service and government            | $-1.1 \pm 0.2$ |
| Transport and public utilities    | $-0.1 \pm 0.8$ |
| Agriculture                       | $+0.5 \pm 0.4$ |
| Construction                      | $-0.7 \pm 0.3$ |
| Mining and quarrying              | $-1.2 \pm 0.9$ |
| All (these) industries            | $-2.0 \pm 0.2$ |
Table 4). Similarly, in the steel industries of the European Communities during the period 1960-72 the accidental mortality rate fell by $3.3 \pm 0.9$ per cent a year, to 220 D/M/Y in 1972 (Eurostat Report, 1973).

**NON-FATAL ACCIDENTS**

Non-fatal as well as fatal accidents should be included in any measure of the total hazard of an industry, but it is difficult to do so in any quantitative way. Apart from the problem of comparing the 'importance' of, say, one fatal accident and a thousand non-fatal ones, it is hard to assess numerically the relative severity of accidents recorded, and the criteria for recording may vary in different industries.

However, a comparison can be made if records give the annual rate of fatal accidents and of those non-fatal accidents regarded as of a given severity; for example, involving more than a certain number of days off work. Thus, for the main groups of occupations listed in Accident Facts, the frequency of 'disabling' accidents can be compared with that of fatal accidents at work. It appears from these data that the frequency of such non-fatal accidents does not remain proportional to that of fatal accidents in industries of different levels of hazard, the former increasing more slowly than the latter as industrial hazard increases (International Commission on Radiological Protection, 1978). (Specifically, the frequency of disabling accidents, $A$, relates to that of fatal accidents, $D$, by the relationship $A = D^n$ where, for the 4 years examined, $n$ has had values of 0.49, 0.46, 0.45 and 0.49; and similar data have been obtained from other countries.)

This suggests that, as might be expected, the fatal accident rate has an increasing importance relative to non-fatal accidents in industries of greater total hazard, but does not assist in defining this relative hazard. Such a definition can be made if records are available on the total number of days off work that are attributable to non-fatal occupational accidents. For a given industry the total period (man-years) off work can be expressed per accidental death (Table 6). Periods of 10 to 100 years of full activity are lost for every fatal accident. It is again evident that, in industries of greater hazard as judged by fatal accident rates, the relative importance of non-fatal accidents decreases, with progressively shorter total periods of lost time from the latter, per fatal accident.

This comparison can be taken one step further. By the courtesy of the Chief Inspector of Factories it was possible to determine the age at death for all fatal occupational accidents in 1971 in the manufacturing occupations (as listed in Table 2) and in construction workers, the mean ages being 43.3 (±0.8 S.E.) years in the former and 40.9 (±1.0) years in the latter. These data correspond to an average loss of expectation of life of 28.6 and 30.2 years respectively (International Commission on Radiological Protection, 1978). It is apparent, therefore, that, even if equal weighting were given to a year's loss of activity through periods off work from non-fatal accidents and to a year's loss of life from a fatal accident, the
Table 6. Fatal and non-fatal accidents

| Activity             | Deaths | Deaths per million per year | Days lost due to non-fatal accidents (thousands) | Time lost (man years) from non-fatal accidents, per one fatal accident |
|----------------------|--------|-----------------------------|-------------------------------------------------|-----------------------------------------------------------------------|
| Laminois             | 170    | 202                         | 3,172                                           | 51                                                                    |
| Cokeries             | 12     | 257                         | 104                                             | 24                                                                    |
| Service auxiliaries  | 339    | 279                         | 2,937                                           | 24                                                                    |
| Acieries             | 189    | 558                         | 1,652                                           | 24                                                                    |
| Hauts-fourneaux      | 101    | 560                         | 628                                             | 17                                                                    |

*European Steel Industries (1960-72)*

| Activity             | Deaths | Days lost due to non-fatal accidents (thousands) | Time lost (man years) from non-fatal accidents, per one fatal accident |
|----------------------|--------|-------------------------------------------------|-----------------------------------------------------------------------|
| Trade                | 700    | 4,706                                           | 34                                                                    |
| Manufacturing        | 1,400  | 11,481                                          | 41                                                                    |
| Services             | 500    | 2,573                                           | 26                                                                    |
| Transportation       | 1,100  | 2,663                                           | 12                                                                    |
| Construction         | 1,500  | 2,640                                           | 9                                                                    |

*US Department of Labor (1974)*

| Activity             | 14 Factory occupations | Manufacturing metal, bricks; and shipbuilding | Construction |
|----------------------|-------------------------|-----------------------------------------------|---------------|
|                      | 166                     | 112                                           | 204           |
|                      | 32                      | 110                                           | 146           |
|                      |                         |                                               | 1,450         |
|                      |                         |                                               | 23            |

Time lost owing to industrial accidents in different occupations, and average time lost from all non-fatal accidents (in calendar years) per each accidental death in each occupation. 'Calendar years' are estimated according to whether 'days lost' are quoted as working days or calendar periods.

(Data reproduced from ICRP Publication 27 by permission of the International Commission on Radiological Protection.)

impact, using this very crude criterion, of fatal accidents is greater than that of non-fatal ones except in a few industries.

**OCCUPATIONAL DISEASES**

The contribution to the hazard of an industry from occupational disease varies very greatly, and for most industries is difficult to assess with any accuracy. It is often hard to establish the extent to which occupational factors were responsible for an illness, and even the extent to which an illness caused, or contributed to, disability or death. In some instances, the total harm from occupational diseases is clearly high, as in coal mining, while in others no such harm can be definitely
established or estimated. In uranium miners, excess death rates from bronchogenic carcinoma in the region of 1,500 per million a year have been observed (Lundin et al., 1971), which are attributable to radiation from radon and its daughter products inhaled during previous working life; in the early days of uranium mining these rates were estimated to have been about ten times as high.

Similarly, in some sections of industries in which exposure to carcinogenic chemicals is involved, high mortalities from induced cancers have been estimated, with rates of over 1,000, or, in some instances, even over 10,000 D/M/Y (Pochin, 1974).

It must be recognised that in industry carcinogenic risks tend to be detected only if they are high, and that other instances at lower risk may continue to be found (Higginson, 1977). It is to be hoped, however, that any substantial carcinogenic hazards may apply only to small sections of certain industries, and that high risks of this type may be detected and progressively eliminated. Certainly, across industry as a whole, the amount of disability from industrial accidents considerably exceeds that from recognised industrial disease. Thus, in the UK, industrial accidents were responsible for a much greater number of spells off work than were occupational diseases (DHSS, 1969-70), the former accounting for 95 per cent of all such spells which involved in-patient treatment, 95 per cent of spells with out-patient treatment of 25 days or more, and 98 per cent of those associated with 'lesser disabilities'. Again, the identification of diseases as being of industrial origin is likely to be less clear than for injuries. It seems probable, however, that in most occupations, although certainly not in all, an evaluation of the accidental hazards, and particularly of fatal accidents, gives some indication of the relative hazard of the industry.

COMPARISONS WITH OTHER SOURCES OF RISK

It is important to place the levels of occupational risk in perspective. While few of the fatal accident rates in manufacturing industries exceed 2 per cent of the average death rate from disease, some death rates in workers exposed to chemical carcinogens in the past are likely to have exceeded the entire mortality from natural causes in populations of corresponding age structure; the average death rate in people aged 20 to 65 is about 6,000 D/M/Y in males and 3,500 in females (Pochin, 1974).

For men aged 15 to 64, about 25 per cent of all fatal accidents occurred at work (Registrar General, 1971); for the whole UK population of all ages, the fatal accident rate from all causes was about 460 D/M/Y in 1972 (Registrar General, 1972), to which traffic and transport accidents contributed 150, accidents in the home 130, suicide 80, and accidents at work 20 D/M/Y (Safety and Health at Work, 1972) — many accidents in traffic or in the home occurring in the young or the elderly.
Attempts have been made to estimate the fatal accident rates in various forms of sport and other self-chosen activities (Clarke, 1966; Sowby, 1975; Pochin, 1975), the problem usually being that of estimating the number of participants at risk, or, on another basis, the number of hours spent in the activity and so the risk per unit time. More might usefully be done in this field to provide comparisons, not necessarily of acceptability, but at least of magnitude, of the risk involved in different procedures (Table 7).

Table 7. One in a million risk of death from each of the following.

| Activity                                      | Risk          |
|-----------------------------------------------|---------------|
| 400 miles by air                              | 1 in 1,000,000|
| 60 miles by car                               | 1 in 1,000,000|
| 3/4 of a cigarette                            | 1 in 1,000,000|
| 1 1/2 minutes of rock climbing                | 1 in 1,000,000|
| 1 1/2 weeks of typical factory work          | 1 in 1,000,000|
| 20 minutes being a man aged 60                | 1 in 1,000,000|

It is not obvious, in the occupational just as in the medical field, whether the maximum available effort should be put into reducing the highest risks or those that could most readily be reduced; it is obvious that all such risks should be reduced by as much as is practicable, and this process can only be based on knowledge of the nature of the risks, their various causes in different industries and their absolute and relative numerical magnitudes.

This article is based on a paper read at the symposium on Assessment of Health Risks at Work held in the Royal College of Physicians in November 1977.

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SYPHILIS 1866. A DYING DISEASE

The ‘Fellows Members and Licentiates of the Royal College of Physicians, Surgeons and general practitioners of medicine and surgery residing in Nottingham and neighbourhood’ made a protest in 1866 against the Contagious Diseases Act that sought to license prostitutes, enforce their regular medical examination and imprison them if infected. The memorialists quite rightly considered such proposals to be barbarous and monstrous. They stated that syphilis was getting milder, less frequent and more amenable to treatment with each decade and that gonorrhoea, a ‘comparatively unimportant local and non-constitutional affection’ was becoming more rare. Therefore the new law would be valueless, especially as ‘we have endured the horrors of Syphilis in its worst form for centuries without legislation’. They also protested ‘against the secret legislation which has marked the progress of this Bill in all its phases’ and deplored ‘the extension of the Act to several towns, in no sense garrison towns’. Perhaps they were wise to distinguish between the civilian population and the licentious soldiery, although they did consider that a promise of freedom from infection would increase the ‘urge to fornicate’.

A French authority had quoted with satisfaction the figure of 8.69 days of sickness from venereal disease for each British soldier serving at home in 1860, compared to 3.9 days for the French soldier. The French regarded the high incidence of venereal disease as a proof of the ‘insufficiency or complete absence of medical police’. Something to think about in the days of permissiveness and penicillin.