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Mortality and cancer incidence among Swedish dock workers — A retrospective cohort study

by Lennart Gustafsson, PhD,[1] Stig Wall, PhD,[2] Lars-Gunnar Larsson, MD,[3] Barbro Skog[4]

GUSTAFSSON L, WALL S, LARSSON L-G, SKOG B. Mortality and cancer incidence among Swedish dock workers — A retrospective cohort study. *Scand J Work Environ Health* 12 (1986) 22—26. The study originates from the arousal of suspicions that, in connection with loading and unloading work involving the use of trucks, exposure to diesel exhaust fumes may be carcinogenic. This report describes a register study in which a broad mapping of the cause-of-death pattern and cancer morbidity has been carried out through the matching of locally compiled personal data with those from a central register, the Cause-of-Death Register, and the Cancer Register. The results obtained thus far show a low total mortality — irrespective of cause of death — but a tendency towards an excess risk for cancer morbidity, mainly due to lung cancer.

Key terms: mortality pattern, register study.

Is there any deviating cause-of-death pattern or any excess morbidity from cancer that may be attributed to specific cancer diagnoses among dock workers in Swedish ports? Since 1979 this issue has been studied in a collaborative project by the Department of Social Medicine and the Centre of Oncology at the Umeå University, the National Swedish Board of Occupational Safety and Health, and concerned trade unions representing both employers and employees.

The study originates from the arousal of suspicions among, for example, the workers' trade unions, that exposure to diesel exhaust fumes, in connection with loading and unloading work by truck, may be carcinogenic, and also, less specifically, that such exposure may cause "problems" in the forms of headaches, respiratory difficulties, tiredness, or loss of memory. One reason for these suspicions was the fact that a number of workers occupied with loading and unloading so-called roro-ships had contracted lung cancer.

Among other things, diesel exhaust contains nitric oxide, carbon monoxide, sulfur oxide, and hydrocarbons. The presence of polyaromatic hydrocarbons has prompted the question of an increased cancer risk related to exposure to diesel fumes. The presence of carbon monoxide also makes the question of an increased risk for circulatory diseases worthy of attention. In an experimental study, Löfroth (6) pointed out that diesel exhaust can have mutagenic characteristics, and he presented results from several experimental studies that indicated carcinogenic effects in laboratory animals exposed to diesel fumes. Nordenson et al (7) studied chromosome aberrations in lymphocytes from 14 miners exposed to diesel exhaust in their work. No increase in the frequency of chromosome aberrations was reported in a comparison with a reference group of office workers. On the other hand, the frequency of chromosome aberrations was associated with smoking. In a pilot study of 129 persons employed by a bus company in Sweden, Edling et al (3) observed that the suspicion of a connection between an increased mortality from circulatory diseases and exposure to diesel exhaust and carbon monoxide has been strengthened.

A general excess mortality from cancer among locomotive engineers in Finland has been noted in an epidemiologic study by Heino et al (4), and Luepher & Smith (5) reported an increased mortality from lung cancer among truck drivers exposed to diesel exhaust. As the number of cancer cases was low in both these investigations, it is difficult to draw any causal conclusions from the results. In a review article Schenker (8), too, observed that epidemiologic studies are few and that results are contradictory. The experimental results strongly indicated a relationship, but further epidemiologic data are required to illuminate the connection between occupational exposure to diesel exhaust and cancer. On the basis of the Swedish Cancer Environment Register, Ahlbom (1) pointed out a significant increase in lung cancer incidence among drivers in comparison with a reference group of wage-earners not exposed to petroleum products or other chemicals in their work. This excess morbidity was somewhat greater for men living in Stockholm, a fact which may be explained by the differences in smoking habits between the groups. However, a survey of the smoking habits among 470 professional drivers carried out by the Health and Safety Services of the Transport Trade in Stockholm indicated that the increase in lung cancer incidence was not attributable only to smoking. In a case-referent study of lung cancer in men in north-

[1] Department of Statistics, Umeå University, Umeå, Sweden.
[2] Health Services Research Unit, Swedish Medical Research Council and Umeå University, Umeå, Sweden.
[3] Centre of Oncology, Umeå University, Umeå, Sweden.
[4] Department of Social Medicine, Umeå University, Umeå, Sweden.

Reprint requests to: Dr S Wall, Department of Social Medicine, University of Umeå, S-901 87 Umeå, Sweden.

ern Sweden (2), there turned out to be a certain overrepresentation of professional drivers among the cases, which can be explained, however, by the fact that there were more smokers and a larger tobacco consumption among the drivers. Even so, a very high relative risk was observed among older drivers who smoked, a finding which may point to a synergistic effect between long-standing occupational exposure and smoking.

Previous studies have been unable to isolate the exposure to diesel exhaust from other, often interacting, factors. At an early stage it was obvious that this study too would not be able to do so directly. Thus the project was divided into two stages. This report deals with the first stage, a register study, in which a broad mapping of the cause-of-death pattern and cancer morbidity among Swedish dock workers has been carried out. The study has been made possible by the matching of locally-compiled personal data with those of central registers, the Cause-of-Death Register, and the Cancer Register. A case-referent study of lung cancer within the cohort is currently under way.

Materials and methods

The study of registers was designed to include the total number of permanently employed dockers in the country, first employed before 1974 and for a continuous period of at least six months. Hence this investigation is a so-called retrospective cohort study.

Local working groups have been responsible for the extensive collecting of necessary personal and employment data from the employers and trade unions. The local working groups have normally consisted of one representative from the employer's side and one or two representatives from the trade unions representing the dockers of the port in question. Some 45 such groups have been active. Besides written instructions, the local groups were given verbal information and training about the aim and the organization of the investigation and about their own role.

The information on specific individuals used in the forthcoming analyses comprises personal identification numbers (for matching with central registers and for age determination) and data about employment and the geographic location of the port (in order to make the regional risk corrections necessary in a study of this kind). These data have been obtained, exclusively, from existing company and trade union registers.

It would, of course, have been desirable if information on diesel exhaust exposure could be analyzed in detail, latency and time of exposure being taken into account. It has not been possible to extract such information for the entire cohort, and the quality of this information varies. Thus it has not been possible to separate truck driving from other work with any high reliability. We have therefore chosen to abstain from using individual exposure data in the register study.

The data based on individuals have been supplemented with annual compilations concerning the activity in the port — tonnage, types of goods, and the number of machines in use and their consumption of diesel oil. From these data it emerges, for example, that diesel-powered trucks were first used in Swedish ports in the late 1950s and that their numbers increased rapidly in the early 1960s. Thus manual work was highly mechanized within a decade. In the analysis of both mortality and cancer morbidity it was therefore warranted that the population at risk be confined to dock workers employed in the beginning of 1961 or later. The cohort has thus been restricted to a total of 6 071 workers. These individuals have been followed from either 1 January 1961 or from the first date of employment (if this date occurred later) until 1 January 1981, their date of death, or until their possible emigration. Altogether, this follow-up has resulted in a total of 97 076 person-years for the mortality study.

In a corresponding manner 6 063 workers alive on 1 January 1961 and cancer-free at that time have been followed for cancer morbidity until either the closing date 1 January 1980, the time of the first cancer diagnosis, or a possible death date. This follow-up has resulted in a total of 91 055 person-years for cancer.

After the personal data reached the project group, extensive monitoring and follow-up work has been carried out. Persons without identity numbers or with faulty or incomplete ones have been traced by a search of the parish office, county council, and central population registers. The nonresponse of named individuals was about 0.5 %.

In a determination of whether mortality and cancer morbidity have differed among dockers, regarding both extent and pattern, comparisons were made with the country as a whole, with the counties where the ports are situated, and with the respective communes for the large ports — Stockholm, Göteborg, and Malmö. For certain diagnoses, eg, lung cancer, the analyses have taken into consideration the fact that risks differ between densely and sparsely populated areas within a county.

Age-specific and calendar-time-specific rates from the population of the county and the metropolitan boroughs, respectively, have been used in order to estimate the expected number of cases in the regional subgroup of dockers. The ratio between the number of cases that actually occurred in the cohort and the expected number of cases estimated on the basis of regional data (but having the age and calendar structure of the cohort) thus constitutes an SMR (standardized morbidity or mortality ratio) index.

Results

Population at risk

The 6 071 dock workers of the study population were located in 17 counties. In the counties of Göteborg and Bohus, the port of Göteborg accounts for about 36 %,

about 20 % have worked in ports of the counties of Stockholm and Malmöhus, while about 25 % can be found in the county of Gävleborg or further north.

During the period 1961—1981 the number of permanently employed dockers fluctuated between 2 000 and 4 000, attaining its peak around the beginning of the 1960s. No less than 20 % of those included in the population at risk had a total length of service of 30 years or more, but about 10 % had fewer than five years of employment. Within the stevedore companies the average number of employment years was about 20.

Before 1 January 1981, 1 062 of the dockers in the population at risk had died, while the number of persons with a cancer diagnosis for the period up to 1 January 1980 was 452. Table 1 shows that most deaths and cancer diagnoses were registered during the last decade. Hence there were 5 009 dock workers of the population at risk still alive at the beginning of 1981.

A distribution of principal diagnoses shows that 28 % of the deaths were caused by cancer, 45 % by diseases at the circulatory organs, an 13 % by violent causes, including suicides. As cancer was of special interest in the study of registers, a breakdown of cancer deaths, as well as of cancer incident cases, has been made according to site of disease (table 2).

Table 1. Distribution of death and cancer diagnosis for the study population from 1961 to 1980.

Year	Decedents		Diagnosed cases of cancer	
	Number	Cumulative percentage	Number	Cumulative percentage
1961—1965	53	5	47	10
1966—1970	207	25	89	47
1971—1975	343	57	155	64
1976—1980	459	100	161	100
Total	1 062	100	452	100

External comparisons of causes of death and cancer incidence

In terms of standardized mortality ratios the dock workers' total mortality was lowered by 11 %. This disparity was expected and probably reflects the fact that, as a rule, a gainfully employed group is healthier than the overall population. Such a strong effect as in this case is most likely a consequence of the further selection that takes place before a dock worker becomes permanently employed ("healthy worker effect"). There was no corresponding effect for cancer incidence, irrespective of diagnosis.

Table 2 summarizes some of the comparisons that refer to mortality and cancer incidence made between the cohort of dockers and the male population. For this table, comparison data were obtained for the periods 1961—1965, 1966—1970, 1971—1975, and 1976—1980. Standardizations of age and regions were carried out in the calculations of the standardized mortality ratios.

From table 2 it appears that the low mortality in the dockers' cohort can be attributed to diseases of the circulatory organs, and to "other causes of death," being 20—25 % lower than could be expected for the country as a whole. On the other hand, cancer mortality was on par with that of the whole country, while there was a suggestion of excess mortality from violent causes, including suicide. This excess mortality, as well as the low mortality for diseases of the circulatory organs and for "other causes of death," was statistically significant ($p < 0.05$).

With regard to the various types of cancer, there emerged an excess mortality from cancer of the respiratory organs. Thus, the 70 cases of lung cancer corresponded to an expected number of 53 (table 2). The distribution of histological types did not differ from that of the cancer register. No mesotheliomas were found. Although statistically significant, the excess

Table 2. Standardized mortality and cancer morbidity ratios for dock workers. A comparison with the Swedish male population in 1961—1980.

Diagnostic category	Mortality				Cancer morbidity			
	Observed	Expected	Standardized mortality ratio	95 % confidence limits	Observed	Expected	Standardized morbidity ratio	95 % confidence limits
All cancers	292	282.6	103	93—114	452	410.1	110*	101—120
Circulatory diseases	482	604.9	80*	73— 87	.	.	.	.
Violent death/suicide	137	111.1	123*	104—145	.	.	.	.
Other causes	151	191.9	79*	68— 92	.	.	.	.
Digestive cancer	104	106.5	98	83—115	127	120.0	106	89—127
Respiratory cancer	71	55.1	129*	102—163	89	58.3	153*	124—188
Urogenital cancer	61	55.5	110	85—142	119	122.5	97	80—117
Leukemias	20	28.1	71	46—110	31	36.0	86	60—123
Other cancers	36	37.4	96	68—136	86	73.3	117	95—144
Stomach cancer	42	34.1	123	91—166	43	35.2	122	91—164
Lung cancer	70	52.9	132*	105—166	86	51.3	168*	136—207
All causes	1 062	1 190.5	89*	84— 94	.	.	.	.

* Statistically significant from 100.

lung cancer mortality must be interpreted with great caution against the background of the regional variations exhibited by the disease.

The observed low mortality of disorders of the circulatory organs applied to both ischemic heart disease and cerebrovascular disease, while low mortality for the group "other causes of death" reflects, above all, the decreased number of deaths due to diseases of the respiratory and urogenital organs.

Lung cancer

The regional analyses for lung cancer, summarized in table 3, showed excess risks in all of the "southern" counties, including Gävleborg, while the three northern counties of Västernorrland, Västerbotten, and Norrbotten exhibited a lower lung cancer risk among dockers than for the population of the region in question. Lung cancer mortality in the port of Göteborg constituted an exception to this pattern, with an SMR index for mortality on the order of 70. On the other hand, the corresponding SMR index for lung cancer incidence in the port of Göteborg pointed to a somewhat elevated risk.

Because lung cancer is one of those diseases that have increased the most among the general population, eg, lung cancer risk has trebled during the last three decades among men over 45 years of age, we felt it was desirable to compare the trend in lung cancer morbidity among dock workers to that of an external reference population. The comparison is shown in figure 1, along with the same comparison for stomach cancer (for reference). It showed that the lung cancer incidence among dock workers has risen faster than among Swedish men in general. For stomach cancer on the other hand the incidence has decreased both among dockers and among the general male population of Sweden.

Table 3. Observed and expected numbers of lung cancer deaths in 1961—1980 and incident cases of lung cancer in 1961—1979 among dock workers, calculated from data for counties and city regions.

Region	Lung cancer deaths		Lung cancer incident cases	
	Observed	Expected	Observed	Expected
Stockholm	12	10.6	16	10.4
Malmö	8	5.4	6	5.7
Göteborg	15	21.3	24	20.8
Södermanland	1	0.3	1	0.3
Östergötland	4	1.3	5	1.5
Kalmar	1	0.3	1	0.3
Gotland	1	0.2	1	0.3
Blekinge	—	0.2	—	0.2
Kristianstad	1	0.1	2	0.1
Halland	3	0.9	1	0.7
Skaraborg	—	0.1	—	0.1
Värmland	1	0.7	1	0.8
Västmanland	3	0.9	3	1.3
Gävleborg	14	4.1	14	4.4
Västernorrland	4	4.5	8	4.9
Västerbotten	—	1.5	1	1.6
Norrbotten	2	3.1	2	4.1
Total	70	55.3	86	57.5

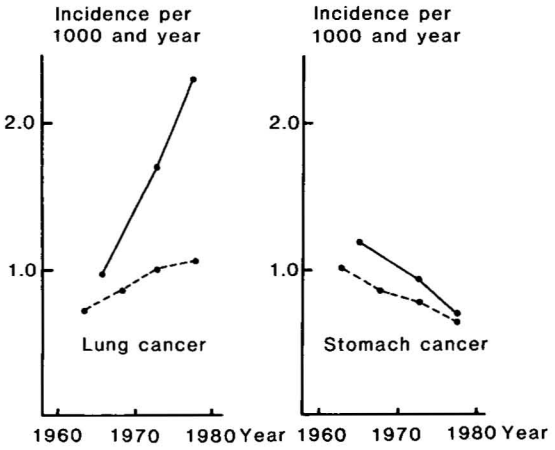

Figure 1. Incidence of lung and stomach cancer among dock workers (—) and Swedish males (---) in 1961—1980 (direct standardization with the corresponding death for "Swedish males" for 1951—1955 as the standard).

Discussion

The results obtained so far point to (i) a low total mortality, irrespective of cause of death, among permanently employed dock workers, (ii) a somewhat higher risk of dying a violent death, (iii) a tendency towards increasing excess risk for cancer morbidity, mostly from lung cancer.

As regards mortality, it has not been possible to demonstrate any change of risks over time that deviate from those applying to the overall Swedish population. The increase in the total cancer incidence, especially that of lung cancer, must be interpreted in the light of the lengthy periods of latency often applicable to malignant diseases. Therefore, it cannot be ruled out that during the 1950s and 1960s dock workers have been subjected to exposures that have increased the risk for lung cancer. If that is the case, this relationship may be expected to become stronger during the next few years. The observed "regional" variations are impossible to interpret from the data available at present.

As smoking (among dockers, as well as among the rest of the population) is certainly a predominant causal factor for lung cancer, the relatively small excess risks arrived at in the studied occupational cohort naturally have to be cautiously appraised. Therefore the possible connection between occupational exposure to diesel exhausts and lung cancer will better be elucidated in the second stage of the project, in which the duration of the exposure, interaction with smoking, and other circumstantial factors are being considered. This second stage, still in its planning phase, will be carried out as a case-referent study within the same cohort of dock workers that has been identified and followed in this study of registers.

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