Scand J Work Environ Health 1978;4(3):15-28

<https://doi.org/10.5271/sjweh.2763>

Issue date: 1978

Work conditions and health of locomotive engineers. II. Questionnaire study, mortality and disability.

by [Hannunkari I](#), [Järvinen E](#), [Partanen T](#)

Key terms: [disability](#); [health](#); [health](#); [locomotive engineer](#); [mortality](#); [questionnaire study](#); [work condition](#)

This article in PubMed: www.ncbi.nlm.nih.gov/pubmed/153582

This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/).

Work conditions and health of locomotive engineers

II. Questionnaire study, mortality and disability

by IRIS HANNUNKARI, ERKKI JÄRVINEN and TIMO PARTANEN

HANNUNKARI, I., JÄRVINEN, E. and PARTANEN, T. Work conditions and health of locomotive engineers: II. Questionnaire study, mortality and disability. *Scand. j. work environ. & health* 4 (1978): suppl. 3, 15—28. A questionnaire study on work conditions, work organization, leisure time, social problems, and health was directed toward active and retired locomotive engineers. This article mainly presents responses of the active engineers. The active locomotive engineers quoted the irregular work hours as the worst occupational problem. They judged noise and vibration in the locomotive cabs as disturbing. The majority of the desired changes in the work and work conditions concerned work time. The most common complaints given on the questionnaire were back trouble, hypertension and dermatitis. Tiredness and exhaustion were the most prevalent neuropsychological symptoms. A retrospective follow-up survey on invalidity and mortality was made. Trainmen and railroad clerks were used as reference cohorts. The engineers had relatively high invalidity and mortality rates in comparison to the reference groups, especially with respect to cardiovascular diseases and malignant tumors. Higher rates for disease of the digestive system and hearing loss were also suggested by the results.

A study on the work conditions and health of locomotive engineers was initiated by the Institute of Occupational Health in Helsinki, the Finnish Union of Engine Drivers, and the Finnish State Railways in 1975 under financial support from the Finnish State Railways. It focused on physical (noise, vibration and microclimate) and chemical factors (diesel exhaust constituents), ergonomics of work postures and movements, a questionnaire on the work conditions and health of the engineers, and an analysis of mortality and invalidity. The primary objective was to pinpoint the needs for improvement in work conditions and occupational health care.

The entire project consisted of five separate subprojects. This article presents the results of two of them, namely, the questionnaire study on work conditions

and health and the analysis of mortality and disability.

The questionnaire study was directed towards the following: (a) features connected with locomotive work (physical and neuropsychological stresses, work postures, accidents); (b) work conditions (general and specific, above all, physical); (c) work organization (work hours, night work, overtime, recuperation time); (d) leisure time; (e) social problems; (f) health (illness, health care, drug use, symptoms, absenteeism); (g) ability to work, occupational diseases, retirement age; and (h) improvements wanted in work conditions. The questions concerned both past and present circumstances.

Mortality and disability were analyzed retrospectively from the calculation of both overall and cause-specific incidences.

Table 1. Age distribution of the active locomotive engineers.

Age (years)	Drivers		Assistants		All engineers	
	N	%	N	%	N	%
25—29	—	—	27	15.3	27	6.2
30—34	—	—	61	34.5	61	14.0
35—39	25	9.6	50	28.2	75	17.1
40—44	38	14.6	23	13.0	61	14.0
45—49	113	43.5	8	4.5	121	27.7
50—54	79	30.4	8	4.5	87	19.9
≥ 55	5	1.9	—	—	5	1.1
Total	260	100.0	177	100.0	437	100.0

MATERIAL AND METHODS

The questionnaire was sent to two groups: (a) 460 active and (b) 220 retired engineers. In this study the term "engineer" refers to both the actual engineers or operators (drivers) of the locomotives and their assistants (or firemen). The terms "driver" and "assistant" have been used to designate the two groups, respectively, whenever there has been a reason to differentiate between the two.

This article reports mainly the results of the active engineers. The age distribution of this group is presented in table 1. The median age of the active engineers was 42.2 years (drivers 47.2 and assistants 35.3 years).

A total of 95 % of the active and 83 % of the retired engineers filled out the questionnaire and returned it.

In the mortality and disability analysis, the follow-up period was from 1 December

1955 to 31 December 1973. The following groups were compared:

1. All engineers employed on 1 December 1955 (N = 4,347).
2. Every second trainman (trainmen, guards, pointsmen) who were employed on 1 December 1955 (N = 1,575).
3. All railroad clerks who were employed on 1 December 1955 (N = 1,224).

WORK CONDITIONS

General aspects

The detrimental factors of the work conditions were inquired about in an open question. The engineers were asked to list the five worst aspects of their work.

The answers of the active (nonretired) engineers are presented in fig. 1. Based on the active engineers' responses, the order of present-day conditions was the following: (a) irregular work hours, (b) noise, (c) vibration, (d) draft, and (e) poor seat.

Although the retired engineers ranked work hours first as the actives did, they gave draft a higher average rating than the actives. Their response is probably a reflection of locomotive development.

Fig. 1. The five worst aspects of locomotive engineers' work.

Irregular work hours

The maximum number of work hours of Finnish railroad engineers has been set at 120 during a period of three weeks. The maximum shift length is 12 h. The weekly resting period is 2 d or 54 h. No more than two successive night shifts (2200—0600), and no more than 50 night hours are allowed during the three-week period.

The work schedule of the majority (95 %) of the active engineers was irregular. The distribution of night shifts in 1974 is presented in table 2.

Night shifts often require staying overnight outside the home locality. Sixty-five percent of the active engineers stayed overnight outside the home at least three times during a typical three-week period in 1974. The majority (85 %) of the active engineers had worked overtime in 1974, but only 2 % more than 30 h during a typical three-week period.

The irregular hours and the nature of the work makes obtaining warm meals difficult. Locomotive personnel still take food with them and eat it in the locomotive cab, the meals therefore containing primarily dry foodstuffs. Only 3 % of the active engineers had a possibility to eat a warm meal during their workshifts; 41 % of the actives never had this possibility during their work time.

Leisure-time difficulties caused by irregular work schedules were inquired about. The worst of these was connected with social activities, e.g., interference with trade union or training activities.

The majority of the active engineers experienced the irregular work hours as extremely disturbing; 38 % considered them to be extremely or particularly disturbing.

Noise, vibration, thermal climate, seats

Noise is a well-known risk factor in locomotive work. Five cases of deafness had occurred during the retrospective follow-up of our investigation (see p. 24). Forty-five percent of the measured equivalent noise levels exceeded 85 dB(A) during a measuring period of 0.5—2 h in the hygienic survey of locomotive cabs (2).

The personal experience of nuisance caused by noise increased according to the

duration of exposure. The majority (74 %) of the active engineers stated that the nuisance of noise had increased during their employment; only 6 % had experienced an improvement in the situation. Nineteen percent had experienced no alteration.

The present noise conditions in the locomotive cabs were judged by the active engineers as follows (response distribution to a multiple-choice question):

no disturbance	3 %
momentary slight disturbance	10 %
clear disturbance sometimes	30 %
clear disturbance often	41 %
continuous disturbance	17 %

Vibration was rated third in the active engineers' list of disturbing factors in the work environment.

The active engineers were currently experiencing the vibration disturbance in locomotives as follows:

no disturbance	5 %
momentary slight disturbance	10 %
clear disturbance sometimes	30 %
clear disturbance often	31 %
continuous disturbance	23 %

The majority of the active engineers had considered vibration disturbing. The ex-

Table 2. Distribution of night shifts during a typical three-week period in 1974.

Number of night shifts	%	N
0	3	14
1—2	5	20
3—5	34	146
6—10	52	226
> 10	6	28

Table 3. Experienced temperature in locomotive cabs in summer and in winter (%).

Experienced temperature	Summer (N=406)	Winter (N=407)
Continuously too warm	13	—
Sometimes too warm	63	4
Suitable	13	16
Sometimes too cold	1	63
Continuously too cold	—	4
Variable, sometimes too cold sometimes too warm	10	14

Table 4. Evaluation of seats (% of respondents). Responses for different seats combined.

Evaluation	Driver's seat (N = 260)	Assistant's seat (N = 137)
The seat is feasible.	53	28
The armrests of the seat are suitable.	35	15
The height of the seat is suited for the purpose.	86	59
The front of the seat is feasible.	62	31
The lining of the seat causes no perspiration.	20	17
The seat is adjustable.	74	38
The adjustment is easy to make.	57	36

Table 5. Subjective work capacity of active locomotive engineers. Mean scale values to question: "Which scale value (1-5) would you give to your present capacity in locomotive work, if 5 represents your highest subjective work capacity?"

Age (years)	Drivers			Assistants		
	Mean	SD	N	Mean	SD	N
25-29	—	—	—	4.5	0.76	26
30-34	—	—	—	4.3	0.72	61
35-39	4.0	0.76	25	3.9	0.86	50
40-44	3.8	0.71	38	3.5	0.66	23
45-49	3.4	0.98	112	3.8	0.71	8
50-54	3.4	0.85	78	3.4	0.92	8
≥ 55	3.0	0.71	5	—	—	—
All	3.5	0.90	258	4.0	0.83	176

perienced nuisance increased with the duration of exposure. The vibration measurements of many locomotive cabs revealed levels in excess of the international recommendations for vibration acceleration (2).

The results of the temperature measurements in the locomotive cabs have been presented elsewhere (2). The great majority (89 %) of the active engineers were of the opinion that the temperature was not suitable throughout the year. Eleven percent of the actives considered it suitable. The responses concerning temperature are presented in table 3.

Only 3 % of the active engineers did not consider locomotive cabs drafty. The rest of the responses were distributed as follows:

at times slightly drafty	9 %
sometimes clearly drafty	27 %
often clearly drafty	48 %
continuously drafty	13 %

Twenty-nine percent of the active engineers experienced no essential alteration in draft during their employment. Twenty-five percent considered draft to have diminished, while 46 % thought it had increased.

The concentration of diesel exhaust constituents was determined in the air of roundhouses and locomotive cabs; the results of these measurements have been presented in the preceding article. No concentrations over the Finnish threshold limit values were observed.

The active engineers were asked whether they experienced air impurities

Fig. 2. Subjective health status of active locomotive engineers.

in the cab. The responses were distributed as follows:

not at all	3 %
very little	10 %
little	24 %
much	48 %
very much	10 %

In addition to the ergonomic survey (2), the engineers were asked in the questionnaire about their seats. Of the assistants, 72 % and, of the drivers, 47 % considered their seat unfeasible. Opinions concerning some overall features of the seats are presented in table 4.

HEALTH STATUS

Health status and work ability

The subjective health status is presented in fig. 2 by age of the active engineers.

The work capacity was rated in relation to the "best" work capacity on a five-category scale. The distribution of the answers is presented in table 5.

Illnesses

The illnesses diagnosed by a physician were inquired about both with an illness list and with an "open" question (table 6). Table 6 contains all the stated illnesses. Thirty-four percent of the active engineers had been bothered by more than one illness. Thirty-three percent of the active engineers and 14 % of the pensioned ones reported no illnesses.

Experienced symptoms and sicknesses

Chest pain. Information on chest pain during exertion was obtained with questions developed by Rose and Blackburn (3). Six percent of the active engineers had chest pain typical of angina pectoris (grades 1 and 2 combined). Eight percent of the actives (28 persons) had had an attack of possible infarction (severe pain across the front of the chest lasting for half an hour or more).

Respiratory symptoms. Respiratory symptoms were studied with a translation of the Medical Research Council's Bronchitis Questionnaire. Thirteen percent of

Table 6. Illnesses diagnosed by a physician.

Illness	Active engineers		Retired engineers	
	Cases	% (N = 437)	Cases	% (N = 183)
Back disorder	145	33	70	38
Hypertension	78	18	58	32
Dermatitis	52	12	19	10
Pneumonia	36	8	25	14
Urinary tract infection	33	8	15	8
Stomach ulcer	32	7	17	9
Bronchitis	29	7	15	8
Other heart disease than coronary infarction	27	6	34	18
Duodenal disease	22	5	15	8
Hypertrophy of the prostate	17	4	15	8
Pleurisy	14	3	6	3
Renal disease	11	2	10	5
Coronary infarction	9	2	28	15
Neurological or mental disease	8	2	2	1
Pulmonary tuberculosis	8	2	3	2
Liver disease	8	2	5	3
Sugar diabetes	6	1	8	4
Emphysema	4	1	10	5

the active engineers had chronic bronchitis, as defined by Fletcher (1). No clear increase was noted in the prevalence of chronic bronchitis as age or the years of employment increased.

Back pain. Two-thirds of the active engineers had experienced back pain. The prevalence of tiredness, stiffness and aches in the back increased with age, which well fits with the nature of these symptoms.

The active engineers with back pain timed the pain as follows:

in the morning	44 %
during work	47 %
after work	53 %

The backaches were timed as follows:

in the morning	24 %
during work	42 %
after work	46 %
during the night	26 %

Forty-two percent of the actives reported pain radiating to the extremities. In the age category of 25—29 years every fifth person had radiating pain; between 50 and 55 years of age every second experienced such pain. Seventy-five percent of the assistants and 64 % of the drivers reported that back pain was relieved during their day off.

Almost one-third of the active engineers reported an illness of the back diagnosed by a physician. The answers of the active engineers were distributed as follows:

degenerative change	16 %
ischias	7 %
lumbago	2 %
sprain	1 %
other	2 %

Neck and shoulder pain. Among the active engineers 43 % had had pain in the neck and 37 % in the shoulders.

Of the actives, 47 % had had no pain in the neck or shoulders, 16 % had had pain in the neck only, 9 % had had pain in the shoulders only, 27 % had had pain both in the neck and in the shoulders.

Pain in the neck and/or in the shoulders caused trouble during work in 47 %, after work in 64 %, and during the night while resting in 37 % of the active engineers. Of those who had experienced pain, 43 %

reported it to radiate to the back of the head, and 60 % to the upper arms or hands.

Out of those engineers who had had pain in the neck and/or in the shoulders, every third reported an illness diagnosed by a physician in the same location. The prevalence was highest among those engineers 45—54 years of age with more than 20 years of experience.

Stomach trouble. Among the active engineers stomach trouble was quite common. The active engineers were currently having trouble as follows:

sometimes	50 %
often	10 %
very often	4 %

The most common types of stomach trouble were heartburn, flatulency, diarrhea, dropsy, and pain in the upper part of the stomach. Stomach problems were reported in all age groups; no correlation with age was noted.

As mentioned earlier, most engineers eat during their work, the meals containing mainly dry provisions. Engineers drink quite a lot of coffee; nearly half of the actives reported that they had three or more cups of coffee during a typical work-shift.

Neuropsychological symptoms. Occupational factors affecting fatigue and psychological strain in locomotive engineers may be considered to be night work, responsibility, accident risk, irregular work schedules, and absences from family and social life.

Every second of the active engineers reported their work to be mentally quite or very tiring. The mental stress of the work was reported by 56 % of the actives to have increased during their employment. Only 8 % of the actives reported that their work had become less stressful mentally.

Ninety percent of the engineers considered the responsibility of their work to be rather or very great. According to the engineers' opinion, responsibility had increased during their years of employment.

The most commonly reported neuropsychological symptoms to have occurred during the past 12 months among the ac-

tive engineers were tiredness (sometimes 69 %, often 21 %), and exhaustion and overwroughtness (sometimes 71 %, often 12 %). Sleeplessness caused trouble sometimes for 48 % and often for 8 % of the active engineers. Fifty-nine percent reported tiredness after their workshift sometimes, and 8 % often. The prevalence of this tiredness increased with age.

Hearing

A medical prerequisite for locomotive engineers is good hearing, which is established with an audiometric examination of job applicants. Audiometric examinations of the engineers are also made periodically.

The answers to the questions on hearing were classified as follows:

Grade 1: No hearing loss in the examination
Grade 2: Hearing loss in the examination
Grade 3: Hearing loss in the examination, as diagnosed by an otologist.

Hearing loss was reported by 17 % of the active engineers on the grounds of an examination. This prevalence was related to age (table 7).

Drug use

Drug use during the week prior to the filling out of the questionnaire was inquired about. One-third of the active engineers had taken medicine either temporarily or regularly during that week. The most common reason for the active engineers to have taken medicine was for the relief of different aches. Table 8 presents drug use among the active and retired engineers.

Sickness absenteeism

Thirty-four percent of the active engineers had had a sick leave of at least 6 d. Thirteen percent of the actives had had more than such leave.

Forty percent of the active engineers had been absent from work during their employment because of sickness or back ailments; the corresponding percentage for the past year was 9.

Table 7. Prevalence (%) of diminished hearing among active locomotive engineers.

Age (years)	Grade 2	Grade 3	Grades 2 + 3	Number of persons
25—29	—	4	4	27
30—34	5	5	10	61
35—39	7	7	14	75
40—44	10	5	15	61
45—49	12	5	17	121
50—54	19	10	29	85
55	20	—	20	5
All	10	6	17	437

Table 8. Drug use during the week prior to the filling out of the questionnaire.

Reason for drug use	Active engineers (N = 437) %	Retired engineers (N = 183) %
Headache	14	7
Ache in the joints or back	8	14
Other ache	2	3
Hypertension	9	27
Angina pectoris	2	19
Other heart diseases	2	15
Stomach trouble	6	7
Common cold	4	6
Sleeplessness, unrest	4	6
Vitamins	3	6
Other drug	3	10

Occupational accidents had caused an absence of at least 6 d for 46 % of the active engineers during their employment. During the last year 4 % of the actives had been absent due to accidents.

OPINIONS CONCERNING WORK AND PENSION AGE

In spite of the fact that the engineers reported many detrimental factors in their work, they felt quite comfortable in their occupation, as is seen in the following

distribution of answers to the general question "How do you feel in your work?"

very well	15 %
well	51 %
average	27 %
bad	6 %
very bad	1 %

Of the active engineers 66 % reported feeling very well or well in their occupation, although 80 % stated that they had felt this way in the beginning of the employment. The number of those who did not feel comfortable at all was small both "now" and "at entry." About half of the engineers felt equally well during their employment. A change for the worse was still perceptible.

The positive and negative aspects of the occupation were inquired about with open questions. The positive aspects of the locomotive engineers' work are presented in table 9.

The independence of the work was the most positive aspect, followed by the fact that it was interesting, there were holidays during the weekdays, employment was secure, and the work was mobile.

Table 9. Positive aspects in locomotive engineers' work.

Positive aspect	%	N
Independence of work	51	167
Interesting work	15	50
Holidays during the weekdays	13	43
Secure employment	7	23
Mobility of work	6	20
Physically light work	2	6
Others	6	19
All	100	328

Table 10. Desired retirement age of active locomotive engineers (% of respondents).

Desired retirement age (years)	Drivers (N = 260)	Assistants (N = 175)	All engineers (N = 435)
45	1	8	4
50	35	53	42
53	49	38	42
55	14	4	10
after 30 years of employment	2	2	2

Among the drawbacks, the irregular work schedule and its effects were the most commonly reported (78 % of 304 respondents).

The desired changes in the work were studied with an open question with a possibility for more than one desired change. The engineers mentioned more than 20 different aspects needing to be changed.

The majority of the desired changes concerned work time. Of all the engineers, 59 % hoped for a decrease in night work or for a complete elimination of night work. The next group of changes requested concerned social aspects, namely, health examinations, warm meals during work, higher salary, and better rest facilities. Changes in physical, chemical and ergonomic work conditions were the most important in the opinion of 7 % of the engineers. A general proposal — locomotives have to be improved — was given by 4 % of all the engineers. Other changes concerned draft, noise, vibration and seats. The need to change the work rhythm was reported as the most important change needed by 7 %. Other changes proposed were: more days off after the night shift, lower speeds and a more relaxed work tempo.

The retirement age of Finnish engineers is currently 55 years. The majority of drivers (85 %) and assistants (94 %) interviewed would prefer a lower retirement age (table 10). It may be noted that the desired retirement age correlated with age, increasing with the age of the respondents.

SOCIAL PROBLEMS AND LEISURE TIME

The active engineers named the irregular work schedule as the most irritating aspect of their work. They have to spend nights in rest places outside their homes, and the work hours do not agree with the requirements of normal family and social life.

The disturbances in family life were the inconveniences to which the engineers

reacted strongly. The majority of active engineers reported that the irregular work hours disturbed their family life (table 11).

The majority of the active engineers were however satisfied with their number of friends.

The majority of the active engineers reported that they had enough energy after work for leisure-time activities.

Engineers do not need to move much during their work. Typical leisure-time physical pursuits of active engineers included:

walking and skiing	54 %
cycling	26 %
gymnastics	18 %
swimming	14 %
playing ball	10 %
other	26 %

Leisure-time interests were inquired into with a list. The most common activities during leisure time turned out to be fishing, hunting, and reading. Work interfered most with those activities which demanded exact time, like meetings. Although group activities were not common among the engineers, work was reported to cause a disturbance more often in sports, trade union and club activities than in others. Work was quite often reported to interfere with fishing and hunting, which were the most common leisure-time activities.

DISCUSSION CONCERNING THE RESULTS OF THE QUESTIONNAIRE

The locomotive engineers experienced the irregular work hours to be the worst aspect of their work, and the majority of the desired changes concerned work time.

The locomotive engineers had experienced pain in the back, neck and shoulders quite often. The importance of preventing these symptoms and illnesses seems well established. Likewise early rehabilitation of these sicknesses might diminish the risk of invalidity and lowered work capacity to a considerable degree.

In addition to back disorders, many other diseases were reported to have been

Table 11. Disturbance caused by irregular work time on the family life of active locomotive engineers.

Degree of disturbance	%	N
Not at all	8	34
Little	23	100
Average	31	137
Much	30	128
Very much	8	35
All	100	434

diagnosed by a physician. Thirty-three percent of the active engineers had no disease stated by a physician. The morbidity structure corresponds to some degree to the answers concerning work conditions.

The irregularity of the meals and their contents may be a partial cause of the stomach troubles reported. Poor hygienic conditions may add to the discomfort. Night work may also disturb digestive organs, because the nightworker eats at a time when digestive functions are slower.

There was a contradiction between measurements and experience with respect to cab air. Many impurities in the cab may be easy to observe and cause the feeling of inconvenience yet being slightly toxic, e.g., the smell of smoke, steam and lubricants. This contradiction may be hereby explained. When improvements are planned, possibilities for improving air quality in the cabs should be taken into account. It should also be noted that the evaluation of the concentrations of the diesel exhaust constituents was made separately for each substance measured. Combination of the concentrations (e.g., applying the well-known addition formula, for example, for acrolein and formaldehyde) could have altered the interpretation of the results for the worse.

The relatively small variety of leisure-time activities may reflect a lack of interest or blocked possibilities for real interest. Engineers with an irregular work schedule cannot regularly participate in team activities or in frequent meetings. They therefore have to choose activities that can be pursued individually after the workday.

The results that (a) the engineers experienced many harmful and disturbing aspects in work and (b) the main part of

the active engineers felt well in their work seem to be contradictory. The question concerning general comfort in work does not measure only the features of working, but also other characteristics of employment, e.g., economic security and experience of (relatively low) pension ages. Therefore the apparent contradiction does not make the answers unreliable, and a great part of the engineers may really be satisfied with their occupation.

DISABILITY

The number of disability pensions granted during the follow-up (1 December 1955 — 31 December 1973) and the corresponding number of person-years (active) for workers aged 30—52 years are presented in table 12.

The incidence of engineer disability was essentially higher than that of railroad

clerks, but on about the same level as that of trainmen. The different physical demands of different professions might yet cause interoccupational differences in disability without differences in health status. This possible effect has been evaluated separately for different illnesses in this report. For example, in five cases, difficult hearing loss was the cause of disability, whereas no such cases were registered for the reference groups (trainmen and clerks), for whom at least moderate hearing is required. Also when the fact is considered that the hearing of locomotive-crew applicants is audiometrically controlled, this feature fits well with the noise exposure of the crew.

Cancer was the cause of disability for 15 engineers, 2 trainmen and no railroad clerks. The granting of a disability pension on the grounds of cancer depends mainly on medical findings and only slightly on occupation. The differences in disability incidence therefore depend on differences in morbidity. Yet, since cancer often leads to death before the granting of a pension, disability and mortality have been con-

Table 12. Granted invalidity pensions by age.

Age (years)	Engineers			Trainmen			Railroad clerks		
	Person- years	Pensions		Person- years	Pensions		Person- years	Pensions	
		N	‰		N	‰		N	‰
30—34	7,815	2	0.3	762	1	1.3	1,711	—	—
35—39	10,530	12	1.1	1,652	2	1.2	2,498	1	0.4
40—44	11,690	50	4.3	2,952	11	3.7	3,361	5	0.5
45—49	10,821	105	9.7	3,670	34	9.3	3,103	8	2.6
50—52	5,224	107	20.5	2,300	40	17.4	1,481	15	10.1
30—52	46,080	276	6.0	11,336	88	7.8	12,154	29	2.4

Table 13. Cases of death by age.

Age (years)	Engineers			Trainmen			Railroad clerks		
	Person- years	Deaths		Person- years	Deaths		Person- years	Deaths	
		N	‰		N	‰		N	‰
30—34	7,819	16	2.0	764	1	1.3	1,711	2	1.2
35—39	10,560	32	3.0	1,656	2	1.2	2,501	5	2.0
40—44	11,820	59	5.0	2,985	6	2.0	3,371	13	3.9
45—49	11,115	81	7.3	3,788	19	5.0	3,135	22	7.0
50—52	5,495	61	11.1	2,420	19	7.9	1,523	14	9.2
30—52	46,809	249	5.3	11,613	47	4.1	12,241	56	4.6

Table 14. Causes of death in the age interval of 30—52 years.

Cause of death	Engineers		Trainmen		Railroad clerks	
	N	%	N	%	N	%
Diseases of the circulatory system	129	52	23	49	36	64
Accidents	53	21	10	21	9	16
Tumors	46	18	6	13	10	18
Diseases of the digestive system	8	3	—	—	1	2
Other causes	13	5	8	17	—	—
All	249	100	47	100	56	100

sidered together as cases of disability and/or death.

MORTALITY

When mortality was analyzed, the years of disability were included in the person-years. The mortality figures are given in table 13.

The level of mortality for railroad clerks was on about the same level as the mortality for all three groups combined. The mortality of engineers was higher, and that of the trainmen lower. The fact that engineers had the highest mortality in all five age groups is a sign of "statistically significant evidence" without further, more powerful tests. The precise level of significance is, in our opinion, not important here. The main causes of death are given in table 14.

Causes other than diseases of the circulatory system, accidents and cancer were quite rare. Yet, the cause of death of eight engineers was a disease of the digestive system, while in the combined reference groups there was only one such case. This finding concurs with the poor possibilities for regular, complete meals. The same type of difference should have also existed between clerks and the two other groups. Therefore the difference suggested by these few cases does not quite agree with the results obtained with the questionnaire.

The sum of person-years of the engineers was less than twice that in the reference groups combined. Yet, the number of engineer deaths due to all three main causes was more than twice that of the reference groups combined. Furthermore, the engineers' person-years accumulated in a relatively smaller quantity between the ages of 45 and 52 years, i.e., ages which play the most important role in mortality from diseases of the circulatory system and tumors.

It can be stated, without a more-detailed analysis, that the engineers' mortality from diseases of the circulatory system and tumors was relatively high, when compared to the mortality of the combined reference groups. The role of these diseases and accidents should become even clearer if a combined analysis of disability and mortality is made. Permanent disability and death can be characterized as terminal losses of health. Often also the availability of medical care has played a determining role in whether the consequence is death or disability in cases of heart attack or accident. In cancer cases, the disease is often detected so late that no disability pension is granted. Many deaths also occurred among the persons on disability pension. Therefore, if disability and mortality are considered separately, some cases add either to disability or mortality figures, while some cases influence both. The incidence of difficult and permanent health losses may be calculated with disability and mortality combined. A person is counted as a "case" of health loss at the time when a disability pension is granted or at the time of death if he is

not yet on a pension. For accidents and tumors, the granting of a disability pension is likely to be very similar for these groups since differences in work conditions should have little effect. For diseases of the circulatory system it seems possible that engineers would, in some stages of disease, more easily receive a disability pension than, e.g., railroad clerks. Engineers may, however, keep their jobs but be given regular work hours and a relatively low level of physical stress. The differences in work conditions thus play a weak role also for diseases of the circulatory system.

PERSONNEL LOSSES DUE TO THE THREE MAIN CAUSES

Comparisons were made for the three main causes of disability and death between the three groups under study. Cases

of death or disability were combined under the label "personnel loss," and the incidence figures were calculated with the active years as person-years. Table 15 concerns diseases of the circulatory system.

Engineers had relatively more losses than the reference groups between the ages of 35 and 52 years. To obtain a condensed description, we calculated the numbers of "expected" cases by age classes and divided all the cases in the age class between groups in relation to person-years. Without applying a more-detailed method, we used the totals of expected cases for testing the significance of frequency differences. Losses due to tumors and accidents were handled in the same manner but, because of the small number of cases, only totals have been presented in table 16. The differences between the observed and "expected" figures were clearest for the diseases of the circulatory system. The tumor cases among the engineers were also relatively frequent, and a comparison to the combined figures of both reference groups gave a statistically

Table 15. Personnel losses due to diseases of the circulatory system.

Age (years)	Engineers			Trainmen			Railroad clerks		
	Person- years	Cases		Person- years	Cases		Person- years	Cases	
		N	‰		N	‰		N	‰
30—34	7,815	2	0.3	762	—	—	1,711	1	0.6
35—39	10,530	16	1.5	1,652	1	0.6	2,498	2	0.8
40—44	10,690	47	4.4	2,952	3	1.0	3,361	7	2.1
45—49	10,821	80	7.4	3,670	25	6.8	3,103	20	6.4
50—52	5,224	81	15.5	2,300	24	10.4	1,481	16	10.8
Total	46,080	226	4.9	11,336	53	4.7	12,154	46	3.8

Table 16. Number of cases of personnel losses.

Group (30—52 years)	Cause of loss					
	Disease of the circulatory system		Tumors		Accidents	
	Observed	Expected	Observed	Expected	Observed	Expected
Engineers	226	200.0	47	38.8	59	56.9
Trainmen	53	68.6	6	12.4	18	15.8
Railroad clerks	46	56.4	9	10.8	11	15.3
Total years	325	325	62	62	88	88

almost significant difference ($\chi^2 = 4.08$; $df = 1$; $P < 0.05$, two-tailed).

The figures concerning accidents were somewhat surprising because railroad accidents are often fatal for the engine crew. In this material 13 engineers had died in a railroad accident. Yet also three trainmen had the same cause of death. These figures correspond very well to the respective proportion in person-years.

In order to complete the information concerning the aforementioned statements, we analyzed the mortality after 52 years of age. The level of mortality continued to be somewhat high in relation to the reference groups until 60 years of age, but thereafter it became somewhat low. The years alive after 60 were mostly accumulated by those who were not retired until 1 December 1955 although being entitled to get an old age pension. Therefore the mortality levels of the groups after 52 years of age fit well with those before 52 years of age.

The incidence of diseases of the circulatory system were about the same in all the groups, and therefore the levels of mortality corresponded to that of total mortality. The share of tumors was however highest among the engineers, also after 52 years of age.

The evidence on the relatively high risk of diseases of the circulatory system and tumors for the engineers during the follow-up period was, as summarized, well established. Some cases of difficult losses of hearing and cases of death due to diseases of the digestive system suggest exposure related to the work environment.

CONCLUSIONS

The primary objective of the whole project was the evaluation of work conditions by measurements of work situations. In addition, effects on health were assessed by a questionnaire and a retrospective survey on disability and mortality. Noise, for example, was evaluated in connection

with the hygienic measurements (2). In the questionnaire personal experience with noise was considered, and, finally, the disability cases were counted. The descriptive chain of the noise problem was thus completed. In addition the possible role of noise as a mentally stressing factor must still be remembered.

The inconveniences noted in the ergonomic observations can mainly be connected to symptoms of the musculoskeletal system. The number of disability pensions granted for these diseases did not measure the illnesses sensitively, because the work is physically relatively light nowadays. The high frequencies of symptoms supported quite well the observations of poorly constructed seats and the measurements of draft.

The food consumed and the irregular mealtimes connected with shift work might cause disturbances in the digestive organs and central nervous system. The eight cases of death among the engineers because of diseases of the digestive system against one in the combined reference groups are in accordance with the background information obtained. The relative excess in mortality alone does not provide adequate evidence of association however. Yet stomach trouble was also common according to the questionnaire.

Literature concerning the effects of whole body vibration also supports the possibility that the stomach trouble could have been caused by exposure.

The possible neuropsychological effects cannot be evaluated from the disability and mortality figures because of the complexity of the phenomenon. Personally experienced mental strain was, however, high, according to the questionnaire. It seems likely, that, connected with other features (e.g., the responsibility of being on time), the demand for fast reactions during driving and the risk of accident added to the mental strain.

The hygienic measurements showed no basis for the increased risk for tumors which was found for the engineers when their disability and mortality figures were compared to those of the reference groups. It seems that the explanation of this phenomenon remains mainly unclear. Only the complex stress involved might be an additional risk factor.

RECOMMENDATIONS

According to the results of the study, the following actions are recommended for the planning and development of the work conditions of locomotive crews:

- (a) decrease in the disadvantages of shift work, reorganization of the shift system,
- (b) improvement of the quality of over-night lodging and rest facilities for driving pauses,
- (c) placement of toilets and refrigerators in locomotive cabs or the first car of the train for the use of the locomotive crew,
- (d) insulation of the walls of the locomotive cabs with materials which are easy to clean,
- (e) improvement of the ventilation system or installation of air conditioning in the cabs,
- (f) additional decrease in railroad crossings,
- (g) ergonomic improvements in furniture and cab space,
- (h) technical improvements which lower noise and vibration levels.

Some work conditions in locomotives have improved gradually as technical development has occurred. All the new possibilities have not yet been put to use however. Improvements can also partly be realized in other ways. The organization of the work schedule plays an important role in the entity of work conditions. As

an example, lack of sufficient recovery before a driving shift adds to the stress and risk of hazardous conditions. When the possibilities for sufficient recovery are estimated, knowledge of human biological rhythms should be taken into account. Finally, the solution demands a reestimation of the personal needs of locomotive crews and measures to obtain a sufficient amount of trained personnel.

ACKNOWLEDGMENTS

We wish to thank the members and officers of the Finnish Union of Engine Drivers and officials of the Finnish State Railways for their cooperation.

REFERENCES

1. FLETCHER, C. M. Definition and classification of bronchitis, asthma and emphysema. In: *Bronchitis, an interventional symposium, 27—29 April 1960, University of Gronigen, The Netherlands*. Royal Van Goorcum Ltd., Assen 1961.
2. HANNUNKARI, I., HEINO, M., JÄRVINEN, E., KETOLA, R., MÄKELÄ, P., MÄKINEN, R., NIEMELÄ, R., PARTANEN, T., STARCK, J. and TIKKA, P. Arbeitsbedingungen und Gesundheit der Lokomotivführer der Finnischen Staatseisenbahn. *Z. Gesamte Hyg. Ihre Grenzgeb.* 23 (1977): 10, 734—737.
3. ROSE, G. A. and BLACKBURN, H. *Cardiovascular survey methods*. World Health Organization, Geneva 1968.