Vocational rehabilitation of locomotive engineers with ischaemic heart disease

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**Background**
There is resistance among railway companies and their occupational health services to rehabilitating locomotive engineers with ischaemic heart disease to their former driving work.

**Aim**
To study the outcome of vocational rehabilitation for locomotive engineers with ischaemic heart disease.

**Methods**
In seven European countries, selected locomotive engineers with ischaemic heart disease were compared to a matched group of healthy engineers. At the end of each calendar year between 1990 and 1999, questionnaires were completed by local occupational health physicians to provide information on accidents, incidents (professional mistakes), sick leave, (recurrent) cardiac events, death and early retirement. We used the life table method with five follow-up years to calculate the risk of accidents, incidents and recurrent cardiac events.

**Results**
The accident rate for the cardiac group was 3.8 accidents per 100 person-years, as compared to a rate of 6.0 in the reference group. The rates for incidents were 0.9 and 2.0, respectively. Neither of these differences were statistically significant. The duration of sick leave was significantly longer among the cardiac group than it was among the reference group, but only in the first follow-up year. Thirteen recurrent cardiac events occurred in the cardiac group, as compared to a single cardiac event in the reference group. There was no difference in the proportion of retirement cases. One engineer in each of the two groups died of cardiac disease.

**Conclusions**
Locomotive engineers can safely resume driving duties following onset of cardiac disease.

**Key words**
Accidents; driving; heart disease; rehabilitation; sick leave.

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**Introduction**

Locomotive engineers are responsible for the safety of hundreds of passengers. Before 1970, technical safety devices were only occasionally available, and safety depended on the engineer’s personal alertness. Railway companies and their occupational physicians therefore believed that engineers had to be in good health, having no diseases whatsoever. Companies could not afford to accept engineers who had even the slightest possibility of becoming less alert, as could happen in the case of (innocent) arrhythmias, sudden (cardiac) incapacitation and collapse.

Despite advances in the technical safety environment, human error and sudden incapacitation can still lead to disaster. Unpublished data from the Netherlands show that accidents caused by sudden cardiac incapacitation occur approximately once every 5 years. The medical and psychological demands on engineers thus remain a valid concern. Since 1990, these demands have been addressed in the guidelines of the International Union of Railway Medical Services (UIMC). These guidelines correspond to those of the European Society of Cardiology for driving and heart disease [1].

The main criteria specify that engineers must

- be free of cardiac symptoms,
- have good left ventricular function,
- have a minimal aerobic capacity of seven metabolic equivalent,
- have no ischaemia or major arrhythmias on exercise electrocardiogram (ECG) and
- have no major arrhythmias on Holter monitoring.

Only seven European countries allow locomotive engineers to resume driving after a cardiac event. These countries are Ireland (CIE), Germany (DB), Belgium (NMBS), the Netherlands (NS), Norway (NSB), Switzerland (SBB) and Sweden (SJ). In these countries, a prospective study on the railway safety of locomotive engineers show...
engineers with ischaemic cardiac disease was performed between 1990 and 1999. The main goal was to study the outcomes of vocational rehabilitation for railway locomotive engineers after cardiac events. To this end, we followed engineers from seven European countries for 9 years; all of the engineers had experienced cardiac disease, comparing their results to those of others who had not experienced cardiac events, focusing primarily on railway safety (accidents and incidents).

Methods

All of the 45 railway companies that participated in the scientific conference of the UIMC were informed about this study. The seven companies that eventually participated represented the same countries that are mentioned above. Printed information about the study was sent to the medical departments of each railway.

Between 1990 and 1999, each engineer who had experienced a cardiac event, was fit for driving according to the UIMC guideline and had resumed work was asked by the local occupational physician to enter the study. Each time that an engineer entered the study, the local manager was asked to identify an engineer from the same geographic region who was best matched for age and years in service and to ask this engineer to participate in the study. These matched engineers formed a reference group. Because periodic medical check-ups are required of all engineers, railway medical departments had access to the medical records, and local occupational physicians could deem engineers healthy.

All of the engineers who entered the study received oral and written information about the study’s purpose and the follow-up procedure. After obtaining informed consent and final agreement, we followed the participating engineers on the following aspects: new cardiac events, number of accidents and incidents, sick leave, death and early retirement. A cardiac event was defined as a myocardial infarction (i.e. the presence of two of the following criteria: clinical symptoms of infarction, ECG changes pathognomonic for infarction and advanced ‘heart’ enzymes in the blood), percutaneous transluminal coronary angioplasty (PTCA), coronary artery bypass graft (CABG) or angina, treated conservatively (typical angina, supported by angiography, with a stenosis >50% in one or more coronary arteries). Accidents were defined as events involving damage to materials or harm to living beings. Incidents were defined as professional mistakes. Sick leave referred to time taken off from work due to any illness or disease. Death referred to dying of any cause during the period of the study. Retirement meant leaving work permanently, whether for medical or non-medical reasons. The railway companies in each of the countries recorded and investigated all accidents and incidents in a similar way. The only incidents that were recorded were driving through red lights or speeding without acknowledging the warning system. Sick leave and retirement were recorded by the railway company, the medical department or both. Cardiac events and death were recorded by the railway medical department.

At the beginning of the study, occupational physicians completed a questionnaire for each engineer, in order to provide baseline information on age, height, body mass index (BMI), smoking habits and blood pressure. At the end of each calendar year, local occupational physicians completed questionnaires providing information on follow-up items. Because engineers entered the study at various times during the 9 years of the study, the follow-up period for the engineers varied from 1 to 9 years. We compared the two groups according to the items mentioned above. During the 9 years of the study, the number of engineers decreased due to lost follow-up, retirement and new cardiac events. We therefore restricted the length of follow-up to 5 years.

Statistical analysis was performed using the EPI 2000 (version 3.3) program of the Centers for Disease Control and Prevention. We calculated 95% confidence intervals to test differences. When comparing means of continuous variables, we performed t-tests using \( P < 0.05 \) as the level of significance. Life tables were constructed by hand using the interval method. Person-time was estimated according to the average number of subjects per follow-up year. This measure was then used to calculate incidence densities per 100 person-years of accidents and incidents. Life tables were also used to calculate the 5-year risk of experiencing a (recurrent) cardiac event.

Results

Eighty-three locomotive engineers were included in each group. The basic characteristics of both groups are presented in Table 1. All locomotive engineers were male, and the mean age for both groups was 48 years. In all, 71% of the cardiac patients and 59% of the reference-group members had a BMI of <25. Sixty-five per cent of the locomotive engineers of the cardiac group had smoked in the year before their cardiac events. Thirteen per cent continued to smoke after their cardiac events. Forty-three per cent of the engineers in the reference group had smoked in the year before they entered the study. Twenty-five per cent were still smoking at the time they entered the study. The blood pressures of the engineers in the two groups were comparable.

Table 2 presents the distribution of the various types of cardiac events across the members of the cardiac group. Fifty-nine of these engineers had experienced myocardial infarctions, including nine engineers who also underwent elective CABG and 15 who underwent PTCA. Of the remaining 24 engineers with angina pectoris, only three had been treated conservatively with medication alone.
Even though the engineers in the cardiac group met the UIMC criteria, not all of them were allowed to drive trains without restrictions. In some cases, the local occupational physician had prescribed one or more professional restrictions. These restrictions included limitations on working hours (21% of cases), restrictions on driving alone and shift restrictions. These measures were maintained during the follow-up period. The proportion of locomotive engineers with professional restrictions is shown in Table 2.

In the first 5 years of follow-up, the engineers in the cardiac group had 15 accidents, compared to 31 accidents in the reference group (Table 3). Seven of the engineers in the cardiac group were involved in single accidents, one engineer was involved in two accidents and another was involved in six. The 15 accidents were thus distributed across nine engineers. In the reference group, 12 engineers were involved in single accidents, one had been involved in two accidents, one had been involved in eight and another had been involved in nine. The 31 accidents were thus distributed across 15 engineers. The accident rate for the cardiac group was 3.8 accidents per 100 person-years; for the reference group, this rate was 6.0 accidents per 100 person-years. In the cardiac group, six of the 59 (10%) engineers who had experienced myocardial infarctions were involved in accidents, as compared to three of the 24 (13%) engineers who had not experienced myocardial infarctions.

None of the accidents in either group were caused by the engineer and none resulted from sudden incapacitation due to cardiac disease. In all, 25% of the accidents were due to suicide by others, and 75% were caused by collisions between road traffic and trains. There were two incidents of collisions between two trains during shunting activities.

Incidents are more interesting than accidents for the purposes of this study, however, as they are caused by professional mistakes due to the inattention of the engineer. The incidents in both groups were equally divided between driving through red lights and speeding. Both are potentially dangerous situations and are unacceptable for railroad safety. None of the reported incidents were due to inattention caused by cardiac incapacitation.

In the first 5 years of follow-up, two incidents were reported in the cardiac group, as compared to eight in the reference group (Table 3). The two incidents that were reported in the cardiac group involved two different engineers. In the reference group, three engineers were involved in single incidents, one engineer was involved in two incidents and one engineer was involved in three incidents. The incident rate for the cardiac group was 0.9 incidents per 100 person-years; for the reference group, it was 2.0 incidents per 100 person-years.

Not every locomotive engineer caused incidents, and some engineers caused more than one. A total of 4% of the engineers in the cardiac group made professional mistakes, as compared to 7% of the engineers in the reference group. In the cardiac group, one of the 59 (2%) engineers who had experienced myocardial infarctions was involved in an accident, and one of the 24 (4%)
engineers who had not experienced myocardial infarctions was involved in an incident.

Table 4 presents the sick leave that was taken by engineers during the five follow-up years, expressed as the mean number of days per year. In each year, the cardiac group took more days of sick leave. Only in the first year, however, was there a significant difference in the number of days that was taken by each of the two groups.

Information on new cardiac events, mortality and retirement is presented in Table 5.

The cardiac group experienced more cardiac events than the reference group did. The 5-year risk of having a cardiac event was 23% for the cardiac group and 1% for the reference group. This difference is statistically significant. Figure 1 shows the cardiac-event-free survival rates for each group. The risk is not distributed equally over these 5 years, varying from 3.0 to 7.4% for the cardiac group.

One engineer in each group died because of a (recurrent) cardiac event. This did not happen during working time, and neither death was sudden.

The retirement rates of the two groups did not differ significantly. Nineteen of the engineers in the cardiac group had at least 1 year of follow-up before they retired, as compared to 25 engineers in the reference group.

Discussion

Our results revealed no more accidents and incidents for the cardiac group than they did for the reference group, even though the engineers in the cardiac group had experienced more recurrent cardiac events than had their reference-group counterparts. The cardiac events in the reference group were obviously first events, while the events in the cardiac group were recurrent by definition.

The two groups are comparable, as they are matched for age, demographic location and number of years of driving experience. This means that, even though several European countries were involved in the study, the working conditions, (occupational) medical care and local environments were comparable across the two groups. The two groups did differ according to BMI and smoking habits (Table 1). Although the BMI of the cardiac group exceeded that of the reference group, the proportion of current smokers in this group was lower (as more of the engineers in the cardiac group had stopped smoking).

Even if obesity and smoking did increase the risk of accidents and incidents, this would not have affected the total result, as the effects of obesity in the cardiac group would have been cancelled out by the effects of smoking in the reference group [2–4].

This study concerns a highly selected group of locomotive engineers. Widespread concern over matters that could affect railroad safety limits the possibilities for engineers to resume their driving duties after cardiac events. The small sample size was thus due to restraints imposed by railroad companies and their occupational health physicians regarding locomotive engineers who have ischaemic heart disease and their driving abilities. The privatization of the European railway companies and the consequent separation of the various occupational medical departments from the railways seriously impeded data collection during the follow-up years. This situation generated a considerable number of ‘lost to follow-up’ cases. The most common cause of this status was the failure of occupational physicians to send information, despite numerous reminders, by both mail and telephone. Other causes included recurrent cardiac events (significantly more in the cardiac group), death and retirement (neither of which differed significantly between the two groups).

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The cardiac group might be expected to have had as many (at best) or more accidents and incidents than the reference group had. Our results show the opposite. One possible explanation is that, although the cardiac events

Table 4. Sick leave per year (mean number of days per year) for each of the 5 years of follow-up in the cardiac and reference groups

<table>
<thead>
<tr>
<th>Years of follow-up</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>76</td>
<td>77.5</td>
<td>64.5</td>
<td>64.5</td>
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<tr>
<td>Days (mean)</td>
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<td>23</td>
<td>39</td>
<td>23</td>
<td>48</td>
</tr>
<tr>
<td>Significance</td>
<td>**</td>
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Card., cardiac group; Ref., reference group; N, number of locomotive engineers according to life table; 95% CI, 95% confidence interval.

**P < 0.01.
did not cause any of the accidents or incidents directly, they may have affected the number of accidents and incidents in the cardiac group during the remaining follow-up period, as these engineers did not continue driving after recurrent cardiac events. Other factors that may have decreased the number of accidents and incidents in the cardiac group include restrictions of driving time recommended by the occupational health physician and the higher rate of sick leave, both of which would have reduced the actual driving time.

The literature on accidents caused by medical conditions is scarce, and most studies concern road-traffic accidents. Liechti [5] found no more accidents among a selected group of locomotive engineers with ischaemic heart disease than among a comparable group of healthy engineers. Jovanovic et al. [6] found twice as many accidents among a group of professional road drivers with ischaemic heart disease than among healthy drivers. Our findings are comparable to those of Liechti, as the populations for the two studies are comparable. The Liechti study, however, concerned a uniform group of engineers from a single railway company, and compared the cardiac group to the entire group of Swiss locomotive engineers. Because the Jovanovic et al. study concerned the different occupational requirements of professional road drivers, these results are not comparable to those of the current study.

Our results show that, among the engineers in the cardiac group, the rate of sick leave after resuming work during the five follow-up years was consistently higher than it was among the engineers in the reference group. This implies that locomotive engineers with ischaemic heart disease take more and longer sick leave than do healthy engineers. The difference was significant only in the first follow-up year, however, largely due to smaller numbers of subjects in subsequent years. Although heart disease itself can partially explain the greater use of sick leave, other non-cardiac reasons could also have played a role. The higher BMI among the cardiac group is one possible explanation, as obesity is known to double the use of sick leave in a working population. The same could be said, however, of smoking among the engineers in the reference group [2].

Nineteen of the 77 (25%) engineers in the cardiac group and 25 of the 78 (33%) engineers in the reference group retired during the 5 years of follow-up. In a review study, Perk [7] reports retirement percentages between 48 and 73% among the general working populations of cardiac patients during the first 5 years. We assume that the lower percentage of retirement in our study is due to the high selection of the cardiac group.

Although the rate of new cardiac events was higher among the cardiac group than it was among the reference group, this did not affect the risk of accidents or incidents, as all of the recurrent cardiac events happened during leisure time. Although this does not mean that no cardiac events could occur during occupational driving, the risk was low in this selected group of locomotive engineers. Despite the small sample, which makes it difficult to draw definite conclusions, we believe that our results show that there is no good reason for many European countries to restrict engineers with ischaemic heart disease from driving duties, even if they meet the basic criteria of the UIMC (e.g. normal heart function, freedom from cardiac symptoms and normal stress test). Further studies are necessary to determine the influence of working restrictions (e.g. time restrictions) on railway safety and to develop evidence-based criteria for assessing locomotive engineers with ischaemic heart disease. This information could also be used to establish driving limits and adapt working conditions for these engineers.

### Key points

- Locomotive engineers with ischaemic heart disease who are free of cardiac symptoms and have normal heart function and normal stress tests pose no threat to railway safety.
- The assessment of these engineers should be conducted without prejudice. Further study is therefore necessary in order to establish evidence-based criteria.
Acknowledgements

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Conflicts of interest

None declared.

References