Roles of age, length of service and job in work-related injury: a prospective study of 446 120 person-years in railway workers

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ABSTRACT

Objectives Because work-related injuries are common and yet the mechanisms through which various types of injuries relate to age, length of service and job remain unknown, this study assessed the role of age, length of service and job in work-related injury.

Methods Prospective study of all 164 814 permanently employed male workers at the French national railway company during 1998–2000, based on the company’s injury database: 446 120 person-years, 15 195 injuries with working days lost, coded using the company’s injury classification, which is derived from that of the French health insurance scheme. We investigated the incidence of 10 types of injury: fall on same level, fall to lower level, handling materials/machine parts during assembly, handling objects, lifting/handling equipment, collision with/by moving objects, collision with/by vehicles, operating machines/equipment, using hand tools and other injuries. Data were analysed using negative binomial regression.

Results Workers aged <25 years were subject to a higher injury risk from handling/materials/machine parts during assembly, and collision with/by moving objects or vehicles. Older workers, especially those aged 50–55 years, were subject to a higher risk of fall and injury resulting from lifting/handling materials/equipment/objects or from collision with/by moving objects/vehicles. Using hand tools was a risky task for workers aged <30 or ≥40 years. The relative risk decreased steadily with increasing length of service with the company, from 2.6 for 1 year to 1.0 for ≥30 years, and the slope of the trend is stronger for fall to lower level, lifting/handling materials/equipment and collision with/by moving objects.

Conclusion Younger and older ages and shorter length of service are at risk for various types of injuries. Preventive measures should improve working conditions, especially for younger/older ages, provide knowledge through specific training during the first years in a job and help workers to be more aware of risks associated with their age, years of employment and job.

Every year, 120 million work-related and 210 000 fatal injuries occur in the world1 and these have severe socioeconomic consequences.2 3 In 2003, there were 721 227 injuries with days lost (incidence rate 4.1%, 36 million days lost), 48 774 injuries leading to permanent disability and 661 fatal injuries under the French general health insurance scheme (17.6 million workers).3

Every year, young people start work lacking job knowledge and experience;4 research has revealed them to be subject to a high risk of injury.4–15 These research studies define young age as <20 or <30 years, which embraces both adolescence and young adulthood. Some studies have highlighted the injury role of diseases and disabilities common among workers older than approximately 40 years.17–20 Diseases and disabilities alter both working skill and the way in which occupational activities and working environment. The findings highlight the benefit of improving working conditions, providing specific training in terms of job knowledge, task performance and occupational hazard assessment from a worker’s first years in a job, as well as ensuring that a worker’s skill corresponds with his occupational roles. Workers should be helped to gain awareness of risks relating to their job, age and experience.
A relationship has been discovered between cumulated physical job demands and injury, and this represents a twofold higher risk for workers >40 years old than for younger workers. Older ages are associated with lack of postural control, favouring a fall, and the risk of falling to lower level may be higher than that of falling on same level because it is more difficult to control one’s balance on less stable raised platforms or on stairs. Lower physical strength and disabilities of older workers mean that the injury risk can be greater among them for the most demanding tasks or those that require greater strength or skill. Note that demanding occupations generate both injuries and disabilities. The impact of older age on injury is a public health problem in Europe because of the lengthening of working life, which results in more people working at an older age. Note that older ages are associated with injuries with longer days lost.

The role of lack of experience in injury, which is measured by length of service, is well known, but some studies have focused on the first 5 years in a given job because of the small samples used. Many workers are confronted by rapid turnover, which leaves them with a lack of job knowledge and experience. This issue affects most jobs and different ages, and thus many older workers may accumulate disabilities and insufficient job knowledge and experience. Age and experience can be distinguished as individual factors, which change with the course of time but which could be controlled in epidemiologic design.

Older age is often associated with greater experience, neglecting the role of disease and disability, whereas experience and disability do in fact play opposite roles in injury. Two questions are of interest. First, what length of service reflects a lack of experience? Second, what are the respective roles of younger and older age, length of service and job, and are they related to injury type? We need to understand the mechanisms, through which these factors contribute to injury, as potential targets for injury reduction programmes, which go beyond conventional methods by considering the various risks to which different age groups are subject. It has been difficult to separate the role of age and length of service in most studies because of their collinear nature, especially when they were categorised in two classes only. A prospective study on a large population of sufficient participants in various age brackets and lengths of service in a number of job groups was therefore necessary. We assumed that gaining experience is a long, gradual process, that there is a link between injury and younger and older age independent of experience and job, and that risk depends on the type of injury.

We assessed the part played by age, length of service with the company and job in various types of injury among French railway workers. We chose this population because many jobs are represented (mechanics, drivers, maintenance workers, construction workers, painters, welders, boilermakers, manual workers, employees, managers, etc) and it therefore constitutes a wide population with enough workers in different age categories, with different lengths of service and in different jobs. Note that the annual injury incidence rate of these workers is the same as for workers within the French general insurance scheme.

**METHODS**

**Population**

The study population consisted of all male participants working with a permanent work contract in the French National Railway Company at some time between 1 January 1998 and 31 December 2000 (3 years). This population was selected from a basic population of all employees comprising 207 872 workers, of whom 20 106 did not have permanent contracts (fixed period or temporary jobs, 9.7%). There were 34 601 female workers (16.6%), of whom 22 952 had permanent contracts and 11 649 did not have permanent contracts.

Thus, our study population comprised 164 814 male workers with permanent contracts (79.5%). For each subject, the day of hiring as well as for each year the active presence in the company and the job were available.

**Study design**

The population was followed up for the incidence of work-related injuries from 1 January 1998 to 31 December 2000. The survey used the company’s systematic database of injuries with sick leave due to work-related accidents (health disorders were excluded) to identify incident cases. This injury database was created by our department to better understand the injury mechanisms for all worker categories and to monitor the injury risk for various jobs, age groups and lengths of service. For each injury, the system recorded the worker’s identification number and an injury description. These data were collected at the time of the injury by the department prevention office in presence of the injured worker. An injury was defined as bodily damage, irrespective of its severity, resulting from an accident with at least one working day lost, in addition to the day on which the accident occurred, and for which the subject received compensation. Fatal injuries were also included (25 deaths).

Outcomes were identified using the company’s injury classification, drawn up based on that of the French general health insurance scheme: falls on same level, falls to lower level, handling materials/machine parts during assembly, handling objects, lifting/handling equipment, collision with/by moving objects, collision with/by vehicles, operating machines/equipment, using hand tools and other injuries.

The personnel database has been constructed by the company personnel office, and is used among others to establish the salary advice and medical examinations by occupational physicians. The database thus contains data for all the staff and is valid. For each new recruitment, one identification number is attributed to the worker for all his careers. It is constructed as follows: year of birth, followed by the month of recruitment, the order number in the recruitment, and one key-letter that is used among others to establish the salary advice and medical examinations. Fatal injuries were also included (25 deaths).

To ensure a sufficient number of participants in each category, age was categorised in seven classes: <25, 25–29, 30–34, 35–39, 40–44, 45–49 and ≥50 years and length of service in 10 groups: <1, 1, 2, 3, 4, 5–9, 10–14, 15–19, 20–24, 25–29 and ≥30 years. Job categories were identified using the SNCF’s job classification and the customer accomplishment operators; mechanical/diagnostic/electrotechnical operators and boilermakers-welders; railway maintenance operators; signposting/telecommunication/energy-electric traction/specialised mechanical operators; other design/construction/basic equipment/rolling equipment operators; transport production operators; traffic operators; other operational production operators train drivers; and other jobs.

Injury data and the personnel database were first transferred to the company’s Working Conditions and Human Factors Department, after first deleting the workers’ names, then to the INSERM research team for statistical analysis. The two...
The study was also presented to all the personnel via the journal of the company. No worker expressed his/her opposition to the survey. However, we did not seek informed consent from workers because it was difficult to contact them all.

During the 3-year follow-up period, which represents 446 120 person-years, 15 195 injuries were observed.

Data analysis
For each subject, the precise date of hiring as well as for each year the active presence in the company and the occupation were available. However, the precise date of leaving the company was not available. The statistical control of the follow-up was therefore approximate for the participants who quitted the firm during the follow-up period and was as follows: a subject who was not present in the firm for a year Y contributed 0.5 person-year for the year Y-1 (this assumes that he quitted the firm at the median date, the 50th June of that year). This procedure only concerns a small proportion of the train drivers who reached the age of 50 years during the follow-up period as all the other workers take their retirement at 55 years. The person-years as well as the injuries were attributed individually and year-wise to the occupation held by each subject every year and to the age group and category of length of service for this year. The injury incidence rate per 1000 person-years, that is, the number of injuries occurring in any time cell defined by the independent variables (groups of age, length of service and job), divided by the total person-years cumulated in this time cell, was analysed using negative binomial regression, which is an extension of the Poisson regression taking into account over-dispersion (ie, the fact that because of unmeasured factors, the variance of the rates was larger than predicted by the usual Poisson approximation). The independent variables considered were regrouped categories of age, length of service and job using STATA V.10 (Stata, College Station, Texas, USA). Before analysis, the individual data were collapsed into total numbers of injuries and person-years in each combination of the independent variables de facto dropping empty cells. The results are expressed as adjusted risk ratios (RRs) and 95% confidence intervals.

RESULTS
The injury incidence rate for the 3-year monitoring period was 34.1 per 1000 person-years. Principal injury types were falls on same level or to lower level or injury resulting from handling materials/machine parts during assembly, lifting/handling equipment and collision with/by moving objects. Those aged <25 years had a higher injury risk due to handling materials/machine parts during assembly, using hand tools and collision with/by moving objects or vehicles (compared with the workers aged 25–44 years). Older workers and especially those aged 50–55 years experienced a higher risk of falling on same level or to lower level or injury resulting from handling materials/machine parts during assembly, lifting/handling objects/equipment, or from collision with/by moving objects or vehicles (compared with the workers aged 50–44 years). Using hand tools was a risky task for workers aged <30 or ≥40 years.

DISCUSSION
Among workers <25 years old, we noted a higher injury risk due to handling materials/machine parts during assembly, using hand tools and collision with/by moving objects or vehicles, whereas among older ages (especially those aged 50–55 years), there was a higher injury risk due to fall on same level or to lower level, handling materials/machine parts during assembly, lifting/
handling objects or equipment, collision with/by moving objects or vehicles, and using hand tools. We found a steady decreasing trend in rates associated with length of service for all injury types. However, among the workers aged <35 years, the incidence rate increased in the first years of employment. As this increase was found up to 4 years of service, we conclude that an experience of <4 years did not contribute to reduce the injury risk among those young workers. These findings are important because they show the respective roles of age, experience and job in the mechanisms involved in various types of injury. Such issues represent a public health problem because of ageing of the working population and the rapid turnover of relatively inexperienced workers in many countries. The impact of rapid worker turnover on injury would be greater for older workers with reduced physical and mental abilities. Choosing French railway workers has several advantages. Many jobs are performed by this population. Length of service represents a good measure of job experience. A number of diseases/disabilities appear after the age of 40 years and retirement age is 50 years for train drivers and 55 for the other workers, which provides a 40- to 55-year interval for examining the part played by older age. The injury incidence rate varies little from year to year. The data are confirmed and there were enough participants in the various age, length of service and job categories. A 3-year monitoring period was nevertheless selected to include enough injuries for statistical analysis. In this study we did not exclude those workers who had an injury before 1998 because having an injury is a risk factor for subsequent injury. Their exclusion would lead to a selection bias, and it is more appropriate to include all the personnel in the study.

Table 1 Work-related injury incidence rate and adjusted risk ratio according to age, length of service and job

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Number of person-years</th>
<th>Number of occupational injuries</th>
<th>Incidence rate per 1000 person-years</th>
<th>Adjusted risk ratio and 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;25</td>
<td>16465</td>
<td>891</td>
<td>54.1</td>
<td>0.94 0.77 to 1.16</td>
</tr>
<tr>
<td>25–29</td>
<td>43383</td>
<td>2040</td>
<td>47.0</td>
<td>0.86 0.72 to 1.04</td>
</tr>
<tr>
<td>30–34</td>
<td>43332</td>
<td>1772</td>
<td>40.9</td>
<td>0.83 0.70 to 0.98</td>
</tr>
<tr>
<td>35–39</td>
<td>78296</td>
<td>2676</td>
<td>34.2</td>
<td>0.86 0.75 to 1.00</td>
</tr>
<tr>
<td>40–44</td>
<td>108486</td>
<td>3474</td>
<td>32.0</td>
<td>0.89 0.79 to 1.01</td>
</tr>
<tr>
<td>45–49</td>
<td>93414</td>
<td>2761</td>
<td>29.8</td>
<td>0.96 0.86 to 1.07</td>
</tr>
<tr>
<td>50–55</td>
<td>62744</td>
<td>1561</td>
<td>24.9</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Length of service (years)

| <1         | 15454                  | 592                           | 38.3                                 | 1.87 1.49 to 2.34               |
| 1          | 13446                  | 751                           | 55.9                                 | 2.64 2.12 to 3.29               |
| 2          | 11856                  | 664                           | 56.0                                 | 2.72 2.18 to 3.39               |
| 3–4        | 13614                  | 656                           | 48.2                                 | 2.29 1.84 to 2.84               |
| 5–9        | 37028                  | 1691                          | 45.7                                 | 1.99 1.64 to 2.40               |
| 10–14      | 20179                  | 741                           | 36.7                                 | 1.86 1.55 to 2.24               |
| 15–19      | 99961                  | 3329                          | 33.3                                 | 1.67 1.44 to 1.94               |
| 20–24      | 110192                 | 3618                          | 32.8                                 | 1.52 1.33 to 1.74               |
| 25–29      | 74855                  | 2215                          | 29.6                                 | 1.41 1.24 to 1.61               |
| ≥30        | 49534                  | 938                           | 19.0                                 | 1.00                            |

Job category

| Train customer accompaniment operators | 25495 | 693 | 26.7 | 1.00 |
| Mechanical/diagnostic/electrotechnical operators and boilermakers-welders | 44248 | 3525 | 79.7 | 2.87 2.53 to 3.26 |
| Railway maintenance operators | 44155 | 2963 | 67.1 | 2.49 2.19 to 2.83 |
| Signposting/telecommunication/energy-electric traction/specialized mechanical operators | 28862 | 1161 | 43.2 | 1.66 1.45 to 1.91 |
| Other conception/construction/basic equipment/rolling equipment operators | 46824 | 922 | 19.7 | 0.78 0.67 to 0.90 |
| Transport production operators | 37612 | 2175 | 57.8 | 2.23 1.96 to 2.54 |
| Traffic operators | 34057 | 623 | 18.4 | 0.69 0.59 to 0.80 |
| Other operational production operators | 21575 | 622 | 28.8 | 1.12 0.96 to 1.30 |
| Train drivers | 51564 | 1238 | 24.0 | 0.82 0.72 to 0.94 |
| Other jobs | 113258 | 1273 | 11.2 | 0.48 0.42 to 0.55 |

Risk ratios were computed using negative binomial regression models featuring age, length of service and job.

Figure 1 Incidence rate (per 1000 person-years) of injuries by age and length of service.
We found that workers aged <25 years had higher injury risk due to handling materials/machine parts during assembly, using hand tools and collision with/by moving objects or vehicles (compared with the workers aged 25–44 years). Note that several studies of us on various populations (construction workers, railway workers, general working population) have also found an increased injury risk among the workers aged <30 years when controlling or not a number of potential risk factors (job, length of service, occupational demands, age, sex, education, obesity, smoking, alcohol abuse, diseases, disabilities, fatigue, sleep disorders, leisure physical/sports activity, income).6–10 Other authors have found the same result for workers aged <25 or <30 years.7–9 The present study is a large investigation that confirms these findings by taking into account a number of categories of length of service and jobs using prospective data on a very large cohort. Our findings indicate that preventive measures aimed at reducing injury among younger workers should include training in handling materials/machine parts, using hand tools and assessing environmental hazards, such as moving objects and vehicles in workplaces.

We found that in the younger age groups the incidence rates increased in the first years of service. Our data suggest that in the first years of service, progressively more risky jobs would be assigned to young workers compared with older workers, although their experience and job knowledge remain lacking.8 However, the change in the mixture of jobs cannot explain the phenomenon alone as, among younger age groups, the incidence rates increase with length of service in several job groups (figures...
by job group) and for several types of injuries, and particularly in the highest risk job group, the incidence rates were higher in the second year of service than in the first. The workers should be followed up during their first years of service.

We found that injuries due to handling materials/machine parts during assembly, lifting/handling objects or equipment or to using hand tools related to older age and that this risk rose steadily from the age of 35 years onwards. This finding suggests that older workers with lower physical strength,24 physical and mental impairments (after 45, >50% of participants suffer from impairments) or disabilities17 18 are subject to higher injury risk.20 although they do not curtail their occupational activities or change their working environment. We also found that older workers were subject to a higher risk of falling and that this risk increased above the age of 40–45 years. Falling often occurs when walking because balance-regulating mechanisms are overwhelmed by a destabilising event. Posture control is a complex sensorimotor function requiring central integration of multiple sensory afferences to select and execute a context-specific motor response leading to stabilisation of antigravity activity and gait. Damage to any of these systems influences the common output of the posture control and therefore causes a fall. Our result may be explained by increased sensorial and cognitive disabilities, which are well known to favour falling.17 18 33 among participants aged ≥40 years.17 Ageing healthy people have reduced posture control, associated with cognitive and brain structural involu-

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controlled. We did not take into account certain potential confounders such as previous job history and previous accident history. Because of the young age of retirement, there would be few participants who were lost due to a premature mortality during the follow-up period. As we focused on participants with a permanent work contract, those who had quit the company are very rare. The frequency of participants having two injuries or more was small. The injury risk found may be underestimated because of the well-known healthy worker effect. We investigated here the length of service with the company and not that in present job. Indeed, most participants have a very dominant job during their career. We should acknowledge that although the study population is very large, some adjusted RRs do not meet traditional levels of significance while their increasing or decreasing trends are often clear.

CONCLUSION
This study sheds light on the roles of younger and older age, length of service and job in injury-related mechanisms. Younger age favours injury due to handling materials/machine parts during assembly, collision with/by moving objects or vehicles and using hand tools, whereas older age (especially 50—55 years) favours falling and injury due to handling materials/machine parts during assembly, lifting/handling objects or equipment, collision with/by moving objects or vehicles, and using hand tools, independently of experience and job. Length of service plays an injury protection role, independently of age and job, and the trend is stronger for fall to lower level, lifting/handling materials/equipment and collision with/by moving objects. Job categories are affected by specific risks reflecting occupational activities. Our findings highlight the benefit of improving working conditions, providing training in terms of job knowledge, task performance and occupational hazard assessment from a worker’s first years in a job, as well as ensuring that a worker’s skill corresponds with his occupational activities. Workers should be helped to gain awareness of risks ensuring that a worker

REFERENCES