Absenteeism and mortality of workers exposed to electromagnetic fields in the French Electricity Company

A. Chevalier,* M. Souques,* F. Coing,* W. Dab† and J. Lambrozo†

*Service de Médecine de contrôle, and †Service des Études Médicales, EDF Gaz de France, 22/28 Rue Joubert, 75009 Paris, France.

The objective of this study was to describe the health status of electricity workers exposed to electromagnetic fields during their job. Two groups of exposed workers were studied from 1978 to 1993: the live line workers (n = 121) and the substation workers (n = 232.7) of the French Electricity Company (EDF). A control group was randomly selected from all the company non-management male employees; one control for each exposed subject was matched for the first year of employment. Absenteeism indices and mortality rates were computed and compared in the exposed and control groups. The absence rates were 1.98% in the substation workers and 2.5% in the control group (p < 0.001) and 2.7% in the live-line workers and 2.8% in the control group (NS). No effect of the length of exposure was found. However the medical causes of sickness absence were different: exposed employees had less psychiatric and respiratory diseases but more accidents at work than their control group. Relative risks of accidents at work were 1.2 [95% confidence interval (CI) = 1.08-1.33] for substation workers and 3.22 (CI = 1.78-5.88) for live line workers. EDF electromagnetic field exposed workers seemed not to be affected by any specific health problems except for an excess of accidents at work.

Key words: Electromagnetic fields; epidemiological surveillance; health status.

INTRODUCTION

The publication of several papers in the Soviet Union during the 1960s and especially a study on childhood leukaemias by Wertheimer and Leeper, led to electric and magnetic fields being considered the cause of many health effects, from loss of libido to cancer, including immunity and fecundity disorders, congenital malformations, miscarriages, suicides, depression, behaviour disorders and cardiovascular diseases. However, the results of all these studies are variable.

Current studies, particularly epidemiological surveys, have focused on the possible carcinogenic effects of extremely low frequency (ELF) electric and magnetic fields. However, no plausible biological mechanism has been found, despite the postulated involvement of such things, such as changes in melatonin levels.

Many studies have focused on electricity workers, because some of them are exposed to ELF electric and magnetic fields frequently during their work — in particular, the live-line workers. Live-line work began in Electricité de France, the French national company, about 30 years ago. It enables repair and maintenance work to be carried out on the transmission network without any interruption of power. This work was on low voltage lines in the 1960s. Work on high voltage lines (≥ 63 kV) began around 1970, but live-line maintenance of substations has been carried out for only about fifteen years. The workers most exposed to electric and magnetic fields hold jobs involving the maintenance and repair of high-voltage lines and substations (interconnections and transformation). These jobs are carried out by the Generation and Transmission Division of Electricité de France (EDF): line workers, substation workers and substation technical maintenance and operation workers (ATEX). The line and substation teams may or may not be qualified for live-line work.
they are, all the workers in the team have had specific training for live-line work. The team is then called a 'live team'. Otherwise, it is known simply as a 'conventional team'.

This retrospective longitudinal study was carried out to describe the health of the EDF employees most exposed to electric and magnetic fields as described above (high voltage live-line workers, substation workers and ATEX workers) over a period of 15 years, and to compare them with a representative sample of workers drawn from Electricité de France Gaz de France (EDF-Gaz de France) employees matched for the first year of employment for the same period (1978–92).

Health status was assessed using absences from work for medical reasons and deaths while still in employment. The specific situation of EDF-Gaz de France has made it possible to collect and analyze this type of data. The employees of EDF-Gaz de France have a common and special social security department. The social security consulting physicians have recorded all the health problems which have medico-administrative consequences, including short and long sickness absences, accidents at work, occupational diseases and deaths. Studies on absence from work have shown that these records can be a useful index of morbidity.12–16

A preliminary enquiry into employees qualified to work on live lines (≥ 63 kV) showed that their health was as good as that of the average for EDF-Gaz de France employees, except that they had more absences due to accidents.17 This cross-sectional preliminary survey covered only two years of absences (1989 and 1990), without reference to the period of employment in the job. A longitudinal survey seemed more appropriate for determining the average duration of exposure and to reveal any cumulative effect.

MATERIALS AND METHODS

Population

The EDF Generation and Transmission Division, which deals with all the employees working on high voltage, has 34 operational subgroups. Each subgroup includes (Figure 1): a line team of about 15 persons (a third of these teams are qualified to work on live lines); a substation team (also of about 15 persons) and 4–5 substation groupings, each with seven or eight ATEX workers.

The conventional line teams are not exposed to high levels of ELF electric and magnetic fields because the current is cut off when they work. But the live-line teams are exposed to very high magnetic fields for a few minutes a year. Their instantaneous occupational exposure while on live lines can reach 7 mT (mean = 160 μT during 20 hours of live-line work a year). The mean occupational exposure have been calculated from measures on live-line teams made by the Research Department of EDF. It is estimated at 9 μT.18 The live-line workers are not exposed to electric fields because they wear suitable clothes (made of metallic fibres forming a Faraday box).

The substation live-line teams are exposed to less intense magnetic fields than the live-line workers but for longer periods. Their average occupational exposure is 35 μT, and 700 μT while working on live lines.19 The substation conventional teams are also exposed because, although they work on a cut off electrical network, neighbouring networks are live. They, however, have a lower exposure than substation live workers. Both these two groups are exposed to electric fields (100 V/m on average). Lastly, the ATEX workers may be exposed for long periods, in cases where they live at their place of work. This was the case for two-thirds of the ATEX workers in 1992.

Figure 1. EDF Generation and Transmission Department.
This study considers two exposed groups, the live-line workers on one hand, the substation workers on the other hand, including maintenance and exploitation workers and those having worked simultaneously or consecutively on lines and at substations.

Methodology

The criteria for inclusion in the exposed group were as follows: male EDF employees who had worked for a total of at least one year in an exposed job between 1978 and 1992. These very specific occupations correspond to three job titles. We selected the exposed workers by using the Job History Database and, for the live-line workers, the Training Course Database. The date of the beginning of the training course (live-line workers) or the date of the first taking over a job (ATEX and substation workers) determined the entrance date in the study for exposed workers. A subject remained in an exposed group even if he left the job, but he only contributed to the study from the date of the first job occupied during the period of the study and until 1992, or his departure if he left the company before that date.

Length of exposure was taken as a surrogate of exposure assessment, no individual measurement of electric or magnetic field being available.

Because exposed workers were manual workers or foremen, the control group was randomly selected from all the EDF-Gaz de France non-management male employees who did not satisfy the above criteria. One control subject for each exposed worker was selected, matched for the first year of employment. Each control subject contributed to the study for the same duration and from the same date as his matched exposed subject. The occupations of the control group workers included: sales worker, skilled worker, technician, clerical worker, mechanic driver, plumber, etc. — occupations in which exposure to electromagnetic fields was not particularly high. The live-line workers were also compared to another control group: the conventional line workers.

Data

The employee database provided the job history (year of employment, position and qualification for each job, date of departure from the company, training courses) and sociodemographic data for 1993 (place of work, marital status, number of dependent children, professional category) for each subject. Sickness absences, long term illnesses and mortality (all identified by medical cause) were taken from the epidemiological database of the Social Security Department for each subject from the year following the first exposure to 31 December 1993 or the date of departure. In EDF-Gaz de France the social security consulting physicians do not monitor health of the workers after retirement.

Health indices were calculated as the annual absence rate, the annual percentage of absentees, the average number of spells of absence a year and the average number of days absent per year for each absentee. These two last indices indicate behaviour in terms of frequency and duration of absence from work.

This study also considers causes of sickness absence, long term illnesses or death before retirement, coded according to ICD-9. Very short periods of sick-leave were not monitored by the consulting physicians, and in these cases no medical cause could be identified. For 95% of sickness absences of more than 7 days medical causes were recorded. A study of very short (under 5 days) periods of sick leave has shown that absences were due to influenza, gastroenteritis or fatigue. It must be noted that workers remained classified as belonging to the company even if they suffered from a serious disease and that the vast majority of them worked for the company during their entire working life (there were fewer than 200 dismissals or resignations per year).

Statistical analysis was done with EPI-INFO and SAS statistical software using the chi-squared test and comparisons of means (two-sided tests).

RESULTS

Substation workers

This group of 2,327 subjects included 685 substation maintenance workers, 1,121 substation operators (ATEX workers) and 521 mixed maintenance/operation workers. Their average time in the job was 11.8 years (range: 1–37 years) in 1993 providing a total of 22,168 person-years. In 1993 the sociodemographic data which could influence absenteeism in the exposed and reference groups were similar: they were roughly the same age (41 and 41.3 years old) and had a similar distribution of marital status (unmarried, married or cohabiting, separated or divorced, widowed) and socio-professional class.

The annual absence rate of the exposed workers (2%) was significantly smaller than that of their matched controls (2.5%) (Table 1). The substation workers were absent less often and their absences were shorter than their matched control subjects. The only exception was the annual percentage of absentees: it was 38.9% in the exposed group and 34.5% in the control group (p < 0.001).

<table>
<thead>
<tr>
<th>Indices</th>
<th>Substation workers</th>
<th>Controls</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual absence rate</td>
<td>2%</td>
<td>2.5%</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Annual percentage of absentees</td>
<td>38.8%</td>
<td>34.5%</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Average number of spells of absence a year</td>
<td>1.5</td>
<td>1.7</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Average absence days a year for each absentee</td>
<td>21.0</td>
<td>23.3</td>
<td>p &lt; 0.001</td>
</tr>
</tbody>
</table>
The distributions of the absences according to medical causes were significantly different (Table 2): psychiatric and respiratory diseases were less frequent in the substation group than in the control group, and the substation group had more accidents at work. The relative risks were 1.2 (95% confidence interval (CI) = 1.08–1.33) for accidents at work and 0.44 (CI = 0.37–0.52) for psychiatric diseases.

When maintenance workers were separated from operational workers, the results were different: the ATEX group had fewer absences (28%) than their control group (36.9%) (p < 0.001). Their average annual number of sickness absences was 1.36 as compared with 1.65 (p < 0.001) and they were absent for 18.9 days a year as compared with 23 (p < 0.001) in the controls.

The difference between substation maintenance workers and controls is more subtle: the average numbers of absences and days absent were very similar but there were more absences per year in the exposed group (45.8%) than in the reference group (39.9%) (p < 0.001). This gives a higher annual absence rate (3.0) compared with 23 (p < 0.001) in the controls.

The effect of length of exposure on absenteeism was investigated by classifying each pair of subjects each year as follows: subjects were divided according to their exposure at that time for ≤ 5 years; 6 to 10 years; 11 to 15 years; 16 to 20 years and more than 20 years. Pairs were reclassified as length of time increased. The results were the same in all groups: exposed workers were absent less than the control group.

Lastly, we counted deaths and long-term illnesses occurring over the 14 years. There were no deaths in the controls and 16 deaths in exposed workers: five of ischaemic heart disease, four accidents, five due to cancer (three upper respiratory and digestive tract cancers, one brain tumour and one lung cancer), one AIDS-related and one suicide. The average annual mortality rate was 72 per 100,000. Twenty-one of the substation workers were affected by long-term illnesses due mainly to psychiatric diseases (five cases), cardiovascular diseases (five) and cancers (four). There were 38 long-term illnesses from 1979–93 in the control group.

**Table 2. Main medical causes of sickness absences for substation workers and controls (according to ICD-9)**

<table>
<thead>
<tr>
<th></th>
<th>Substation workers</th>
<th>Controls</th>
<th>x^2 test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Cancers</td>
<td>27</td>
<td>(0.2)</td>
<td>15</td>
</tr>
<tr>
<td>Psychiatric disorders</td>
<td>239</td>
<td>(2.1)</td>
<td>568</td>
</tr>
<tr>
<td>Circulatory disorders</td>
<td>168</td>
<td>(1.5)</td>
<td>201</td>
</tr>
<tr>
<td>Respiratory disorders</td>
<td>1,490</td>
<td>(13.4)</td>
<td>2,205</td>
</tr>
<tr>
<td>Digestive disorders</td>
<td>436</td>
<td>(3.9)</td>
<td>627</td>
</tr>
<tr>
<td>Genito-urinary disorders</td>
<td>125</td>
<td>(1.1)</td>
<td>189</td>
</tr>
<tr>
<td>Osteoarticular disorders</td>
<td>743</td>
<td>(6.7)</td>
<td>1,032</td>
</tr>
<tr>
<td>Accidents at work</td>
<td>778</td>
<td>(7.0)</td>
<td>853</td>
</tr>
<tr>
<td>Accidents outside work</td>
<td>675</td>
<td>(7.8)</td>
<td>1,060</td>
</tr>
<tr>
<td>Other causes</td>
<td>550</td>
<td>(4.9)</td>
<td>860</td>
</tr>
<tr>
<td>Missing diagnosis</td>
<td>5,718</td>
<td>(51.4)</td>
<td>6,951</td>
</tr>
<tr>
<td>Total</td>
<td>11,149</td>
<td>100.0</td>
<td>14,381</td>
</tr>
</tbody>
</table>

The annual absence rates in the two groups were very close: 2.7% for the line workers and 2.6% for controls, and the annual percentage of absentees were 42.3% and 42.1% (Table 3). The only significant difference was the annual number of absences per absent employee: 1.71 in controls and 1.45 in line workers.

The range of medical diagnoses of absences in the two groups (Table 4) was also different. The results were the same as for the case of the substation group but more marked: respiratory, digestive and psychiatric diseases were less frequent in the live-line group than in the control group. The results for osteoarticular diseases and accidents at work were the reverse. Accidents outside the workplace were similar in the two groups. The relative risk of psychiatric disorders was 0.078 (CI = 0.01–0.62); 1.89 (CI = 1.11–3.27) for osteoarticular diseases and 3.22 (CI = 1.78–5.88) for accidents at work.

We intended to carry out a complementary survey of these accidents to find out more about their circumstances and severity by means of a questionnaire completed by the social security consulting physicians. Only two out of 47 accidents could be linked to live work. The other 45 seemed to be associated with aspects of the occupation of lineman such as travel, outdoor activities, use of dangerous tools, etc.

This greater incidence of accidents at work was further analyzed by comparing the sickness absence of live-line workers to that of conventional linemen in the EDF Generation and Transmission Division whose...
occupation, except for live work, was similar. The average age of conventional linemen in 1993 was 40.1 years — not significantly different from live-line male workers. The absence indices of the live-line workers were lower than for the conventional line workers (Table 3). They had significantly more absence spells for accidents at work and osteoarticular diseases than the conventional line workers. The number of absences due to respiratory diseases, however, was smaller (Table 4). The medical reasons for absence in the two line man groups were more similar than for the control group. For instance, the annual percentage of absences due to accidents at work was 7.2% for live linemen and 6.1% for conventional linemen vs. 2% for controls.

As for the substation group, we investigated the effect of exposure time on absenteeism of line workers, classifying them in two groups: in the first group were the live linemen who had spent less than 5 years in that job; in the second group were those who had been in their job for more than 5 years. There was no significant difference between the exposed and unexposed subjects (Table 5).

Table 3. Absence indices for live-line workers, controls and conventional line workers

<table>
<thead>
<tr>
<th>Indices</th>
<th>Live line workers</th>
<th>Controls</th>
<th>Conventional line workers</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual absence rate</td>
<td>2.6%</td>
<td>2.6%</td>
<td>3.4%</td>
<td>(1.2): NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.3): p &lt; 0.02</td>
</tr>
<tr>
<td>Annual percentage of absentees</td>
<td>42.3%</td>
<td>42.1%</td>
<td>50.6%</td>
<td>(1.2): NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.3): p &lt; 0.001</td>
</tr>
<tr>
<td>Average number of spells</td>
<td>1.4</td>
<td>1.7</td>
<td>1.6</td>
<td>(1.2): p &lt; 0.01</td>
</tr>
<tr>
<td>of absence a year</td>
<td></td>
<td></td>
<td></td>
<td>(1.3): p &lt; 0.01</td>
</tr>
<tr>
<td>Average absent days a year for</td>
<td>23.0</td>
<td>22.3</td>
<td>24.9</td>
<td>(1.2): NS</td>
</tr>
<tr>
<td>each absentee</td>
<td></td>
<td></td>
<td></td>
<td>(1.3): NS</td>
</tr>
<tr>
<td>Person-years</td>
<td>624</td>
<td>624</td>
<td>4,490</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Main medical causes of sickness absences for live-line workers and controls (according to ICD-9)

<table>
<thead>
<tr>
<th>Causes</th>
<th>Live-line workers (1)</th>
<th>Controls (2)</th>
<th>Conventional line workers (3)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancers</td>
<td>2 (0.5)</td>
<td>0</td>
<td>9 (0.2)</td>
<td></td>
</tr>
<tr>
<td>Psychiatric disorders</td>
<td>1 (0.3)</td>
<td>21 (4.6)</td>
<td>37 (1.0)</td>
<td></td>
</tr>
<tr>
<td>Circulatory disorders</td>
<td>5 (1.3)</td>
<td>6 (1.3)</td>
<td>45 (1.2)</td>
<td></td>
</tr>
<tr>
<td>Respiratory disorders</td>
<td>34 (6.8)</td>
<td>68 (15.1)</td>
<td>464 (12.5)</td>
<td></td>
</tr>
<tr>
<td>Digestive disorders</td>
<td>12 (3.1)</td>
<td>29 (6.4)</td>
<td>121 (3.3)</td>
<td></td>
</tr>
<tr>
<td>Genito-urinary disorders</td>
<td>2 (0.5)</td>
<td>10 (2.2)</td>
<td>23 (0.6)</td>
<td></td>
</tr>
<tr>
<td>Osteoarticular disorders</td>
<td>40 (10.4)</td>
<td>22 (4.9)</td>
<td>302 (8.2)</td>
<td></td>
</tr>
<tr>
<td>Accidents at work</td>
<td>47 (12.2)</td>
<td>16 (3.5)</td>
<td>302 (8.2)</td>
<td></td>
</tr>
<tr>
<td>Accidents outside work</td>
<td>34 (8.8)</td>
<td>40 (8.9)</td>
<td>302 (8.2)</td>
<td></td>
</tr>
<tr>
<td>Other causes</td>
<td>7 (1.8)</td>
<td>22 (4.9)</td>
<td>160 (4.3)</td>
<td></td>
</tr>
<tr>
<td>Missing diagnosis</td>
<td>200 (52.2)</td>
<td>217 (48.1)</td>
<td>1929 (52.2)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>384 (100.0)</td>
<td>451 (100.0)</td>
<td>3695 (100.0)</td>
<td></td>
</tr>
</tbody>
</table>

Significance of the test comparing groups 1 and 2: p < 0.01.
Significance of the test comparing groups 1 and 3: p < 0.02.

Table 5. Absence indices of substation workers and controls according to exposure length

<table>
<thead>
<tr>
<th>Indices</th>
<th>Group 1 (exposure 1 to 4 years)</th>
<th>Group 2 (exposure 5 to 13 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exposed</td>
<td>Unexposed</td>
</tr>
<tr>
<td>Annual absence rate</td>
<td>2.7%</td>
<td>2.5%</td>
</tr>
<tr>
<td>Annual percentage of absentees</td>
<td>47.0%</td>
<td>43.8%</td>
</tr>
<tr>
<td>Average annual number of spells of absence a year</td>
<td>1.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Average absent days a year for each absentee</td>
<td>21.2</td>
<td>20.9</td>
</tr>
</tbody>
</table>
Lastly, we considered two important health events, long-term illness and death. None of the 121 live line- 
men or any of the controls suffered long-term illness or death during the study period.

DISCUSSION

This study focuses on two workforces who were highly 
exposed to ELF electromagnetic fields but in two different 
ways: firstly, the exposure was for a limited period 
only to high and intense magnetic fields for the live line-
men; secondly the exposure was over a longer period and 
at a lesser intensity to magnetic and electric fields for the 
substation workers. Among these people, some were live-
line workers having had a specific training and others 
were not. We put together in the 'substation group' the 
maintenance substation workers and the ATEX workers 
because some of these people performed both of those 
jobs in their career and because the exposures associated 
with these two jobs seemed comparable to us. We also 
included in that group the few linemen who worked 
afterwards as substation workers or ATEX workers.

The live linemen formed a very interesting group 
because their magnetic field exposure was very specific. 
Nevertheless, the analysis of their health problems was 
limited because of their small number: only 121 subjects 
were suitable for inclusion in the study; therefore, only 
very common diseases could be studied. It is noteworthy 
that results in that group were similar to that of the sub-
station group, which was composed of more subjects.

The epidemiological surveillance of substation and 
live-line workers was undertaken by analyzing absences 
for medical reasons, short and long duration and deaths 
before retirement. Medical absenteeism and health status 
are two different concepts but in the special context of 
EDF-Gaz de France, previous studies have shown that 
absence from work is a reliable indicator for the most 
disabling diseases.13

Assessing morbidity using absenteeism has obvious 
limits: diseases such as diabetes, arterial hypertension or 
cardiac dysrhythmias rarely cause worker disability. On 
the contrary, with other diseases, such as myocardial 
infarction or cancer, it appears to be a valid approach so 
that two registers could be set up at EDF-Gaz de France 
based on medically related absences.23,24 Its usefulness 
for depression is slightly different: some subjects, recog-
nized as depressed by diagnostic tests such as MINI, 
do not take sick-leave. Therefore, the absenteeism ap-
proach underestimates the number of depressed workers 
and gives greater weight to serious cases.

This study showed that the health of these workers 
was not different to that of the control group: almost all 
the global absence indices were lower for the exposed 
workers than for the control groups. For these two work-
ers' groups, exposed to different levels of electromagnetic 
field, the medical causes of absences were similar and 
clearly different to the control results. These observations 
could be due to the choice of the controls because in the 
two exposed groups, workers had jobs that required 
good physical and mental health.

In such a study, the choice of controls is difficult. For 
the live line group, we managed to find the best control 
group: the conventional linemen. The jobs are identical 
except for the live work. For the other group, it seemed 
to us that a randomization from non-executive EDF and 
Gaz de France employees was the best way to obtain a 
comparable group. It is possible that a 'selection effect' is 
present, due to the difficulty in controlling for compar-
able physical jobs.

When all diagnoses are considered, exposed workers 
had more accidents at work and fewer respiratory and 
psychiatric disorders than their matched controls, in 
agreement with the findings of a preliminary study17 
for the years 1989 and 1990. The small number of absences 
taken for psychiatric disorders could be due to selection 
for high voltage work training. This kind of job is prob-
ably offered only to workers who are psychologically and 
physically stable. However, the same result was also ob-
served in conventional line workers and ATEX workers, 
who do not attend the training. It could also be the effect 
of having a 'vital' occupation, because of the associated 
risks and because of their important role in ensuring the 
continuation of the power supply. A recent study in 
EDF-Gaz de France on occupational factors influencing 
occupational role in the genesis of these troubles.26 The small 
number of absences taken for respiratory disorders could 
also be interpreted as a positive effect of working in a 
natural atmosphere — outdoor workers having a higher 
resistance to respiratory viruses — or of a lower con-
sumption of tobacco. The excess of accidents at work 
could be due to a harmful effect of live-line working; 
procedures while live-line working are very precise and 
workers are careful in their work. During mundane work, 
it is possible that their vigilance decreases. The other 
medical causes, including cancers and circulatory dis-
orders, are too rare to be compared.

Somewhat surprisingly, there were no deaths among 
the controls of substation workers while 16 were observed 
in the exposed group. The annual mortality rate among 
male employees of EDF-Gaz de France declined in 
1979–92: the average was 231 per 100,000 — three 
times the mortality rate in substation workers of 72 per 
100,000. The causes of death seem to be the same as in 
EDF-Gaz de France male employees.27 It is noteworthy 
that cancer is the primary cause of death in the age 
group 35–60 years in France28 as in the EDF-Gaz de 
France Company27 and that, probably due to a high level 
consumption of both tobacco and alcohol, upper respira-
tory and digestive tract cancers are very common in 
France.29 The cancer mortality rate of substation workers 
is comparable to that of all the company employees.

Long-term illnesses were also under-represented in the 
exposed group: the annual incidence was 95 per 100,000 
in the substation group, whereas it was 200 among EDF-
Gaz de France employees during the same period.30
One of the aims of this study was to determine whether there were cumulative effects of electromagnetic field exposure, evaluated by the duration in an exposed job. The results were the same, regardless of the length of the exposure for live line workers or for substation workers. Thus, data for short and long absences and deaths while employed indicate that EMF exposed workers at EDF do not experience any major problems. However, only health status before retirement is covered by this statement. The next step will be to explore the study population mortality with the help of the national mortality database. This study was not an aetiologial one. The role of exposure to electromagnetic fields in the occurrence of cancer among EDF–Gaz de France employees was examined in the Franco–Canadian study. The present study is an epidemiological surveillance study. This kind of survey is rare. Knave studied transformer substation workers and found no chronic health effects that were different from those of controls from the same company matched for age, geography and duration of employment. Malboyyson has also conducted a similar survey. The results were negative, as were those of Broadbent. Unlike Poole and Perry, we found no excess of mental diseases, especially depression, among the live workers. Other authors, like Savitz and McMahon, also found no evidence of such disorders in the population which they studied. Two recent studies on populations living near high voltage transmission lines showed a small association between electromagnetic field exposure and psychiatric symptomatology that needs to be investigated more carefully.

In conclusion, the epidemiological database of the Social Security Department made it possible to survey a specific group of employees, the workers of Electricité de France most exposed to electric and magnetic fields. No specific health problems could be detected except for an excess of accidents at work. To complete this work it would be interesting to study the workers' mortality including that after retirement, every five years.

REFERENCES

1. Asanov TR, Rakov AL. The state of health of persons working in electric field of outdoor 400 kV and 500 kV switchyards. Hyg Labor Prof Dis 1966.
21. EPI-INFO, Version 5.1. Atlanta, GA (USA): CDC.


