

## EPIDEMIOLOGY OF SUICIDES AMONG WORKERS EXPOSED OCCUPATIONALLY TO ELECTROMAGNETIC FIELDS, ORGANIC SOLVENTS AND PESTICIDES

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**Summary.** We present an epidemiological study on a possible association between suicide and occupational exposure to electromagnetic fields, pesticides and organic solvents. A total of 7,512 deaths within the period 1994-2002 were analyzed. The assessment of occupational exposure was based on the job title reported in death certificates and medical protocols. The exposed group comprised 5,762 deaths (1,890 workers exposed to pesticides, 1,945 to organic solvents, and 1,927 to electromagnetic fields). The control group consisted of 1,750 deaths with no prior exposure to these noxae. The exposure assessment has shown that the incidence of suicide deaths was significantly higher in the workers exposed to electromagnetic fields, pesticides and organic solvents, compared to controls. Suicide mortality in the exposed group increased with the length of exposure to these noxae. Our results suggest an association between suicide and occupational exposure to electromagnetic fields, organic solvents and pesticides. More research involving a greater number of exposed deaths is warranted for further evaluation of the results.

**Key words:** Suicides, workers, electromagnetic fields, pesticides, organic solvents

### Introduction

The problem of suicide is as old as man and his civilisation. A suicidal act is a man-specific phenomenon and has therefore been present in all human cultures and historical epochs. Being still an enigma, it is a subject of contemplation and debate among experts in various fields. The term itself refers to a voluntary act leading to death as an expression of one's despair, helplessness and anger.

In the United States, suicide is currently the 11<sup>th</sup> leading cause of death (1). An increased risk of suicide is found among the elderly, divorced and widowed individuals of both genders (2,3).

The etiology of suicide is multifarious. The most frequent causes include illness, social and family circumstances, spiritual disorientation, hopeless situations, loneliness, neglect, helplessness, failure, emotional blows, fear, strong sentiment of responsibility or striving for a heroic act (4-14). Boxer et al. (15) reviewed several studies that evaluated the risk of suicide in relation to employment in specific occupations. Many of these occupational cohort studies reported a suicide risk among workers potentially exposed to chemicals as compared to an external reference population. Few studies, however, focused on specific occupational exposures that could have neurobehavioral effects possibly leading to suicide. Literature data provide evidence that

the factors of occupational exposure can play an important role in suicide etiology, as well (16-19).

An analysis of suicide etiology is most important as it provides the basis for preventive measures that, if adequate, can reduce the number of potential suicides by almost 60% (20,21,22).

### Aim

The aim of the study was to investigate a possible association between suicide and occupational exposure to electromagnetic fields, pesticides and organic solvents.

### Method

The study population comprised 7,512 deaths within the period 1994-2002, whose profession was identified on the basis of death certificates. Eligible subjects were workers between the age 18-65 at the time of death, for whom informative occupational data and complete information on marital status were available. Subjects with unknown occupation, students, volunteers, or those who never worked were excluded. Data from the original certificates of death from suicides and data from medical protocols were analyzed. The analysis focused on specific occupational exposures that could have neu-

robbehavioral effects possibly leading to suicide. The subjects were classified as the exposed or the unexposed based on their occupation (23,24). The specific exposure analyses focused on electromagnetic fields, organic solvents and pesticides. The following jobs were thought to involve exposure to electromagnetic fields: electrical and electronic engineers, electrical, household and telephone repairers, electrical and electronic technicians, broadcast equipment operators, electricians and electrician apprentices, power plant operators and motion picture projectionists.

Jobs considered to involve direct exposure to organic solvents included painters, mechanics and repairers, carpenters, furniture and wood finishers, shoe repairers, machine operators, printers and laborers.

Occupations taken as involving potential exposure to pesticides included farmers and farm workers, veterinarians, pest-control-related occupations, farm managers and supervisors, marine life cultivation workers, nursery workers, groundskeepers and gardeners, animal caretakers, graders and inspectors of agricultural products, forestry workers and loggers.

The exposed group comprised 5,762 workers who died within the period 1994-2002 and who had been exposed occupationally to pesticides (1,890 workers), organic solvents (1,945 workers) and electromagnetic fields (1,927 workers).

The control group included 1,750 workers who died within the examined period and who were assumed not to have been significantly exposed to chemical or physical agents: clerks, engineers, entertainers, legal workers, managers, salesmen, surveyors, teachers and writers. As marital status, age and gender are all relevant to suicide (2,3), they were considered potential risk factors in our study. Marital status was classified as single, married, divorced or widowed as indicated in the death certificate.

The subjects were divided into three groups on the basis of the age at death: 18-34 years, 35-49 years, and 50-65 years.

An analysis of statistical significance was performed using Chi-squared values.

### Results

The incidence of suicides in the exposed group (15.2%) was statistically more significant compared to the control (1.1%) ( $p < 0.001$ ). The highest rate was registered in the group exposed to electromagnetic fields (17.7%). The association between suicide and exposure to electromagnetic fields is given in Table 1. The suicide rate was slightly higher in males than females, and in divorced, widowed or single workers than married ones. Suicide mortality showed to increase with the length of exposure to electromagnetic fields. The highest mortality was found in the age group of 18-34 years.

The association between suicide and exposure to pesticides is given in Table 2. Suicides were statistically more frequent in the workers exposed to pesticides (16.4%) than in controls (1.1%) ( $p < 0.001$ ). Suicide among females and divorced, widowed or single workers occurred at a rate slightly higher than that observed among males and married workers. Suicide mortality increased with the length of exposure to pesticides. The highest suicide incidence was found in the age group of 18-34 years.

The association between suicide and exposure to organic solvents is given in Table 3. Suicide mortality was statistically more significant in the group exposed to organic solvents (11.5%) than the control group (1.1%) ( $p < 0.001$ ). The suicide rate was slightly higher in males than females, and in divorced, widowed or

Table 1. Suicides in workers exposed to electromagnetic fields

Items	Exposed to electromagnetic fields			Control group		
	Number of deaths	Number of suicides	Percent of suicides	Number of deaths	Number of suicides	Percent of suicides
<b>Age (years)</b>						
18-34	341	92	26.9	275	7	2.5*
35-49	647	135	20.9	594	6	1.0*
50-65	939	114	12.1	881	6	0.7*
<b>Length of exposure (years)</b>						
Under 10	282	35	12.4	239	4	1.7*
11-20	488	84	17.2	435	5	1.1*
21-30	474	89	18.8	428	5	1.2*
31-40	683	133	19.5	648	5	0.8*
<b>Sex</b>						
Male	971	271	27.9	878	8	0.9*
Female	956	70	7.3	872	11	1.3*
<b>Marital status</b>						
Married	483	81	16.8	441	4	0.9*
Single	477	88	18.4	437	5	1.1*
Divorced	485	90	18.6	439	5	1.1*
Widowed	482	82	17.0	433	5	1.1*
Total	1927	341	17.7	1750	19	1.1*

\* Differences between the exposed and control group are statistically significant.

Table 2. Suicides in workers exposed to pesticides

Items	Exposed to electromagnetic fields			Control group		
	Number of deaths	Number of suicides	Percent of suicides	Number of deaths	Number of suicides	Percent of suicides
<b>Age (years)</b>						
18-34	325	75	23.1	275	7	2.5*
35-49	632	133	21.0	594	6	1.0*
50-65	933	103	11.0	881	6	0.7*
<b>Length of exposure (years)</b>						
Under 10	275	34	12.4	239	4	1.7*
11-20	469	72	15.3	435	5	1.1*
21-30	481	74	15.4	428	5	1.2*
31-40	665	131	19.7	648	5	0.8*
<b>Sex</b>						
Male	952	132	13.8	878	8	0.9*
Female	938	179	19.1	872	11	1.3*
<b>Marital status</b>						
Married	474	68	14.3	441	4	0.9*
Single	479	78	16.3	437	5	1.1*
Divorced	468	79	16.9	439	5	1.1*
Widowed	469	86	18.3	433	5	1.1*
Total	1890	311	16.4	1750	19	1.1*

\* Differences between the exposed and control group are statistically significant.

Table 3. Suicides in workers exposed to organic solvents

Items	Exposed to electromagnetic fields			Control group		
	Number of deaths	Number of suicides	Percent of suicides	Number of deaths	Number of suicides	Percent of suicides
<b>Age (years)</b>						
18-34	351	55	15.7	275	7	2.5*
35-49	643	93	14.5	594	6	1.0*
50-65	951	76	7.9	881	6	0.7*
<b>Length of exposure (years)</b>						
Under 10	291	31	10.6	239	4	1.7*
11-20	485	54	11.1	435	5	1.1*
21-30	488	56	11.5	428	5	1.2*
31-40	681	83	12.2	648	5	0.8*
<b>Sex</b>						
Male	984	149	15.1	878	8	0.9*
Female	961	75	7.8	872	11	1.3*
<b>Marital status</b>						
Married	495	51	10.3	441	4	0.9*
Single	483	57	11.8	437	5	1.1*
Divorced	487	59	12.1	439	5	1.1*
Widowed	480	57	11.9	433	5	1.1*
Total	1945	224	11.5	1750	19	1.1*

\* Differences between the exposed and control group are statistically significant.

single workers than married ones. The incidence of suicides increased with the length of exposure to organic solvents. The age group of 18-34 years was found to be at the highest risk of suicide.

## Discussion

The elevated risks for a specific occupation could be a consequence of a complex interaction between job factors, such as work stress or isolation, access to medical care, environmental and occupational exposures, and other risk factors including the presence of mental and addictive disorders. In addition, the type of personality

that chooses to enter a specific profession may be important (15). Previous research suggested that physicians and nurses are at increased suicide risk (15,25), whereas the evidence is somewhat more inconsistent for other occupations such as dentists, electric utility workers, farmers, forestry workers, and police officers (15, 26,27,28). A recent study has found the highest risk of suicide in the mining industry (29). In another study, the increased risk of suicide was found in the occupations such as a dentist, electrician, fisherman, logger, metal miner, and welder, but for physicians and nurses it could not be confirmed (30). The obvious variations in occupational suicide risks could be due to methodologi-

cal differences between various studies, including study population, statistical model, covariance included in the statistical analysis, time period of study, definition of exposure, and definition of the reference group.

The years of the economic crisis in our country, war, waves of refugees, intensive political turmoil, ongoing transition, low income and uncertainty have certainly contributed to an increased number of vulnerable subjects who choose to commit suicide.

The association between suicide and exposure to electromagnetic fields is inconsistent. Some studies have found evidence for the association (31, 32), whereas others have not (33,34). In our study, suicide is related to occupations potentially involving exposure to electromagnetic fields. The association was somewhat more convincing in the younger age groups and males. Age correlates inversely with suicide risk, in a manner similar to the pattern previously observed (35). The findings correspond to the results of those authors who register an increased number of suicides among electricity-related professions (36,37). These results may be accounted for by the property of electromagnetic fields to inhibit production of melatonin, the lack of which may lead to mental depression as an important risk factor for suicide (31).

A limited number of epidemiologic studies have investigated the association between suicide and occupational exposure to organic solvents and pesticides. Welp et al. (38) studied the mortality from nervous system diseases and mental disorders, including suicide, with respect to occupational exposure to styrene. Having found that the mortality from suicide was highest among short-term workers and those with the lowest cumulative exposure, the authors hypothesized that the patterns observed for suicide may have been due to non-occupational factors, including alcohol use (38). In our study the incidence of suicide in the workers exposed to organic solvent was significantly higher compared to controls. These results can be explained by the neurotoxic effects of organic solvents. Solvents are soluble in fat and may produce chronic neurotoxicity, including emotional disturbances (19) as a contributing factor in the suicide. Frequent suicides among the workers exposed to organic solvents may be accounted for by the cumulative effects of this noxa, as well as by work-related stressful factors such as hard physical effort, mental effort, dysfunctional interpersonal relations, dis-

satisfaction with the job, and bad socioeconomic status in that industry branch (39, 40).

Two studies have evaluated the association between pesticide exposure and death from suicide. Paron et al. (34) found that the suicide rate in a geographic area with farmers chronically exposed to pesticides was higher than the suicide rates in other geographic areas with similar demographic and socioeconomic characteristics. In addition, farmers were found to be at a higher risk of suicide as compared to the general population. In a more recent study, Pickett et al. (41) evaluated suicide mortality in relation to pesticide use among Canadian farmers. Although a suicide risk was generally not associated with pesticide use in this population, some evidence suggests an elevated risk among farm operators. Further suggestive evidence for a role of pesticide exposure in the etiology of suicide was found in studies of forestry workers (42, 43). Our study demonstrates an elevated risk among professions involving a likely pesticide exposure. The highest risks were found among females between the ages 18-34, but these findings were based on a relatively small number of exposed deaths. The results are consistent with the findings of those authors who demonstrated that the use of pesticides in regular work could have a special role in the origin of suicide (44). It has also been claimed that various chemicals used in farming can contribute to a higher incidence of suicides due to their neurotoxic effects (45). Some agricultural pesticides are cholinesterase-reducing agents that may affect the function of neurons and transmission of information through the central nervous system, possibly leading to psychiatric disorders such as anxiety and depression (46). An English study also confirms a high incidence of suicides in farmers and pesticide-production-related jobs (45). Australian authors register a high rate of depression and suicide among the rural population, recommending that special counseling offices should be opened to deal with this problem (47).

## Conclusion

The results of our study provide additional evidence for an association between suicide and occupational exposure to electromagnetic fields, organic solvents and pesticides. More research with a greater number of exposed deaths seems warranted for further evaluation of the findings.

## References

1. Hoyert DL, Freedman MA, Strobino DM, Guyer B. Annual summary of vital statistics 2000. *Pediatrics* 2001; 108: 1241-1255.
2. Monk M. Epidemiology of suicide. *Epidemiol Rev* 1987;9: 51-69.
3. Moscicki EK. Identification of suicide risk factors using epidemiologic studies. *Psychiatr Clin North Am* 1997;20: 499-517.
4. Gould MS, Fisher P, Parides M. Psychosocial risk factors of child and adolescent completed suicides. *Archives of General Psychiatry* 1996; 53: 1155-1162.
5. Cheng ATA, Mann AH, Chan KA. Personality disorder and suicide. A case control study. *British Journal of Psychiatry* 1997; 170: 441-446.
6. Appleby L, Cooper J, Amos T. Psychological autopsy study of suicides by people aged under 35. *British Journal of Psychiatry* 1999; 175: 168-174.
7. Fombonne E. Suicidal behaviours in vulnerable adolescents. Time trends and their correlates. *British Journal of Psychiatry* 1998; 173: 154-159.
8. Gunell D, Wehner H, Frankel S. Sex differences in suicides trends in England and Wales. *Lancet* 1999; 353: 556-557.

9. Gunnell D, Lopatatzidis A, Dorling D. Suicide and unemployment in young people. Analysis of trends in England and Wales, 1921-1995. *British Journal of Psychiatry* 1999; 175: 263-270.
10. Harris EC, Barraclough B. Excess mortality of mental disorder. *British Journal of Psychiatry* 1998; 173: 11-53.
11. Borges G, Rosovsky. Suicide attempts and alcohol consumption in an emergency room sample. *J Stud Alcohol* 1996; 57: 543-548.
12. Shaffer D, Gould MS, Fisher P. Psychiatric diagnosis in child and adolescent suicide. *Archives of General Psychiatry* 1996; 53: 339-348.
13. Greenberg PE, Stiglin LE, Finkelstein SN, Berndt ER. Depression: a neglected major illness. *J Clin Psychiatry* 1993; 54: 419-424.
14. Feldmann TB, Holt J, Hellard S. violence in medical facilities: a review of 40 incidents. *J Ky Med Assoc* 1997; 95: 183-189.
15. Boxer PA, Burnett C, Swanson N. Suicide and occupation: a review of the literature. *J Occup Environ Med* 1995; 37: 442-452.
16. Boglioli LR, Taff ML. Deaths at the workplace. Accidents or homicides? *Am J Forensic Med Pathol* 1990; 11: 66-70.
17. Eisele GR, Watkins JP, Mathews KO. Workplace violence at government sites. *Am J Ind Med* 1998; 33: 485-492.
18. Pelpins LA, Burnett C, Alterman T, Lalich N. Mortality patterns among female nurses: a 27 state study, 1984 through 1990. *Am J Public Health* 1997; 87: 1539-1543.
19. Abbate C, Giorgianni C, Munao F, Pesarin F, Salmaso L. Neurobehavioral evaluation in humans exposed to hydrocarbons: a new statistical approach. *Psychother Psychosom* 2001; 70: 44-49.
20. Rutz W. Preventing suicide and premature death by education and treatment. *J Affect Disord* 2001; 62: 123-129.
21. Doege TC, Holinger PC. Understanding and preventing injuries. *Am Fam Physician* 1990; 42: 680-686.
22. Thase ME, Saloum IM, Cornelius JD. Comorbid alcoholism and depression. Treatment issues. *J Clin Psychiatry* 2001; 20: 32-41.
23. Shnidzer PG, Teschke K, Olshan AF. A classification scheme for aggregating U.S. census occupation and industry codes. *Am J Ind Med* 1995; 28: 185-191.
24. Savitz DA, Loomis DP, Tse CK. Electrical occupations and neurodegenerative disease: analysis of U.S. mortality data. *Arch Environ Health* 1998; 53: 71-74.
25. Kposowa AJ. Suicide mortality in the United States: differentials by industrial and occupational groups. *Am J Ind Med* 1999; 36(6): 645-652.
26. Goodman RA, Jenkins EL, Mercy JA. Workplace related homicide among health care workers in the United States, 1980 through 1990. *JAMA* 1994; 272: 1686-1688.
27. Allgulander C, Evanoff B. Psychiatric diagnoses and perceived health problems in a sample of working Swedes treated with psychoactive medications. *J Psychoactive Drugs* 1990; 22: 467-478.
28. Aleksander RE. Stress related suicide by dentist and other health care workers. Fact or folklore? *J Am Dent Assoc* 2001; 132 (6): 625-629.
29. Perry FS, Reichmanis M, Marino AA, Becker RO. Environmental power-frequency magnetic fields and suicide. *Health Phys* 1981; 41: 267-277.
30. van Wijngaarden E. An Exploratory Investigation of Suicide and Occupational Exposure. *Occup Environ Med* 2003; 45 (1): 96-101.
31. van Wijngaarden E, Savitz DA, Kleckner RC. Exposure to electromagnetic fields and suicide among electric utility workers. *Occup Environ Med* 2000; 57 (4): 258-263.
32. Baris D, Armstrong BG, Deadman J, Theriault G. A case cohort study of suicide in relation to exposure to electric and magnetic fields among electrical utility workers. *Occup Environ Med* 1996; 53: 17-24.
33. Johansen C, Olsen JH. Mortality from amyotrophic lateral sclerosis, other chronic disorders, and electric shocks among utility workers. *Am J Epidemiol* 1998; 148: 362-368.
34. Parron T, Hernandez AF, Villanueva E. Increased risk of suicide with exposure to pesticides in an intensive agricultural area. A 12-year retrospective study. *Forensic Sci Int* 1996; 79: 53-63.
35. Kposowa AJ. Unemployment and suicide: a cohort analysis of social factors predicting suicide in the US National Longitudinal Mortality Study. *Psychol Med* 2001; 31: 127-138.
36. Poole C, Kavet R, Funch DP, Donelan K, Chary JM, Dreyer NA. Depressive symptoms and headaches in relation to proximity to an altering current transmission line right of way. *Am J Epidemiol* 1993; 137: 318-330.
37. Foster T, Gillespie K, McClelland R. Risk factors for suicide independent of DSM-III-R Axis I disorders. *British Journal of Psychiatry* 1999; 175: 175-179.
38. Welp E, Kogevinas M, Andersen A. Exposure to styrene and mortality from nervous system diseases and mental disorders. *Am J Epidemiol* 1996; 144: 623-633.
39. Romanov K, Appelberg K, Honkasalo ML, Koskenvuo M. Recent interpersonal conflict at work and psychiatric morbidity: a perspective 15,370 employees aged 24-64. *J Psychosom Res* 1996; 40: 169-176.
40. Feskanich D, Hastrup JL, Marshall JR, Colditz GA, Stampfer MJ, Willett WC et al. Stress and suicide in the Nurses Health Study. *J Epidemiol Community Health* 2002; 56: 95-98.
41. Picket W, King WD, Lees RE, Bienefeld M, Morrison HI, Brisson RJ. Suicide mortality and pesticide use among Canadian farmers. *Am J Ind Med* 1998; 34: 364-372.
42. Green LM. A cohort mortality study of forestry workers exposed to phenoxy acid herbicides. *Br J Ind Med* 1991; 48: 234-238.
43. Green LM. Suicide and exposure to phenoxy acid herbicides. *Scand J Work Environ Health* 1987; 13: 460-469.
44. Stallones L. Suicide mortality among Kentucky farmers, 1979-1985. *Suicide Life Threat Behav* 1990; 20: 156-163.
45. Maroni M, Colosio C, Feroli A, Fait A. Biological Monitoring of Pesticide Exposure. *Toxicology* 2000; 7(1): 110-118.
46. Amr MM, Halim ZS, Moussa SS. Psychiatric disorders among Egyptian pesticide applicators and formulators. *Environ Res* 1997; 73: 193-199.
47. Malkom H. A primary mental health care model for rural Australia: outcomes for doctors and the community. *Aust J Rural Health* 2000; 8(3): 167-172.

## EPIDEMIOLOGIJA SAMOUBISTAVA KOD RADNIKA PROFESIONALNO IZLOŽENIH ELEKTROMAGNETNIM POLJIMA, ORGANSKIM RASTVARAČIMA I PESTICIDIMA

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Kratak sadržaj. Ova epidemiološka studija izučava povezanost samoubistava i profesionalne ekspozicije elektromagnetnim poljima, pesticidima i organskim rastvaračima. Studija analizira 7512 smrtnih ishoda koji su se dogodili u periodu od 1994 do 2002 godine kod radnika. Procena profesionalne ekspozicije je vršena na osnovu zanimanja umrlog upisanog u sertifikat o uzroku smrti i medicinske dokumentacije umrlog. Eksponovanu grupu je činilo 5762 umrlih (1890 radnika koji su ranije bili eksponovani pesticidima, 1945 radnika koji su ranije bili eksponovani organskim rastvaračima i 1927 radnika koji su ranije bili profesionalno izloženi elektromagnetnim poljima). Kontrolnu grupu je činilo 1750 umrlih koji nikada ranije nisu bili profesionalno eksponovani ovim noksama. Prevalencija samoubistava je bila statistički značajno češća u grupi radnika koji su bili profesionalno eksponovani elektromagnetnim poljima, pesticidima i organskim rastvaračima nego u kontrolnoj grupi. Prevalencija suicida u eksponovanih radnika raste sa dužinom ekspozicije ovim noksama. Rezultati istraživanja ukazuju na povezanost samoubistava i profesionalne ekspozicije elektromagnetnim poljima, organskim rastvaračima i pesticidima. Dalja istraživanja u ovoj oblasti su poželjna i potrebno ih je provesti na većem broju ispitanika.

Ključne reči: Samoubistvo, radnici, elektromagnetno polje, pesticidi, organski rastvarači