

ABSTRACT

In order to apply the precautionary principle to the possible cancer risks from occupational ELF magnetic fields, cost-effective measures to reduce time-weighted average (TWA) exposures were developed in four Dutch factories. Communication materials were also prepared to persuade occupational hygienists and managers to implement these measures voluntarily and to train workers in precautionary work practices. Follow-up measurements in a Dutch paper mill suggest that such training can reduce TWA magnetic fields exposures. However, the other factories did not implement our recommended precautions, showing the many barriers faced by voluntary exposure reductions. Going forward, health communication models will be used to overcome barriers to the adoption of precautionary reductions in occupational ELF magnetic field exposures.

INTRODUCTION

Magnetic fields (MF) at extremely low frequencies (ELF) are a possible human carcinogen based on associations of leukemia and brain cancer with time-weighted average (TWA) exposures as low as $0.3 \mu\text{T}$ [1,2]. A quantitative risk assessment [2] reported that a $1 \mu\text{T}$ reduction in TWA occupational magnetic fields might reduce the possible risks of premature cancer deaths by 0.40% (0.07-0.73%), which **Figure 1 compares to other common mortality risks.**

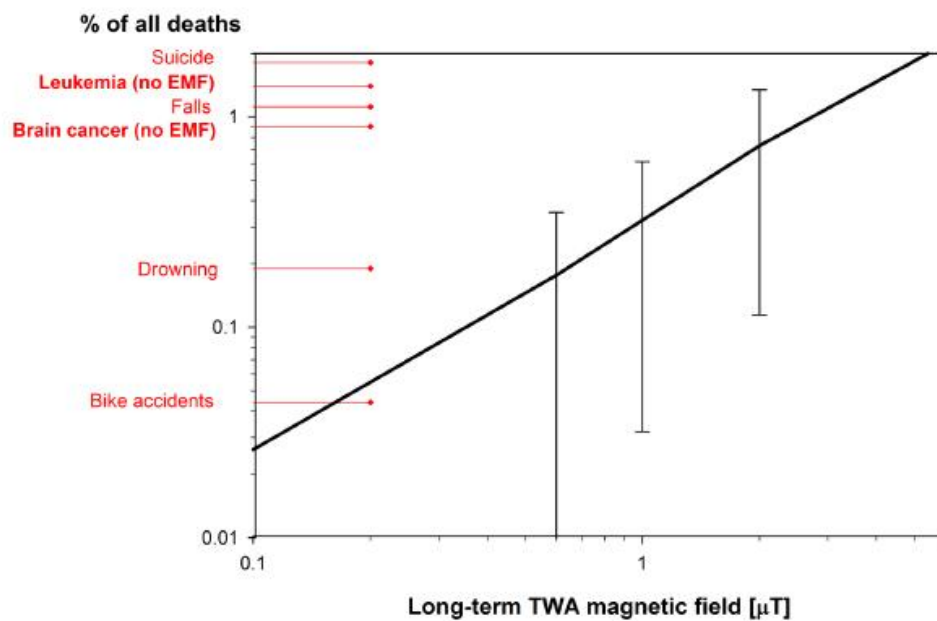


Figure 1. Possible risks of premature deaths from workplace magnetic fields (with 95% confidence limits) derived from the mortality rates adjusted for the causality probability in NIOSH's quantitative risk assessment [2].

To address these possible cancer risks, the recommendation of the World Health Organization's 2007 criteria on ELF-MF was:

Provided that the health, social and economic benefits of electric power are not compromised, implementing very low-cost precautionary procedures to reduce exposures is reasonable and warranted... [1]

However, precautionary methods for reducing occupational ELF exposures are lacking.

These findings suggest a precautionary strategy for workplace MF:

- 1) Design cost-effective measures to reduce TWA exposures;*
- 2) Develop messages to persuade employers, occupational hygienists and workers to adopt these precautionary measures.*

To pilot this strategy, NIOSH collaborated with the Institute of Risk Assessment Sciences (IRAS) at Utrecht University to help develop these methods and test them at four Dutch workplaces.

Acknowledgments: Dr. Yvette Christopher-de Vries (IRAS) was invaluable in directing the Dutch pilot study.

METHODS

Study Design

Table 1 summarizes the five phases of the study design. Based on an ELF-MF survey of 35 Dutch workplaces, companies with 2 or more occupations with TWA > 0.3 μ T were asked to participate in this pilot study. From walk-through surveys and the baseline MF monitoring at the participating companies, low-cost engineering and administrative controls were designed for sources that exposed workers to TWAs above 0.3 μ T. The measures were refined through discussions with the company's occupational hygienists and supervisors of the high MF processes. Where changes in work practices would be cost-effective, presentations were developed to teach workers the precautionary measures designed for their work area. The Dutch companies were asked to use our presentations to train their workers in the precautionary work practices, and then repeat the full-shift monitoring. The TWAs from these follow-up measurements were compared with the baseline measurements in order to evaluate the effectiveness of our recommendations.

Table 1. Company participation in each stage of the study

	Requests	Participants	Rate
Pre-measurements for survey study	65	35	54%
Walkthrough for precautionary study	14*	4	29%
Presentation to IHs and foremen	4	3	75%
IHs agree to worker training	3	2	67%
Management agrees to training and post-measurement	2	1	50%

*Companies with TWAs > 0.3 μ T in at least 2 occupations

Precautionary Messages

Slide shows for training the Dutch workers on precautionary work practices were developed and tested with NIOSH's Training Research Branch (Figure 2). The language and numeric information in the slides were tailored to worker audiences by avoiding complex sentences, jargon, and equations. For each company, a slide show targeted at its MF sources was presented to occupational hygienists and supervisors so that they could train their workers (the "train the trainer" model of health communications). When a company declined to use the NIOSH slide show with their workers, we asked for their reasons.



Figure 2. Two slides from the presentations given to the occupational hygienists and supervisors at Dutch companies for training their workers on precautionary exposure reduction measures. The hygienist who recommended this training to his management translated the slides into Dutch.

References:




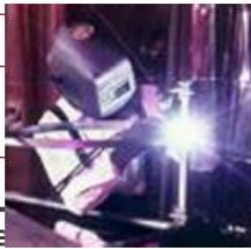
1. World Health Organization. *Extremely Low Frequency Fields*. Environmental Health Criteria #238 (2007), p. 372.
2. Bowman JD, Ray T, Park R. Possible health benefits from reducing occupational magnetic fields *American Journal of Industrial Medicine* 56:791-805 (2012).
3. Bowman JD, Touchstone J, Yost MG. A population-based job exposure matrix for power-frequency magnetic fields. *Journal of Occupational and Environmental Hygiene*. 4:715-728 (2007).
4. McMahan S, Witte K, Meyer J. The perception of risk messages regarding electromagnetic fields: Extending the extended parallel process model to an unknown risk. *Health Communication*, 10: 247-259 (1998).

RESULTS

Table 1 gives the number of Dutch companies that participated in the five stages of this study. Table 2 lists the factories which participated in walk-through surveys, their sources of high ELF-MF exposures, and the cost-effective interventions designed from the collected data.

Table 2. Precautionary measures for reducing TWA magnetic fields

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Source	Exposure reduction measure	
<u>Railroad car refitting plant</u>		
Induction furnace	Install remote control	
Handheld fault tester	Purchase lower emission model	
Induction heater	Increase distance when operating	
Arc welder	Do not run cable over the shoulder	
<u>Auto body plant</u>		
Manual spot welder	Install jig for part + remote control	
Robotic spot welding	Electric-work-only zones	
Arc welding	Do not run cable over shoulder	
Power center	Electric-work-only zones	
<u>Plastics plant</u>		
Chlorine cell hall	Electric-work-only zones	
	Install video cameras for inspections Turn off neighbor cells during repairs	
Power center	Electric-work-only zones	
Rectifier rooms	Electric-work-only zones	
<u>Paper mill</u>		
Arc welding	Do not run cable over shoulder	
Power plant	Electric-work-only zones	
Transformers by walkway	No-go zone	
Maintenance jobs	Identify hi-field sources to avoid	
Other jobs	Training on EMF hazards and exposure	

The “electric-work-only zones” were developed for tasks whose TWA can be reduced by spending less time in an area with elevated exposures. Work practices in these zones minimize the time spent on tasks that do not involve direct work with the MF field source (Fig. 3).

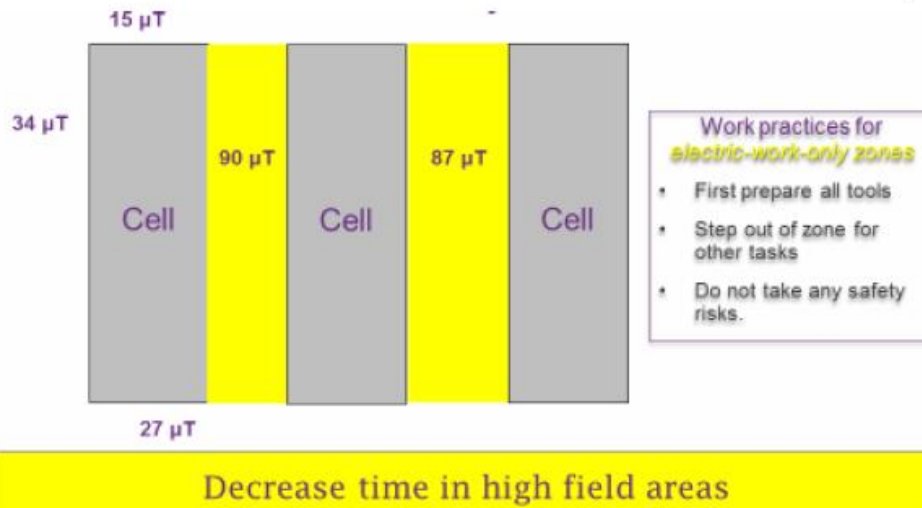


Figure 3. Electric-work-only zones in passageways between rows of electrolysis cells identified from spot measurements (above) and personal monitoring data.

The “no-go zone” in Figure 4 was also identified by spot measurements, but in this case, workers were trained not to enter the zone except to work on the transformers.

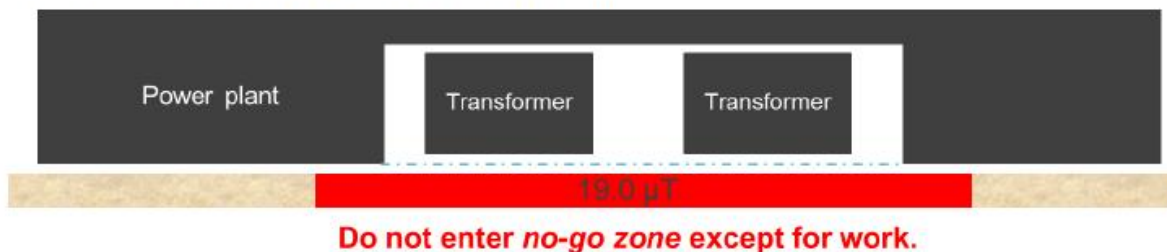


Figure 4. No-go zone recommended for a walkway beside two transformers in the Dutch paper mill.

After paper mill workers were informed about avoiding high magnetic field sources, follow-up MF monitoring suggested some reduction in TWA exposures (Figure 5).

RESULTS (continued)

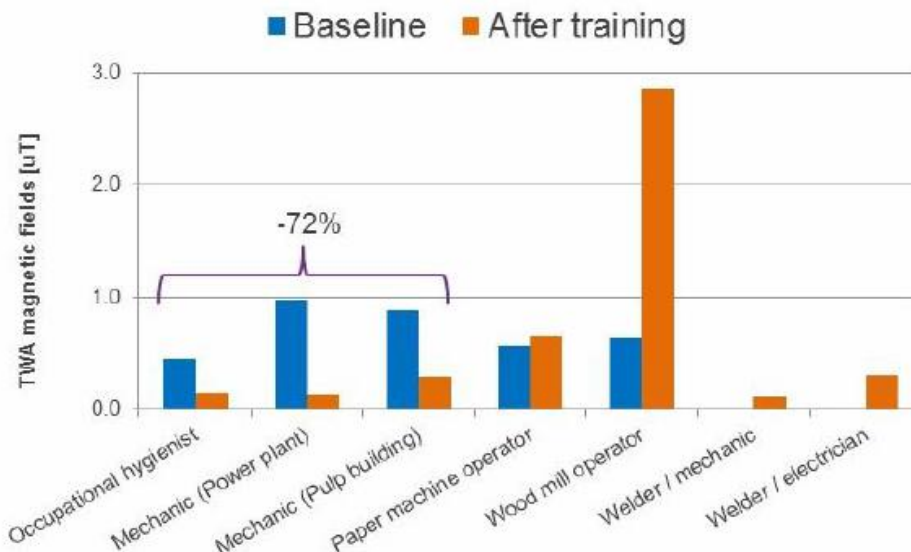


Figure 5. Magnetic field exposures measured on paper mill workers before and after training on sources of high ELF-MF and work practices for reducing exposures. TWAs = 0.1 – 0.2 μT for welder/mechanic and welder/electrician after training were less than the population means for these occupations (welder = 0.83 μT , electrician = 0.44 μT and mechanic = 0.21 μT [3]).

However, the management at the other three factories did not adopt our recommended precautions because: 1) EMF regulations are not based on the cancer risks; 2) Other workplace hazards were a higher priority; and 3) reluctance to raise the cancer-EMF association with their workers. In the focus groups, U.S. occupational hygienists suggested other barriers: the scientific controversy over ELF-MF carcinogenicity, and the difference between precautionary exposure reductions and the standard paradigm of compliance with exposure limits. The hygienist's acceptance of precautionary recommendations was greater, however, when they are combined with strategies to prevent the proven hazards from ELF-MF, including electromagnetic interference with pacemakers and other electronic implants.

CONCLUSIONS

The Dutch pilot study showed that practical low-cost measures can be identified for reducing the TWA of ELF-MF and therefore the possible cancer risks associated with occupational exposures. However, precautionary exposure reduction through changes in work practices is a novel paradigm for occupational health practice, which faces several barriers to adoption by managers, workers and occupational hygienists. Going forward, NIOSH has identified models of health communication (Figure 6, for example) that address these barriers and will be using them to strengthen the communication materials on ELF-MF precautionary recommendations.

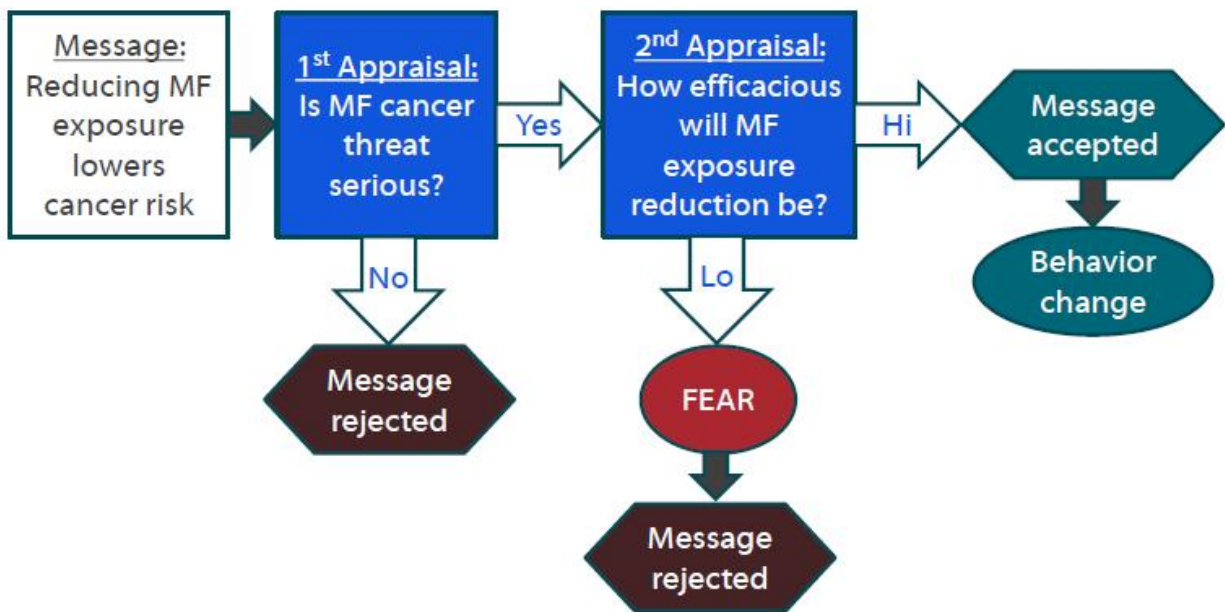


Figure 6. Extended Parallel Process Model [4] applied to a worker's response to a precautionary message.

The ultimate goal is to develop a comprehensive package of recommendations for managing the proven and possible hazards of occupational ELF-EMF.

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