



Epidemiological studies on health effects of ELF MFs with a novel approach for exposure assessment

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Extremely low frequency magnetic fields

- Frequency range: $0 < f \leq 300$ Hz
- Main sources to general public: powerlines, in-house electrical installations, household appliances...



ELF MFs and health/ Childhood leukemia

- A large number of epidemiological studies published since 1979
- Classified as a possible human carcinogen (Class 2B) in June 2001 by IARC
 - Mainly based on two pooled analyses showing 2-fold risk with ELF MFs above 0.3 – 0.4 μ T (Ahlbom et al. 2000, Greenland et al. 2000)
- Pooled analyses of more recent studies of ELF MF and childhood leukemia are in line (Kheifets et al. 2010; Zhao et al. 2014)
- Causality of the association?

Problems in previous studies

- Low number of highly exposed subjects
- Exposure assessment
- Confounding
 - E.g. socioeconomic status
 - Other environmental exposures
- Selection bias
 - Differential participation of cases and controls

ELF MFs and health/ Adult cancers

- Research data on adult cancers more limited and contradictory
- Most existing studies focus on occupational exposure
- In residential exposure studies, exposure estimate often solely on distance to powerline
- Diseases studied: leukemias, lymphomas, breast cancer, brain and CNS cancers...
 - Several studies have suggested stronger effects for some of the disease subtypes
 - Female breast cancer: most studies negative

Experimental findings

- No generally accepted biophysical mechanism
- Animal and *in vitro* studies
 - Possibly affecting cancer risk with other exposures
 - Studies showing that biological processes in cultured cells can be influenced by relatively weak ELF MFs
- Radical pair mechanism (review by Juutilainen et al. 2018)

ELF MFs and health/ Alzheimer's disease

- Most existing studies focusing on occupational exposure
 - Meta-analyses suggest that there might be an association (the most recent Jalalian et al. 2018)
- Two studies addressing residential exposure (using distance to power lines as metrics) had slightly different results
- A systematic review on environmental risk factors for dementia (Killin et al. 2016) listed EMFs as one of the factors which future research should focus on
- Often mortality data used
- Also studies related to other neurodegenerative diseases

ELF MFs and health /Reproduction

- Miscarriage
 - Limited evidence available
 - Problems with e.g. exposure assessment
- Other endpoints e.g. birth weight, small-for-gestational age, stillbirth
- Our recent study (Eskelinen et al. 2016): ELF MF exposure not likely associated with time to pregnancy or foetal growth

Conclusions on the existing knowledge

- Seems clear that further research is needed
 - New findings from experimental studies
- If we want to truly increase the knowledge of this topic -> new approaches are required
- Indoor transformers in residential buildings provide such an approach
 - Indoor transformers generate stronger MFs than commonly in the environment

Development of the new approach

- Major advantages:
 - More highly exposed subjects in the study group
 - No contact with the study participants needed, possible to avoid selection bias
 - Exposure assessment carried out blind to the health status
 - Study subjects live in same buildings, effect of confounding lower

Development of the new approach



Kuva 2: Rakenneluokka U1



Kuva 7: Rakenneluokka M1



Kuva 13: Rakenneluokka D

Pictures borrowed from the Final Report of TransCat project

Development of the new approach

- Validation study carried out in Finland (Ilonen et al. 2008)

TABLE 1. Results of Spot Measurements of Magnetic Fields in Apartments Above Transformer Stations and in Reference Apartments in the Same Buildings

	Apartments above transformer stations (<i>n</i> = 30)	Reference apartments, first floor (<i>n</i> = 28)	Reference apartments, other floors (<i>n</i> = 30)
All apartments			
Apartment mean, μT	0.62 (0.20–1.36)	0.21 (0.04–0.84)	0.11 (0.02–0.50)
Apartment maximum, μT	2.57 (0.34–13.43)	0.61 (0.08–4.59)	0.22 (0.03–1.30)
Apartment minimum, μT	0.17 (0.04–1.14)	0.09 (0.01–0.43)	0.05 (0.01–0.27)
Mean $\geq 0.2 \mu\text{T}$, <i>n</i> (%)	30 (100)	10 (36)	3 (10)
Mean $\geq 0.4 \mu\text{T}$, <i>n</i> (%)	21 (70)	4 (14)	2 (6.7)
Mean $\geq 0.8 \mu\text{T}$, <i>n</i> (%)	8 (27)	1 (3.6)	0 (0)

Table modified from Ilonen et al. 2008

Development of the new approach

- If first floor "reference" apartments excluded, a transformer station under the floor predicts 24-h mean MF with
 - a sensitivity of 0.41 (or 0.58)
 - a specificity of 0.997 (or 0.97) depending on cut-off point (0.2 or 0.4 μT)
- Similar validation studies carried out also in Bulgaria, Hungary, Israel, the Netherlands, Switzerland
 - Similar kind of results obtained

Development of the new approach

- Does classification based in structural characteristics of the transformers improve exposure assessment? (Okokon et al. 2013)
 - High exposure, intermediate exposure
 - Not necessary to detect existence of an increased risk
 - Useful for evaluating exposure-response relationship

U1: Bus bars near the ceiling

U2: Cables near the ceiling

U3: Shielded bus bars or cables near the ceiling

M1: Transformer and low-voltage switchboard next to each other, unshielded connection

M2: Transformer and low-voltage switchboard next to each other, shielded connection

M3: Cables on the wall

D: Cables on or under the floor

Conclusions on the usability of the new approach

- Allows accurate exposure assessment
- Finnish registries facilitate completing of the study
- International TransExpo study on childhood leukemia launched and provided financial support



Let's proceed to the epidemiological study

How the register was compiled?

- Electricity distribution companies operating in major Finnish cities contacted and asked for a list of addresses of indoor transformers
- Companies were not able to provide data on structural characteristics of transformers, only installation and renovation dates
- Total of 3498 addresses received
 - Some were directly identified as non-residential and removed from data
 - Some addresses were incomplete and had to be removed
 - Approximately 1300 buildings remained in the data-set

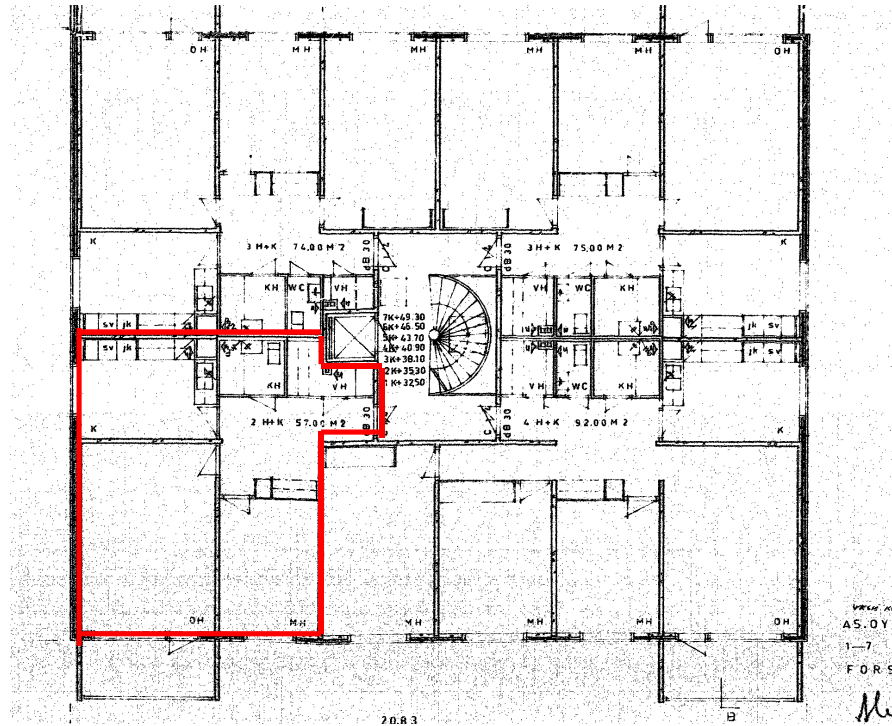
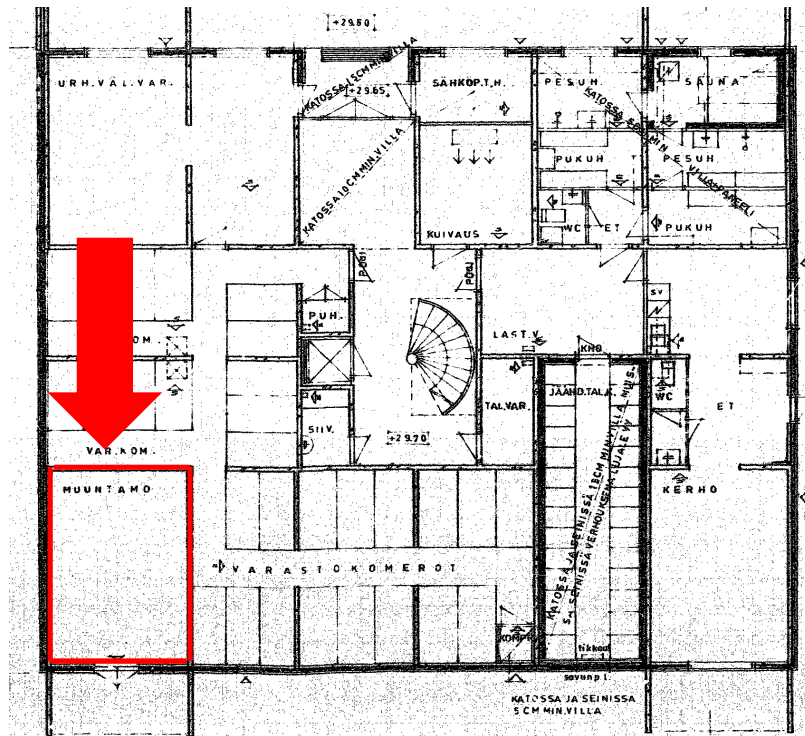
How the register was compiled?

- Blueprints of these 1300 buildings were obtained from municipalities
 - Some were missing or incomplete
 - Some were still found to be non-residential
 - In many cases, the transformer was in a separate building (e.g. garage) or there was no apartment above or adjacent to the transformer
 - In some cases, not possible to correctly number the apartments
- Approximately 700 buildings included in the final data-set
 - 25 100 apartments

How the register was compiled?

- Every apartment of these buildings classified according to their location in relation the transformer:
 - Above the transformer (1)
 - Sharing a wall with the transformer (2A, 2B)
 - One floor above the transformer (3)
 - Apartments above apartments in class 1 (4)
 - Other apartments (5)
- Classification checked with building data obtained from Population Registry

An example of a blueprint



How the register was compiled?

- Information on people who live or have lived in these buildings obtained from Population Registry
- Total of 305 369 residents
- People are classified according to in which type of apartments they have lived
 - Basis for the exposure assessment

What will be done to complete the study?

- Several health effects can be studied using this data-set
 - Childhood leukemia (international TransExpo study)
 - Adult cancers: leukemias, lymphomas, brain cancers, skin cancers
 - Alzheimer's disease
 - Data on diagnoses from Drug Imbursement Register
 - Miscarriages
 - Data from Birth Register and Care Registers of Health Care

What will done to complete the study?

- Permissions obtained for using data from Cancer Registry and Health Care Registers (miscarriage data)
 - Childhood leukemia data will be sent to UCLA and analysed together with similar data from other countries (results ready 2020?)
 - Adult cancer and miscarriage data analysed by us by the end of 2019
- Application for a permission to use data on Alzheimer's disease will be submitted soon

Thank you!



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