



Exposure to extremely Low Frequency Magnetic Fields (ELF-MF) in the workplace: JEM validation

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Overview

- ELF-MF and long-term health effects?
- EU Regulations
- Validation of a Job Exposure Matrix using ELF-EMF measurements from the Netherlands
 - Results & Conclusions to date

Electromagnetic Spectrum

Extremely
Low
Frequencies
(ELF)

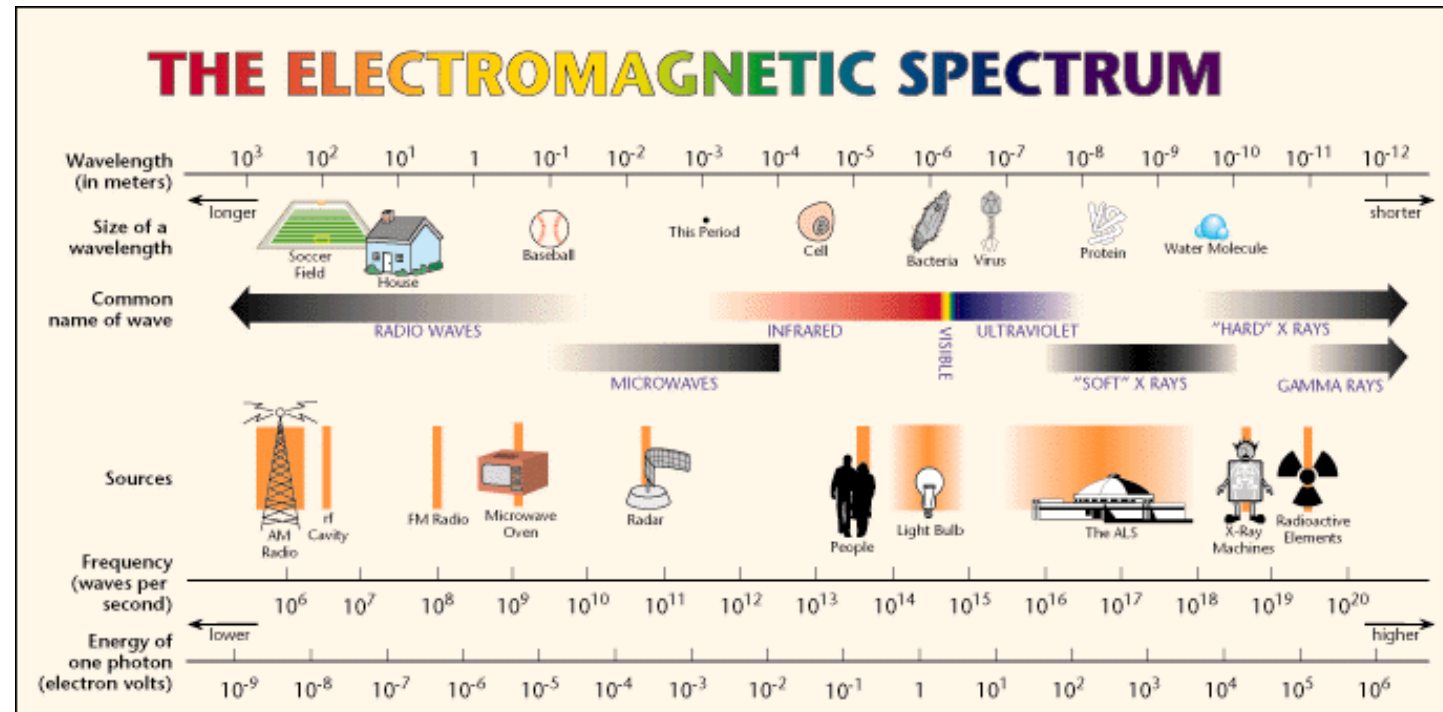
60 Hz

Electrostimulation & ???

Heating

Photo-
chemistry

Ionization



EMF Units

- Electric fields

- Electric field strength (**E**)

- Units: volts / meter (V/m)

- Magnetic fields

- Magnetic field strength (**H**)

- Units: amperes / meter (A/m)

RF magnetic
fields

- Magnetic flux density (**B**)

- Units: microtesla (μT)

- **B** [μT] = 1.26 **H** [A/m] in air and our bodies

High-Voltage Transmission Lines



- Line under repair is usually de-energized in the Netherlands.
- Current is switched to lines on other side of tower.
- Worker magnetic field exposure less than 500 μT .

Bare-hands Work on Transmission Lines



- Worker bonded electrically to line.
- Suit shields against electric fields.
- Depending on the line current, magnetic fields can exceed 1,000 μT exposure limit.

Induction Metal Heating



Heat treating
209 kHz, 2.4 kW

Ladel furnace

50 Hz, 3.6 MW



- Metal heated by magnetic fields
- Frequencies from 50 Hz to 8 MHz
- Little harmonics
- Greatest source of workplace MFs (up to 20,000 μT)

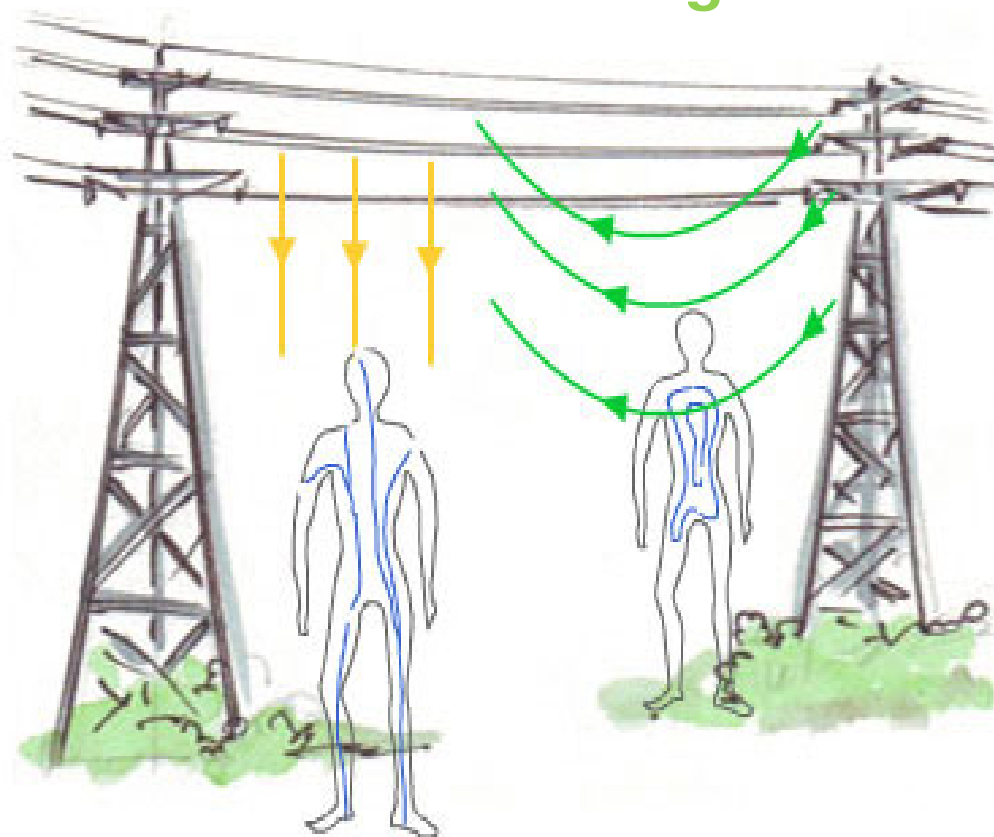
EMF sources: Man-made - Home

	50 cm	30 cm	5 cm
Coffee machine	-	0.08 – 0.15	-
Toaster (800 W)	0.07 μ T	0.4 μ T	5.25 μ T
Microwave oven	0.07 μ T	0.2 μ T	17 μ T
Stove hotplate	-	0.1 – 0.35	-
Extractor fan (153W)	0.5 μ T	1 μ T	6 μ T
Electric shaver			15 – 1500
Electric toothbrush (plugged)	-	0.02 μ T	-
Hair dryer	0.2 μ T	1 μ T	18 μ T
Halogen lamp (500W)	-	0.2	-
Florescent tube	-	0.6 μ T	-
Electric alarm clock	0.25 μ T	0.75 μ T	2 μ T

ELF-EMF and their Interaction with the Body

Electric field **Magnetic field**

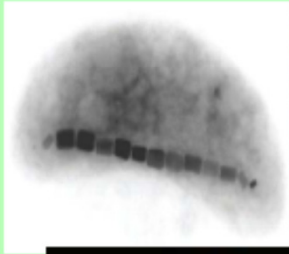
**Induced current
by 50Hz electric
field**



**Induced current
by 50Hz magnetic
field**

Magnetic Navigation

Due to magnetite particles found in animals and humans



All possess biogenic magnetite or other membrane bound iron-mineral particles (magnetosomes) used for navigation

(magnetic sensitivity exists in all major groups of vertebrate animals, as well as in some molluscs, crustaceans and insects, including flies, chickens and mole rats)





Health Effects from ELF-EMF

- Neurological disturbances like *magnetophosphenes*
- Basis for OELs
 - For example, magnetic field TLV = 1,000 micro- Tesla (uT) peak at 60 Hz
- Exceeded only in a few work sites like underground distribution vaults



ELF Magnetic Fields and Chronic Diseases

- Leukemia and brain cancer
 - IARC Possible Carcinogen (Group 2B)
 - Based on epi studies in homes
 - Associations with childhood leukemia for home TWA > 0.3 μ T
 - Little support from animal and cellular studies
 - Occupational cancer risks?
 - IARC and WHO → Insufficient evidence
 - NIEHS and the California Health Dept. → Possible Ca
 - Occupational TWA > 0.3 μ T → cancer risks > 1:1,000 [Bowman et al., 2012]
- Neurodegenerative diseases
 - Possible for Alzheimer's disease and ALS

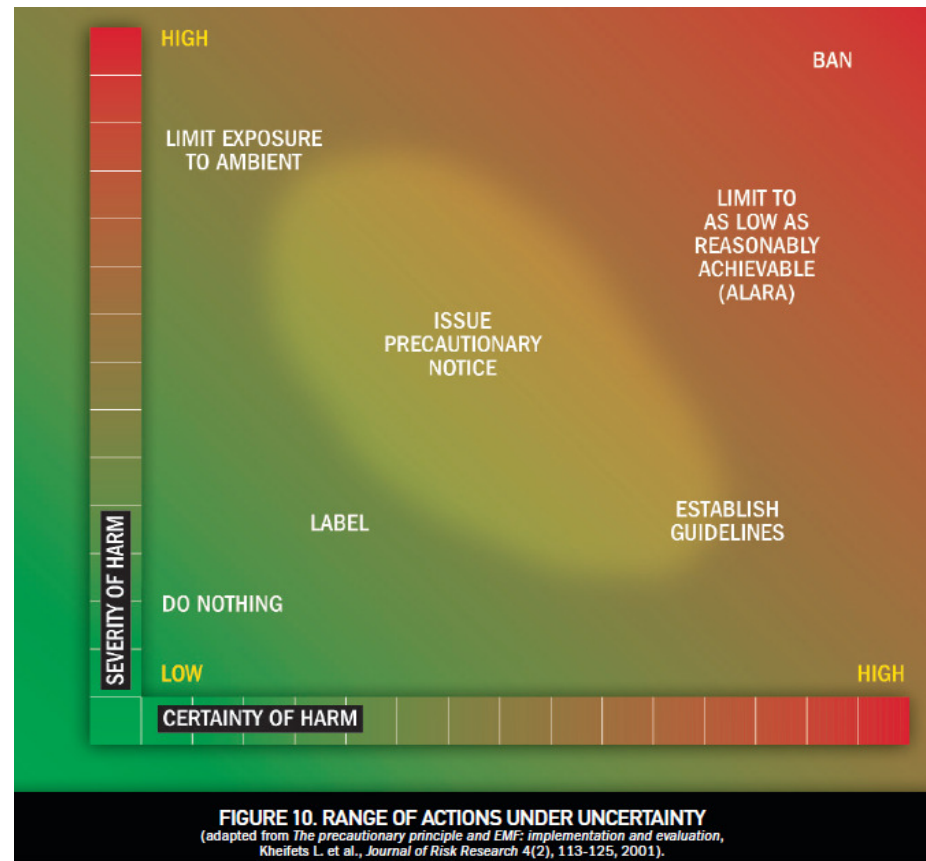


ADVISORY AND REGULATORY BODIES

Institute for Risk Assessment Sciences

IARC, WHO and the precautionary principle w.r.t 50 Hz EMF

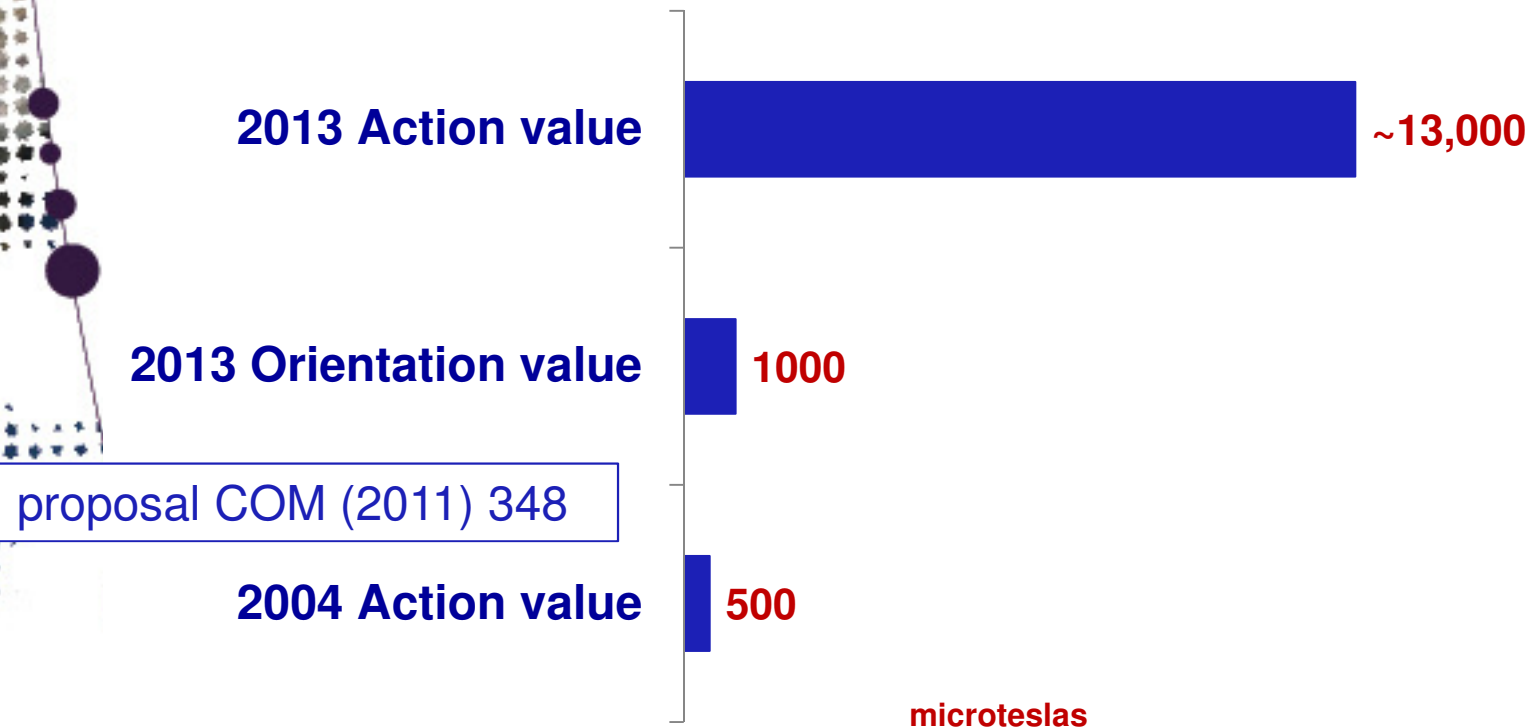
- IARC
 - 2B (possible carcinogen)
- WHO
 - Precautionary principle



Source: WHO Establishing a dialogue on risks from EMF

http://www.who.int/peh-emf/publications/en/emf_final_300dpi_chp3.pdf

EU regulations: EU Directive (2004/40/EC)





VALIDATION OF A JOB EXPOSURE MATRIX

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Aim(s)

- To validate and refine an ELF-JEM for use in epidemiological studies
- Tool to inform industry about job titles/tasks with expo that may exceed EU regulations
(2004/40/EC amended by 2008/46/EC)

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	A	C	D	E	F	G	H	I	J	P	R
1	ISCO88	DESCRIPTION	Subjects	Records	Sources	AMuT	SDuT	GMuT	GSD	DataType	Definite
169	3130	Optical and electronic equipment	49	41		0.319	0.473	0.169	3.030	Raw	1
170	3131	Photographers and image and sound	9	1	1	0.182	0.123	0.148	1.916	Raw	0
171	3132	Broadcasting and telecommunications	14	14	1	0.795	0.679	0.625	1.979	Raw	2
172	3133	Medical equipment operators	26	26	2	0.110	0.074	0.087	2.123	Raw	1
173	3139	Optical and electronic equipment operators not elsewhere classified	23	15	2	0.555	0.609	0.355	2.647	Inferred	1
174	3140	Ship and aircraft controllers and technicians	259	8		1.090	0.618	0.939	1.665	Raw	1
175	3141	Ships' engineers				0.820	0.915	0.548	2.457	Judgment	1
176	3142	Ships' deck officers and pilots				0.306	0.286	0.224	2.207	Judgment	1
177	3143	Aircraft pilots and related associate professionals	256	5	1	1.103	0.611	0.972	1.491	Raw	2
178	3144	Air traffic controllers	3	3	1	0.050	0.012	0.049	1.253	Raw	1
179	3145	Air traffic safety technicians	3	3	1	0.050	0.012	0.049	1.253	Inferred	1
180	3150	Safety and quality inspectors	8	8		0.169	0.130	0.120	2.528	Raw	0
181	3151	Building and fire inspectors	5	5	2	0.083	0.069	0.068	1.917	Inferred	0
182	3152	Safety, health and quality inspectors	5	5	2	0.083	0.069	0.068	1.917	Raw	0
183	3200	Life science and health associate	99	48		0.145	0.143	0.112	1.952	Raw	0
184	3210	Life science technicians and	12	12		0.133	0.069	0.116	1.782	Raw	0
185	3211	Life science technicians	12	12	4	0.133	0.069	0.116	1.782	Raw	0

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Draw AutoShapes

Ready

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	A	C	D	E	F	G	H	I	J	P	R
1	ISCO88							GMUT	GSD	Data Type	
169	3130	Original						0.169	3.030	Raw	
170	3131							0.148	1.916	Raw	
171	3132							0.625	1.979	Raw	
172	3133							0.087	2.123	Raw	
	3139							0.355	2.647	Inferred	
173											
174	3140							0.939	1.665	Raw	
175	3141							0.548	2.457	Judgment	
176	3142							0.224	2.207	Judgment	
177	3143							0.972	1.491	Raw	
178	3144							0.049	1.253	Raw	
179	3145							0.049	1.253	Inferred	
180	3150							0.120	2.528	Raw	
181	3151							0.068	1.917	Inferred	
182	3152							0.068	1.917	Raw	
183	3200							0.112	1.952	Raw	
184	3210							0.116	1.782	Raw	
185	3211							0.116	1.782	Raw	

ELF JEM Joe 012_HansRoel

Draw AutoShapes

Ready

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Original • IRAS: HK, RV

• NIOS

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▪ Exposure probability

▪ Intensity

▪ Semi-quantitative

▪ 0: low;

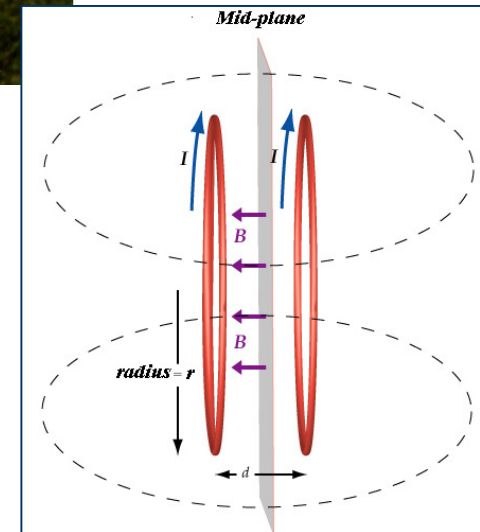
▪ 1: medium;

▪ 2: high

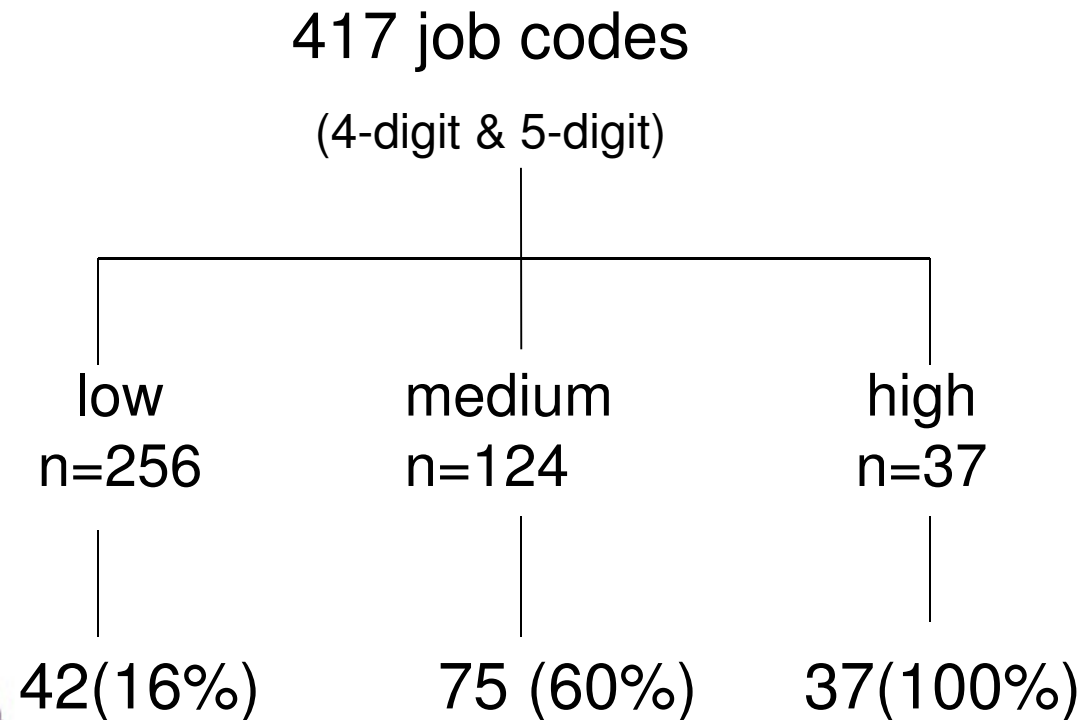
▪ Validation?

Measurement and sampling strategy

- Personal full-shift ($\geq 75\%$ shift)
- Worker day logs
- Data collected in the Netherlands



Measurement and sampling strategy



~4 workers per jobtitle from different companies
~repeat measurements: 40% from ea. expo. cat.

Data collection to date

Expo category	Target Ncodes	Coll. Ncodes number (%)	N obs	N wrks	N rpts (%)
0: low	42	46 (109)	205	136	66 (49)
1: med	75	47 (63)	293	200	85 (43)
2: high	34	16 (47)	140	94	40 (43)
	154	109 (71)	638	430	191 (44)

Nobs: number of measurements

Nwrks: number of workers

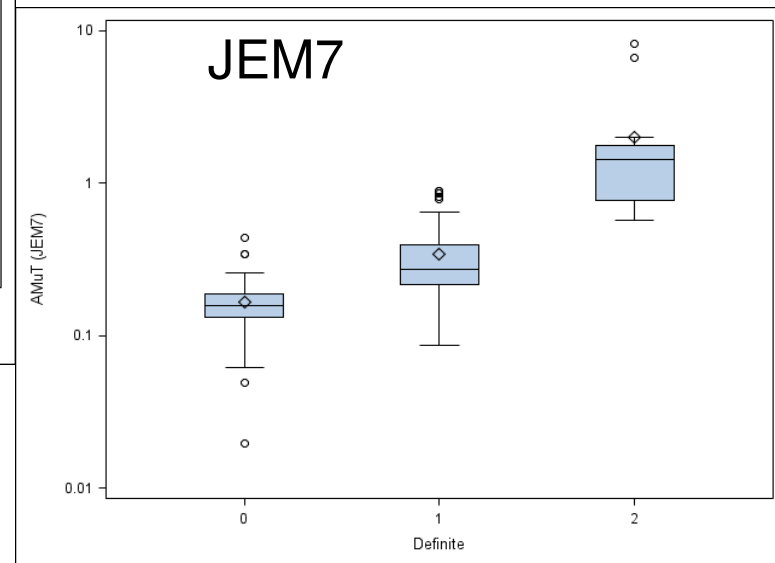
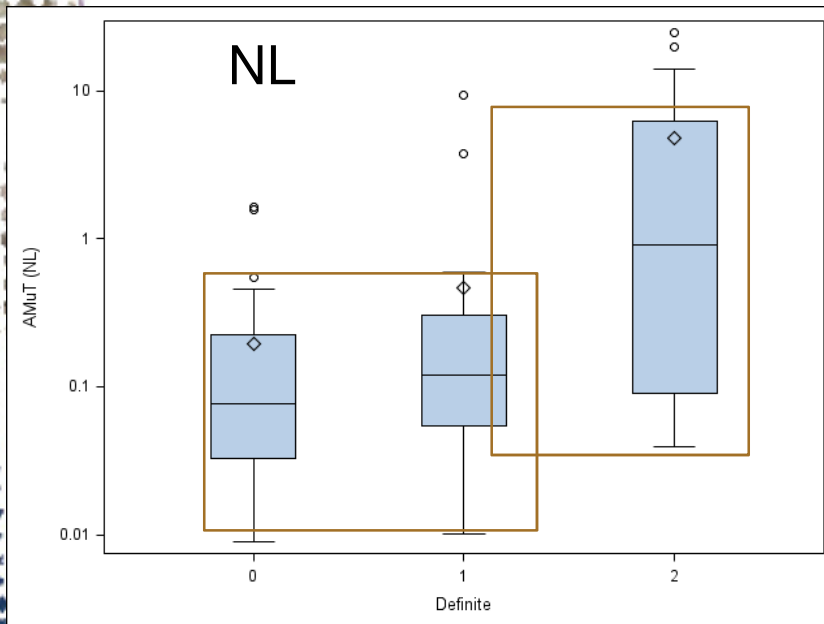
Nrpts: number of workers with repeat measurements

Results

Survey vs Original JEM data

Expocat	N ISCOs	Source	Label	Mean	Std Dev	Minimum	Maximum
0	43	survey	AMuT	0.19	0.34	0.01	1.64
		jem		0.17	0.08	0.02	0.44
		survey	GMuT	0.11	0.13	0.01	0.60
		jem		0.13	0.07	0.02	0.44
1	46	survey	AMuT	0.46	1.45	0.01	9.33
		jem		0.34	0.22	0.09	0.90
		survey	GMuT	0.15	0.21	0.01	1.10
		jem		0.21	0.09	0.08	0.55
2	16	survey	AMuT	4.82	7.87	0.04	24.65
		jem		2.00	2.20	0.57	8.20
		survey	GMuT	3.00	5.06	0.04	13.65
		jem		0.83	1.25	0.30	5.48

Survey and original JEM data vs exposure categories of modified JEM (based on AM-TWA)



- N codes=105



Discussion

- Exposure categories were partly based on cutoffs using the original JEM data
- Expo categorisation is based on jobtitle (not at task level)
- Collection from wide variation of companies



Preliminary conclusion

- Collapse low/med categories into one.
- Use of JEM for quantitative exposure estimation in NL epi → misclassification
-
- When using it for semi-quan exposure classification → both JEMs may rank similarly
- Task exposure matrix will be useful tool for this type of exposure



Thank you!

Questions?

Comments?

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