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Nederlandse Vereniging voor Arbeidshygiëne

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STYRENE exposure in the European GRP industry

Trends and differences between regions and job-categories in the period 1970 – 2002

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Association of Plastics Manufacturers

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Set up

- Exposure data from CEFIC reports, scientific literature and European databases (MEGA-Germany, NSDB-UK, etc)
- Type of data: Styrene in breathing zone, styrene metabolites in urine, styrene in blood
- Data collation:

  - **standardized units of measurement**
    . air monitoring data: mg/m^3,
    . urinary metabolites: mg/gr creatinine
    . styrene in blood: µg/L

  - **standardized statistic descriptives**: AM, sd, GM, gsd, 10% and 90%

- Statistic analyses on:
  - Differences between job categories
  - Regional differences
  - Trend

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Project-team

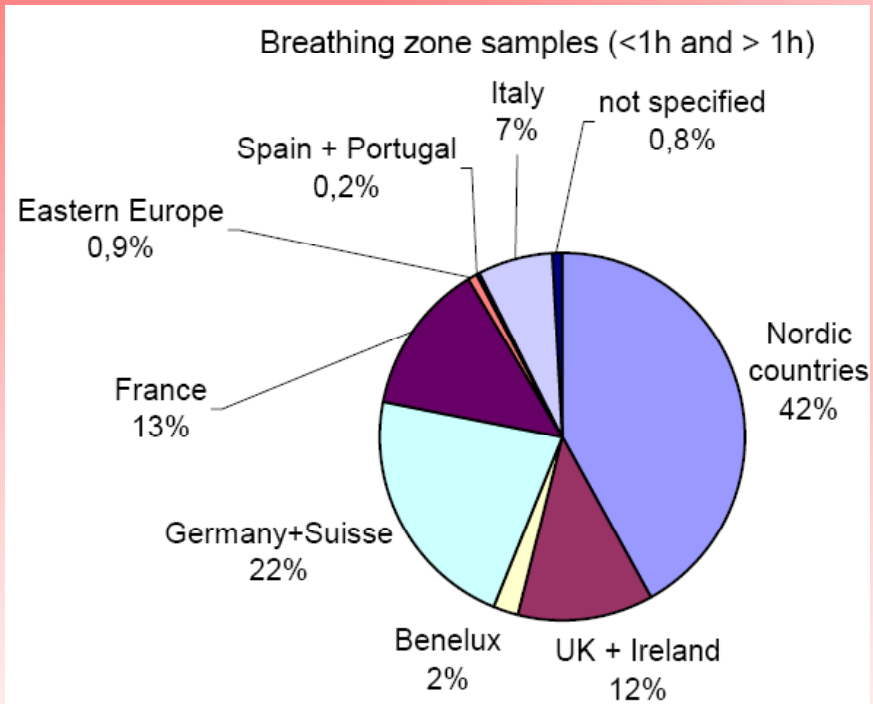
Joost van Rooij
Toxicologist/occupational hygienist
Nijmegen, The Netherlands

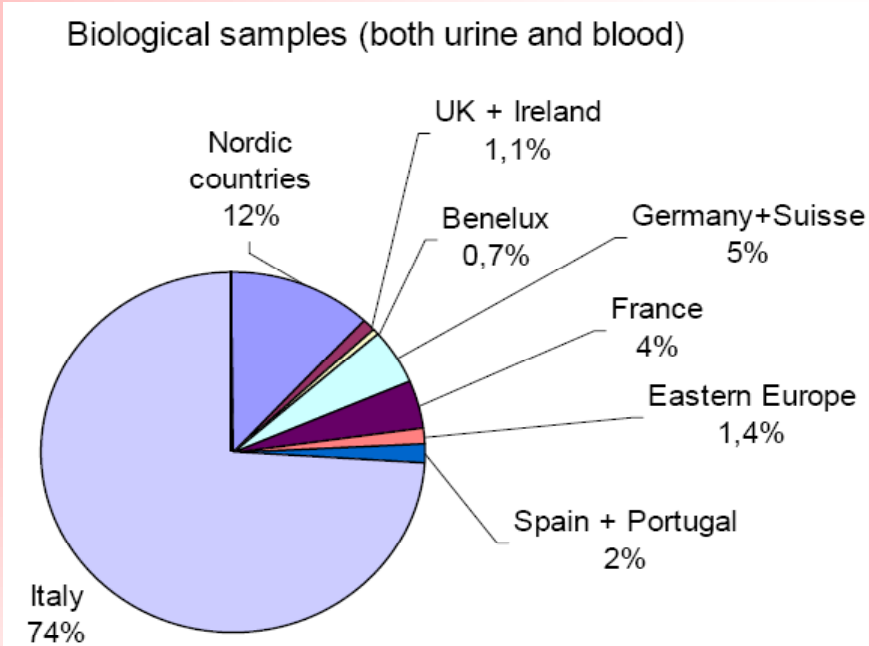
Ab Kasper
Technical consultant GRP, Zwolle, The Netherlands

Support/advise:
Dr. H. Kromhout: Statistical analysis of data
Prof Dr. Triebig: exposure data and advice
Prof dr. M. Kogevinas: sharing European styrene exposure data (IARC-mortality study 1993)

Project monitoring group:
Dr. P.M. Bever: Plastics Europe – CEFIC, Brussels, Belgium
Prof Dr. H-P Gelbke: Ludwigshafen, Germany
M. Johansson: Ashland, Brussels, Belgium
Ing. A. Kasper: Quantor, Zwolle, Nether lands

Retrieved styrene exposure data per country





Total number of AIR samples: **27169** (271 AMs)

Total number of BIOLOGICAL samples: **7030** (88 AMs)

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Representativity per country

Country / Region	Tonnes per year (2002)	% of total	Styrene expusure data (samples)	% of total
Nordic countries	37.800	7 %	12262	36 %
UK/Ireland	85.833	16 %	3329	10 %
Benelux	22.200	4 %	725	2.1 %
Germany	85.700	16 %	5962	17 %
France	82.100	15 %	3895	11 %
Switzerland	5.300	1 %	266	0.8 %
Eastern Europe	?	?	379	1.1 %
Spain/Portugal	85.033	16 %	174	0.5 %
Italy	116.000	22 %	6996	20 %
Greece	3.933	0.7 %	-	-
Austria	6.700	1.3 %	-	-
Various			211	0.6 %
Total	530.600	100 %	34199	100 %

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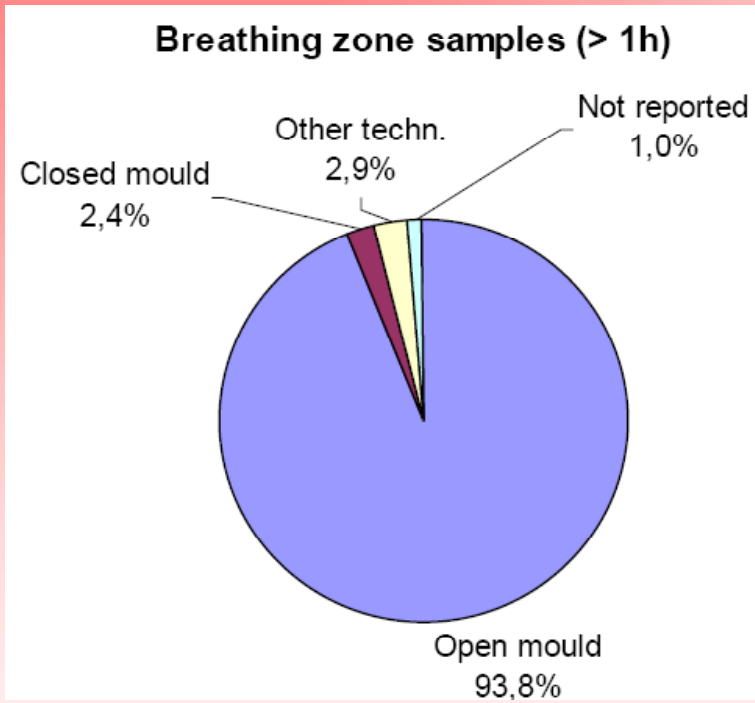
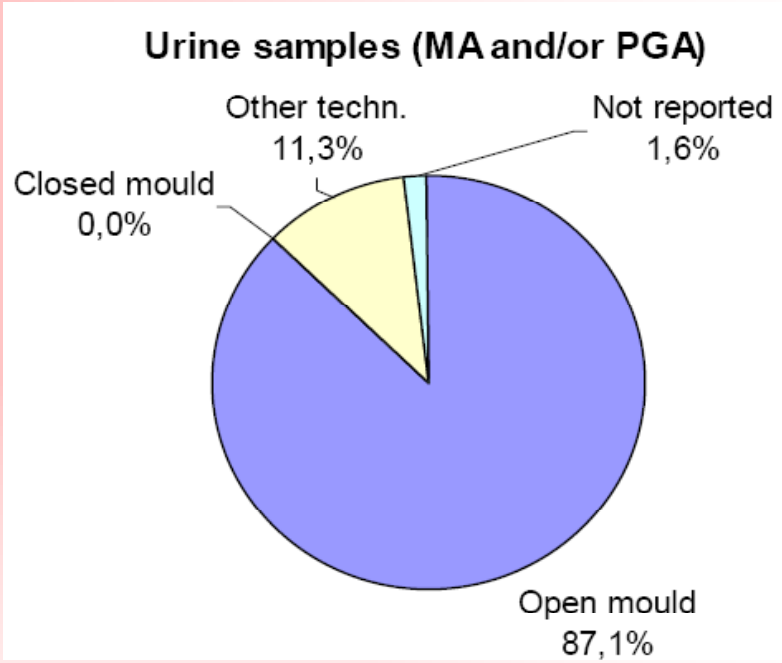
Retrieved styrene exposure data per production technique





Total number of AIR samples (> 1 h):

24145 (268 AMs)

Total number of URINE samples:

6638 (62 AMs)

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Representativity per job category

Job category	*Tonnes per year (2002)*	*% of total*	*Styrene exposure data (samples)*	*% of total*
Open mould processing				
Hand lay-up, Spray up	173.500	33 %	30.964	91 %
Filament winding	38.600	7 %	314	0.9 %
Pastes, putties	16.100	3 %	194	0.6 %
Polymer concrete, synthetic marble	52.200	10 %	291	0.9 %
Closed mould processing				
Cont.lamination	49.600	9 %	23	0.1 %
Inj. processes	16.600	3 %	9	0.0 %
SMC/BMC	94.600	18 %	434	1.3 %
Pultrusion	13.600	3 %	0	0 %
Warm/Cold press	13.100	3 %	25	0.1 %
Centrifugal casting	23.200	4 %	-	-
Others	39.500	7 %	-	-
Non classifiable			1941	6 %
Total		100 %		100 %

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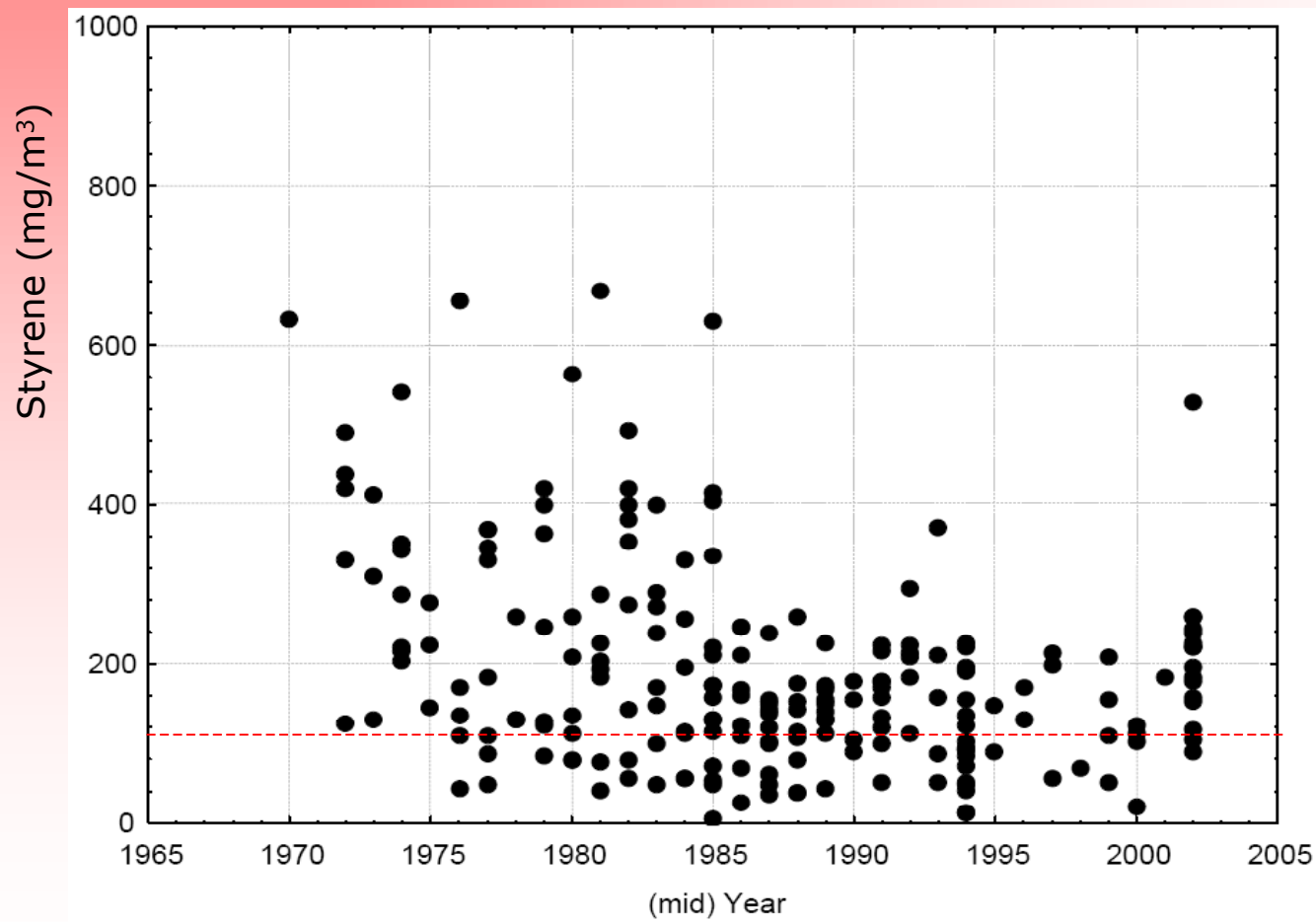
Styrene in breathing zone (> 1h)

***Open mould* techniques** *(all job categories)*



OEL-NL (8h twa)
107 mg/m^3 ≈ 25 ppm

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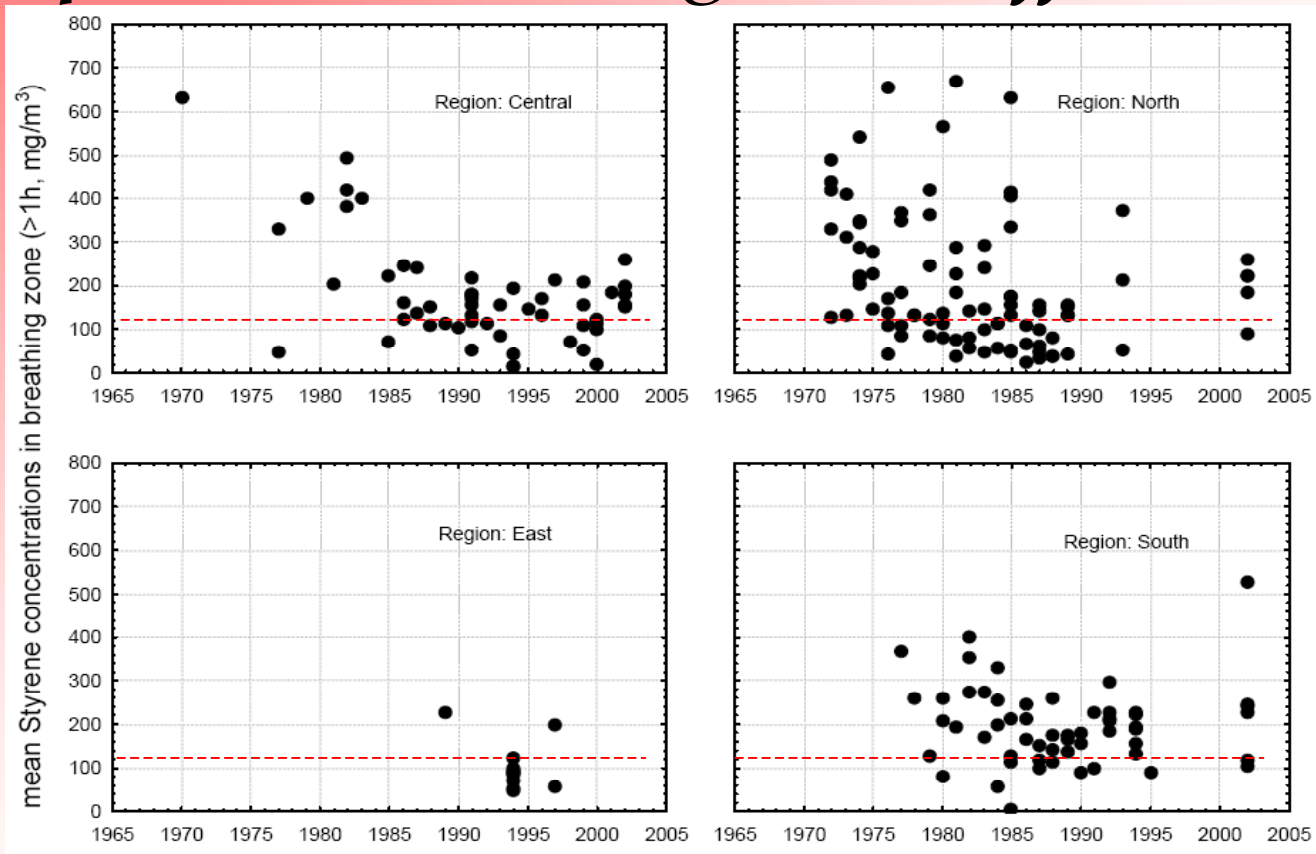
Styrene in breathing zone (> 1h)
Open mould *- regional differences*



OEL-NL (8h twa)
107 mg/m^3 ≈ 25 ppm

Region North: Norway, Denmark, Sweden, Finland
Region Central: UK + Ireland, Benelux, Germany, Switzerland
Region East: countries classified as 'Eastern countries'
Region South: France, Italy, Spain+ Portugal

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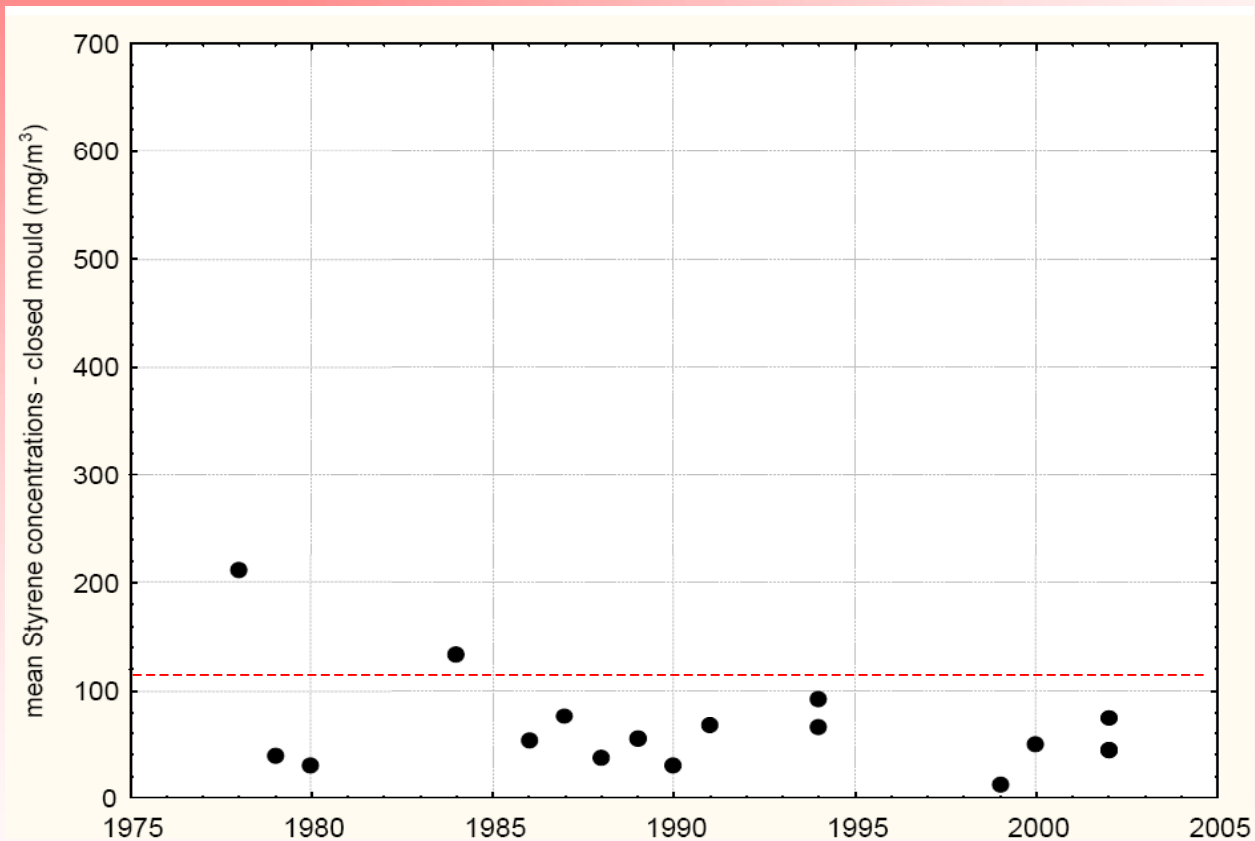
Styrene in breathing zone (> 1h)
***Closed mould* techniques** *(all job categories)*



OEL-NL (8h twa)
107 mg/m^3 ≈ 25 ppm

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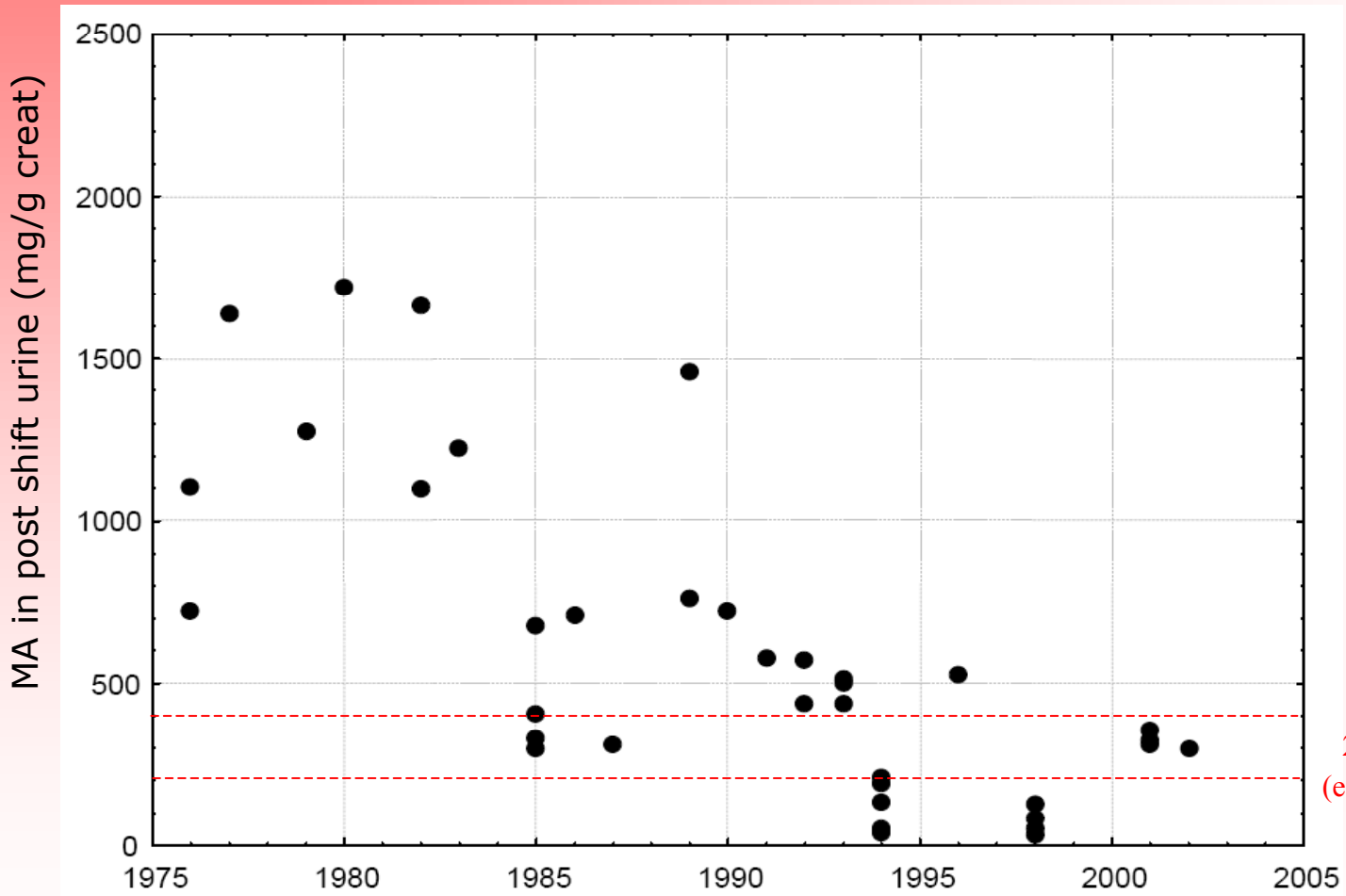
Mandelic acid in post-shift urine
***Open mould* techniques** *(all job categories)*



BM-guidance value
200 – 400 mg/g creat
(equiv. with 107 mg/m^3)

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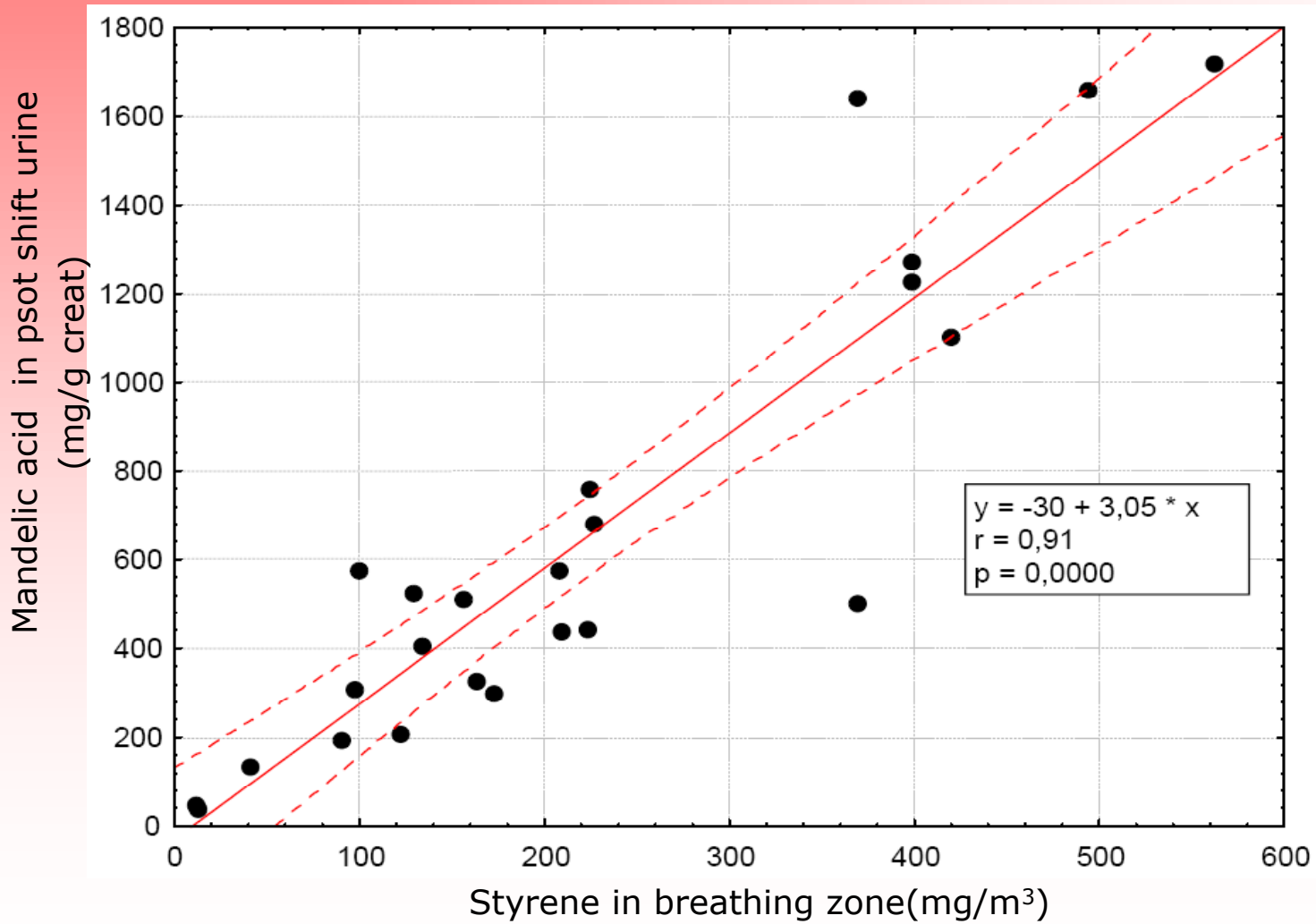
Correlation between styrene in breathing zone and MA in urine



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Statistical analyses

- Step-wise analysis applying linear mixed models (SAS 9.1)
- Dependent variables – log transformed value of:
  - **mean styrene concentration** (> 1h)
  - **mean mandelic acid in post-shift urine**
- Weighted analysis of aggregated data (weighting unit: **number of observations**)
- Effect of **year since 1967** was analysed taking into account **job-category**, **region** and interactions
- potential confounding factors, such as **purpose of measurement**, **sampling strategy** and **sampling method** were considered.
- **literature reference** was used as random effect

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Statistical analyses

Available observations

Styrene in breathing zone (>1)

Region	*mid year range*		*Retrieved number of AM-values*	*Total number of samples from which AMs were calculated*
North	1972	2002	**91**	8662
Central	1970	2002	**54**	8884
East	1989	1997	**12**	219
South	1977	2002	**56**	4953
All regions	*1970*	*2002*	***213***	*22718*

Mandelic acid in post-shift urine samples

Region	*mid year range*		*Retrieved number of AM-values*	*Total number of samples from which AMs were calculated*
North	1976	1998	**12**	792
Central	1979	1996	**10**	153
East	1989	1994	**3**	28
South	1985	2002	**12**	3984
All regions	*1976*	*2002*	***37***	*4957*

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Statistical analyses
Trend in styrene exposure

Estimated annual decline in styrene concentration in breathing zone of European GRP-workers (open mould) since 1967.

Region	*No of observations*	*Period (mid-year range)*		*Estimated annual decline (in % per year)*
North	91	1972	2002	**4,3%**
Central	54	1970	2002	**3,4 %**
East	12	1989	1997	**(2,0 %)***
South	56	1977	2002	**1,0 %**
All regions	*213*	*1970*	*2002*	***3,3%***

** based on only 12 observations in a relative short period of 9 years*

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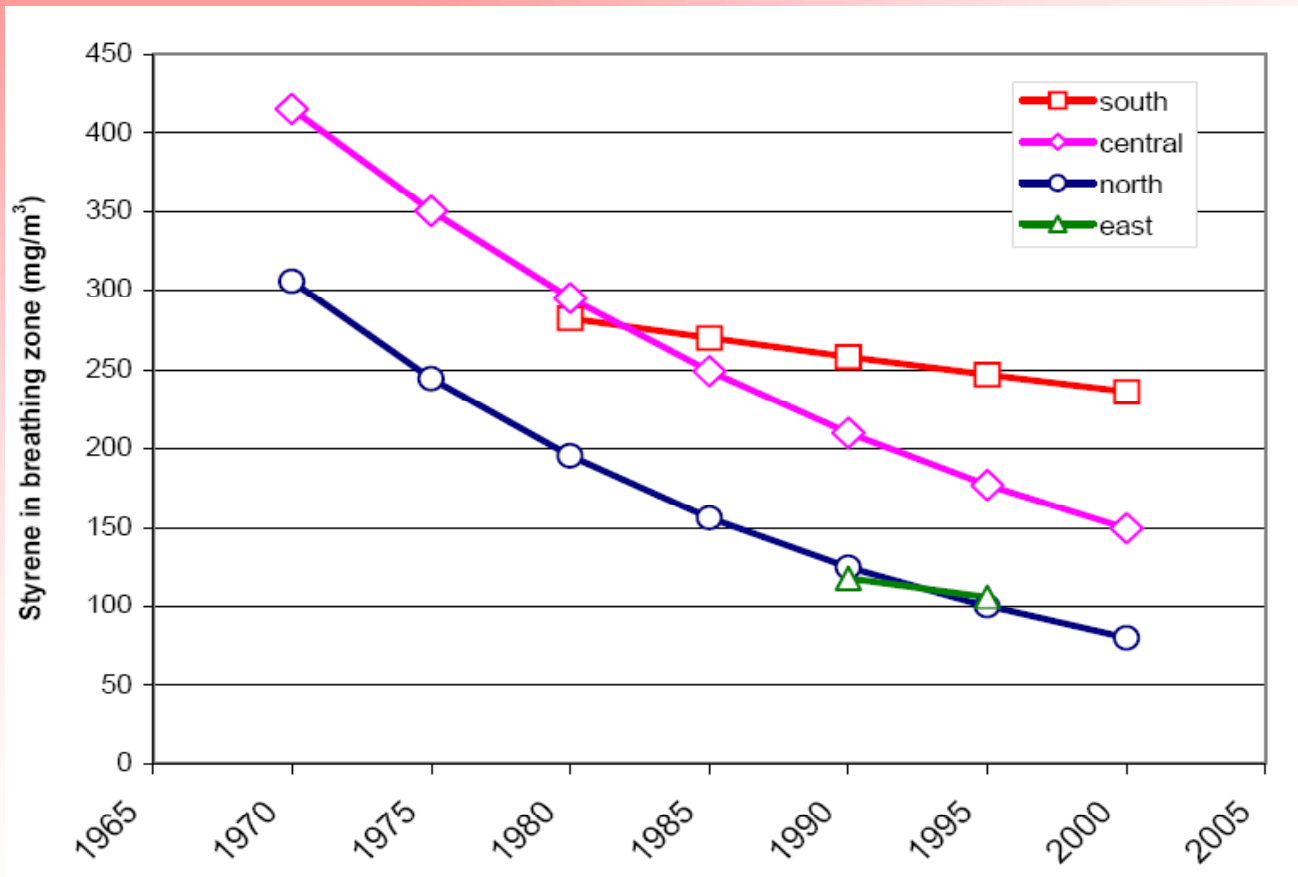
Statistical analyses
Regional differences

Regional differences of styrene in breathing zone of laminators in the European GRP-industry



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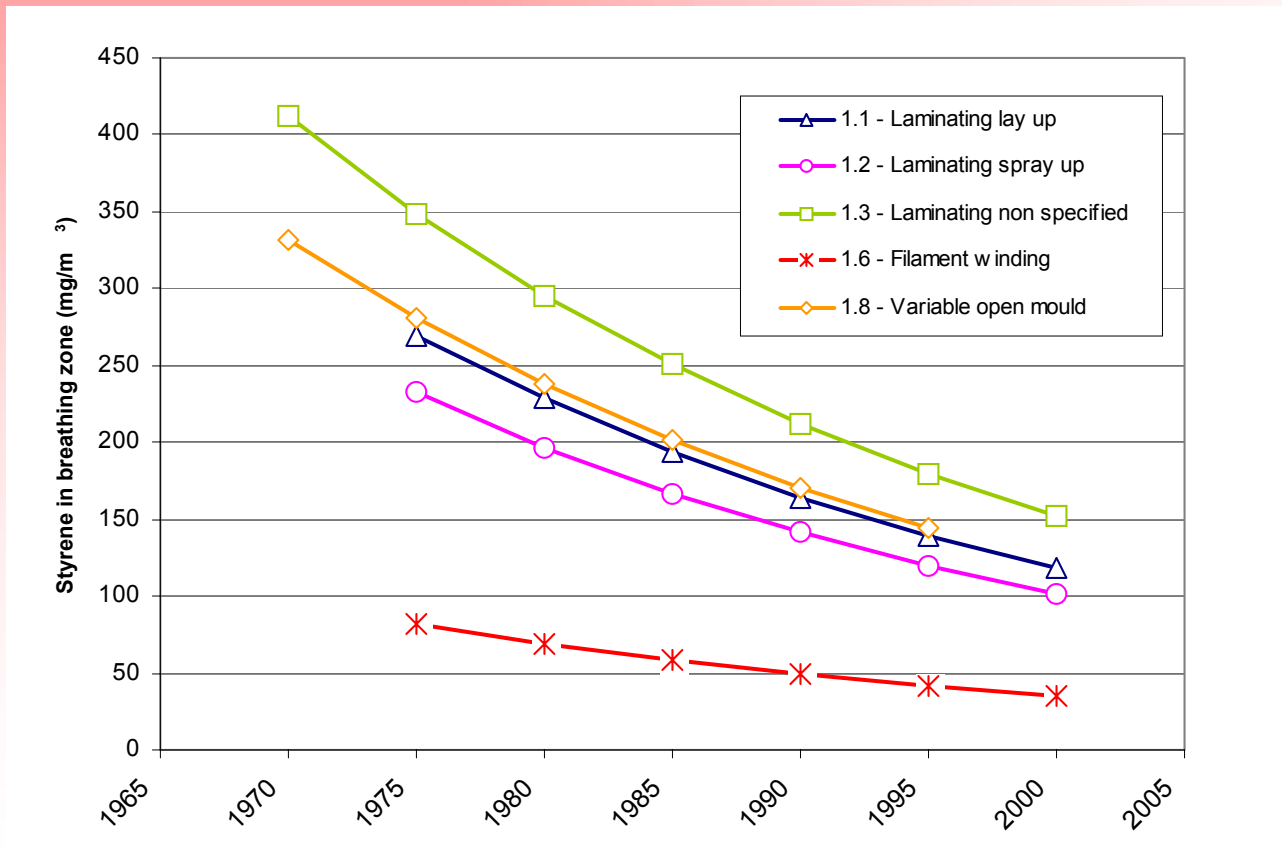
Statistical analyses
Differences between job categories

Styrene in breathing zone of European open mould process operators **per job category** (n=213)



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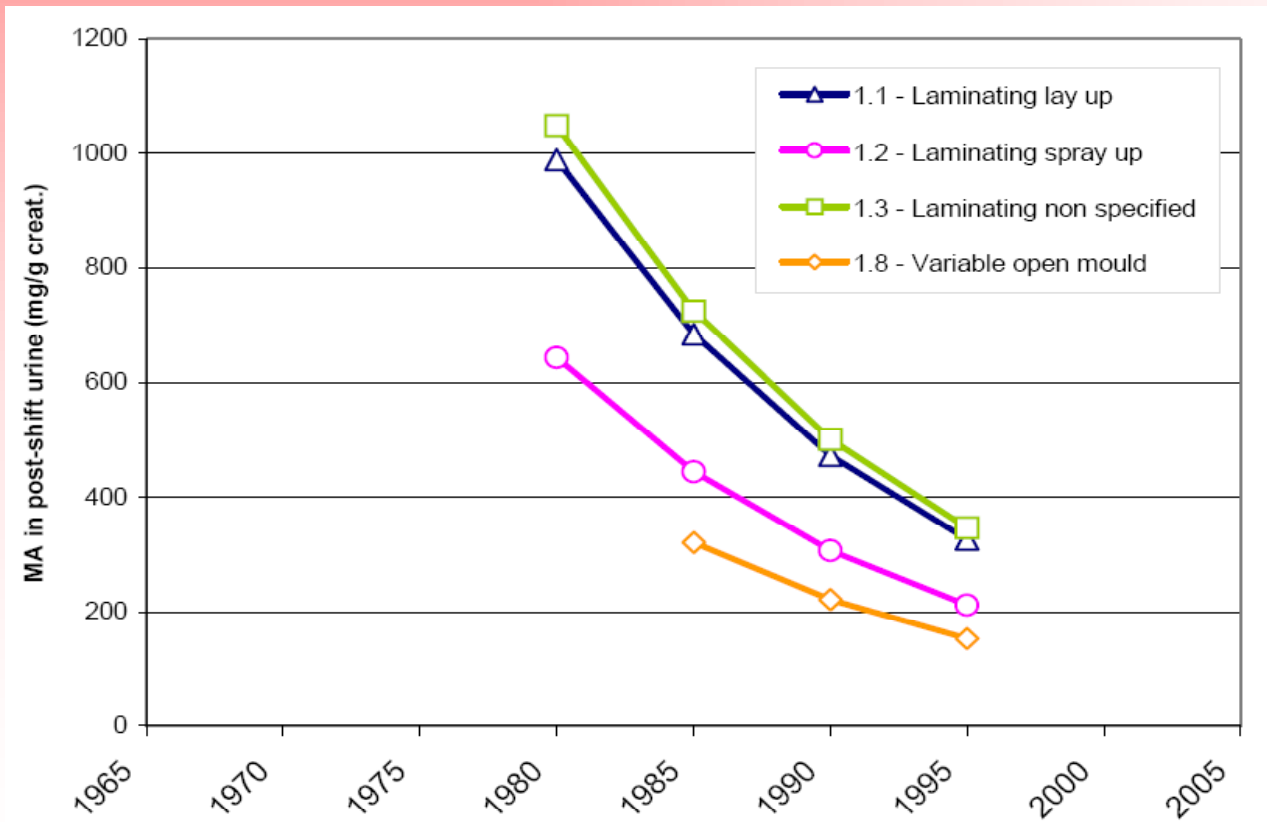
Statistical analyses
Differences between job categories

Mandelic acid in post-shift urine of European open mould process operators **per job category** (n=24)



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Conclusions (1)

- All data collected are not yet sufficient to get an overall picture of the European occupational exposure to styrene:
  - about 90% of styrene exposure data are from open mould workers, available data on closed mould workers are limited
  - relative many data from Nordic countries and limited data from Spain, Portugal and countries in Eastern Europe
  - data are probably biased towards higher values (non random sampling, health effect studies)

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Conclusions (2)

- Annual decline and estimated average styrene exposure in 2003:

Region	*Styrene in breathing zone of European open mould laminators*	
	*Annual decline** *(% per year)*	*Estimate for **2003*** *mg/m³ (95%-CI)*
North	**4,3 %**	**70** (47-103)
Central	**3,4 %**	**135** (97-189)
East	*(data too limited)*	
South	**1,0 %**	**230** (164–324)
All regions	***3,3 %***	***117*** *(88-154)*

* in period 1970-2000

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Conclusions (3)

- Within the group of open mould workers the styrene concentration in the breathing zone differs considerably between job-categories: laminating non specified > laminating lay up or spray-up > filament winding

- Mandelic acid in post-shift urine of open mould workers shows an annual decline of about 7.4%

  note: the annual decline in styrene concentrations in the breathing zone of these workers was 8.1 % (higher than the average decline in that period)

- Estimated mean styrene exposure of closed mould workers in 2003 is about 62 mg/m3 (≈ 14 ppm) and considerably lower than in open mould workers

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