HAND ARM VIBRATION

International conference
6-9 JUNE 2023
Espace Prouvé,
Nancy, France

Dose-response relationship between hand-arm vibration exposure and musculoskeletal disorders of upper extremities: a case-control study among German workers

Yi Sun[1], Frank Bochmann[1], Winfried Eckert[2], Benjamin Ernst[1], Uwe Kaulbars[1] Uwe Nigmann[3], Nastaran Raffler[1], Christina Samel[1], Christian van den Berg[4]

[1]IFA-DGUV, Sankt Augustin, Germany
[2]BG Bau, Stuttgart, Germany
[3]BGHM, Düsseldorf, Germany
[4]BGRCI, Bochum, Germany

Background

- Hand arm vibration syndrome (HAVS): vascular, neurological and musculoskeletal disorders
- Vibration-induced musculoskeletal disorders – legal occupational disease (BK 2103) in Germany since 1929.
- Approximately 1.5 – 2 million employees in Germany have significant exposure to hand-arm vibration.
- BK 2103: about 350 suspected and 100 recognized cases per year.
- Limited knowledge of the exposure-response relationship for vibration-induced musculoskeletal disorders.

Design of an epidemiological case-control study

Objective:

Quantitative assessment of exposure-response relationship between work-related hand-arm-vibration and musculoskeletal disorders (defined according to BK 2103)

Study design: Industry-based case-control-study.

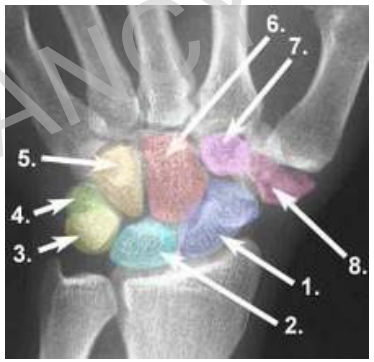
Base population:

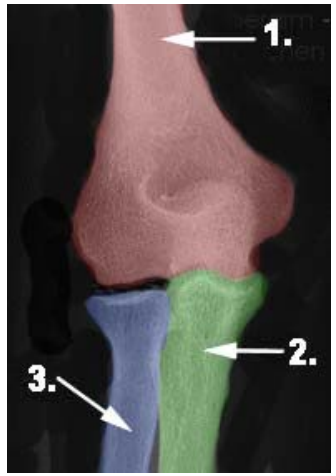
All blue-collar workers in the German construction, wood, metal and mining industries

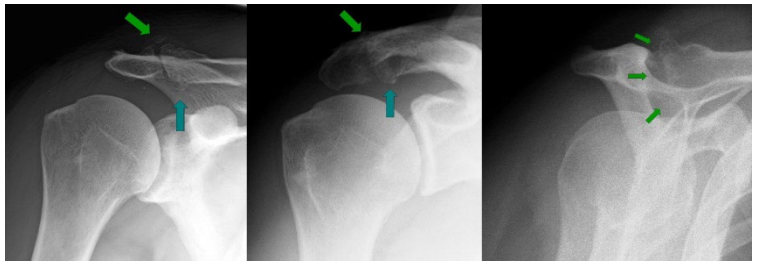
Cases

Incident male cases of musculoskeletal disorders defined according to BK 2103:

- Hand osteoarthritis
- Elbow osteoarthritis
- Shoulder osteoarthritis
- Kienbock's disease
- Stress fracture and pseudoarthrosis of the scaphoid
- Osteochondritis dissecans of elbow







Controls

A random sample of male cases of compensable occupational injuries (matching ratio 1:3)

Matching criterion:

- Birth year
- Gender
- Industrial sector

Exposure assessment methods

- Reconstruction of Individual work history by personal interviews (by experienced labour inspectators of the German Social Accident Insurance).
- Identification of all relevant work machines used in various segments of the work history (duration, frequency)
- Establishment of a “Machine-Vibration Database” based on standardized industrial hygiene measurements
- Quantification of daily and lifetime vibration dose by combing the machines used and the “Machine-Vibration Database”

Quantification of hand-arm-vibration

- Vibration values assessed

$$a_{hv} = \sqrt{a_{hwx}^2 + a_{hwy}^2 + a_{hwz}^2} \text{ and } a_{hw(x,y,z)}$$

- Daily vibration exposure

$$A(8) = \sqrt{\frac{1}{T_0}\sum_{i=1}^{n}\left(a_{hvi}^2 \cdot T_i\right)}$$

T_i: working hours with ith machine

- Long-term cumulative vibration dose

$$D_{hv} = \sum_{i,j=1}^{n,k} A(8)^2 \cdot d_i \cdot a_j$$

d_i: working days per year

a_j: total working years

Statistical Analysis

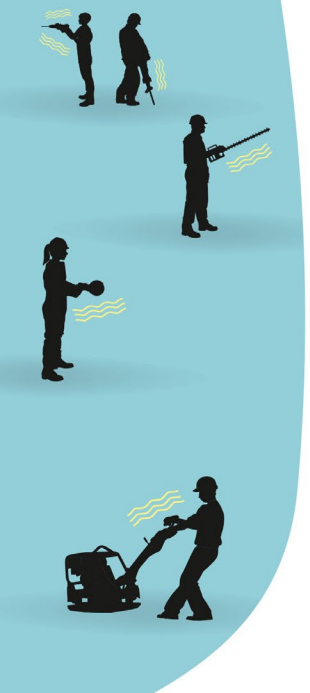
- Descriptive/inductive statistic
- Multivariate conditional logistic regression analysis

Confounders considered in the analysis

- Age and sex (by matching)
- Injuries of hand, elbow and shoulder joints
- Inflammatory disorders of hand, elbow and shoulder joints
- Generalized osteoarthritis and other comorbidities

Description of the study sample

		Cases	Controls
N		209	614
Age (year)	Mean (SD)	53 (9)	52 (9)
	Median (range)	53 (22-84)	52 (22-83)
BMI	<=25	17%	22%
	25 – 30	51%	52%
	>30	32%	27%
Nationalities	German	90%	92%
	Turkey	6%	6%
	Others	4%	2%



Comorbidity

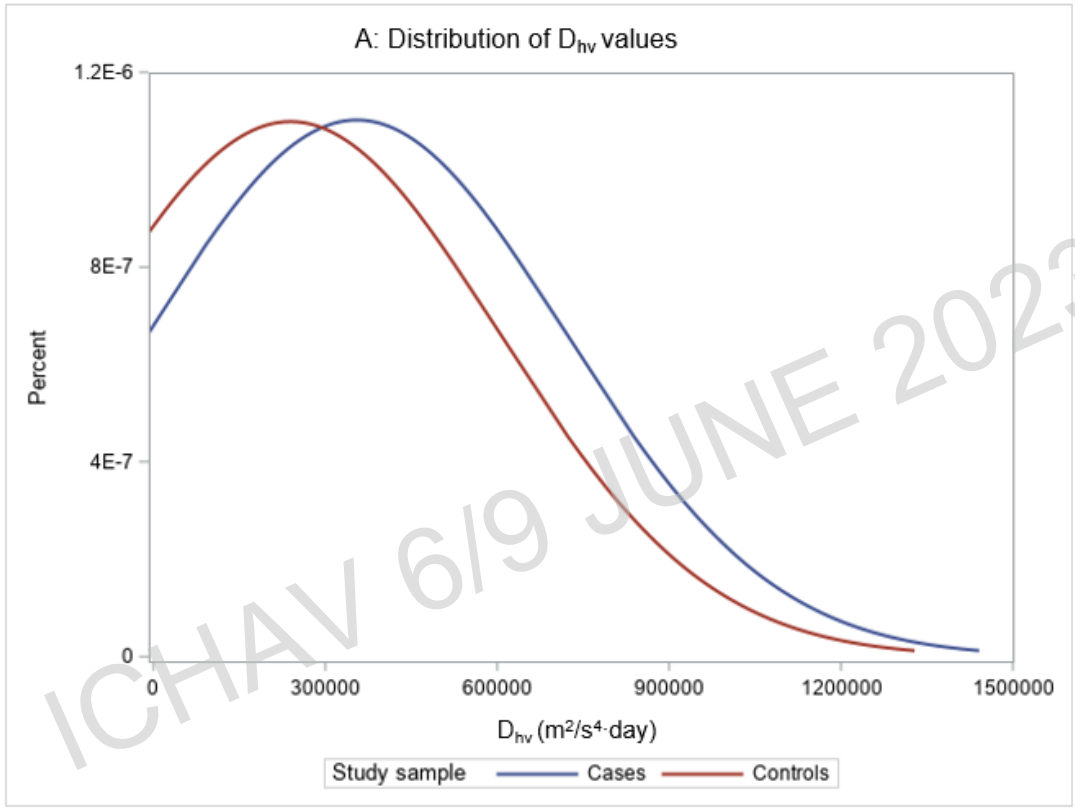
Comorbidity	Cases (n=209)	Controls (n=397)
Gout*	14%	9%
Hand injuries***	40%	26%
Elbow injuries**	12%	6%
Shoulder injuries*	14%	9%
Arm fracture	10%	7%
Inflammatory disorders of wrists***	26%	6%
Inflammatory disorders of Elbow***	24%	6%
Inflammatory disorders of shoulder***	17%	9%
Osteoporosis	2%	2%
Knee osteoarthritis***	29%	15%
Hip osteoarthritis***	10%	4%
Spinal OA***	19%	9%
Rheumatism	6%	4%

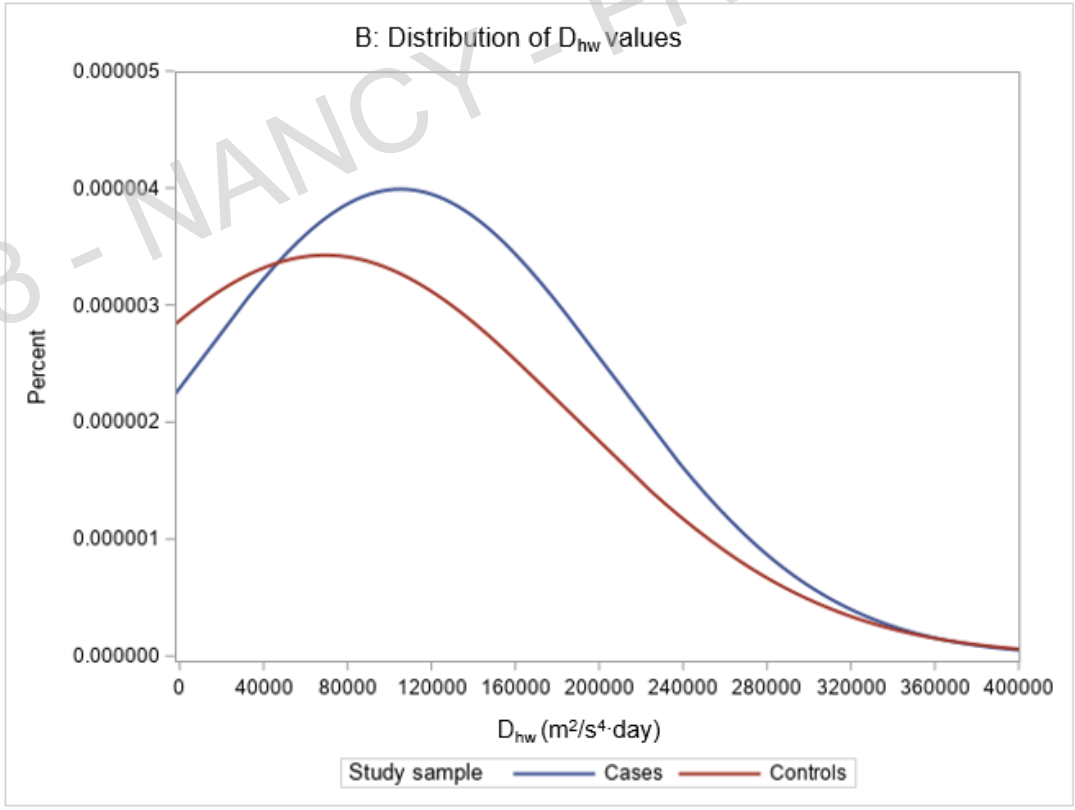
Chi-squared test *p<0.05; **p<0.01 ***p<0.001

Occupational exposure to hand-arm-vibration

		Cases (n=209)	Controls (n=614)
Employment duration (years)			
	Mean (SD)	25 (9)	24 (11)
	Median (range)	26 (1-44)	25 (0.5-49)
Daily vibration exposure			
A(8) (m/s^2)	n	1863	3252
	Mean (SD)	8.9 (5.5)	7.2 (5.0)
	Median (range)	8.4 (0.2-29.4)	6.5 (0.3-34.4)
Cumulative exposure doses			
D_{hv} (m^2/s^4 •day)			
	Mean (SD)	355,093 (361,991)	239,227 (363,068)
	Median (range)	241,152 (976-2,114,916)	121,995 (23-3,374,370)

Distribution of cumulative vibration doses

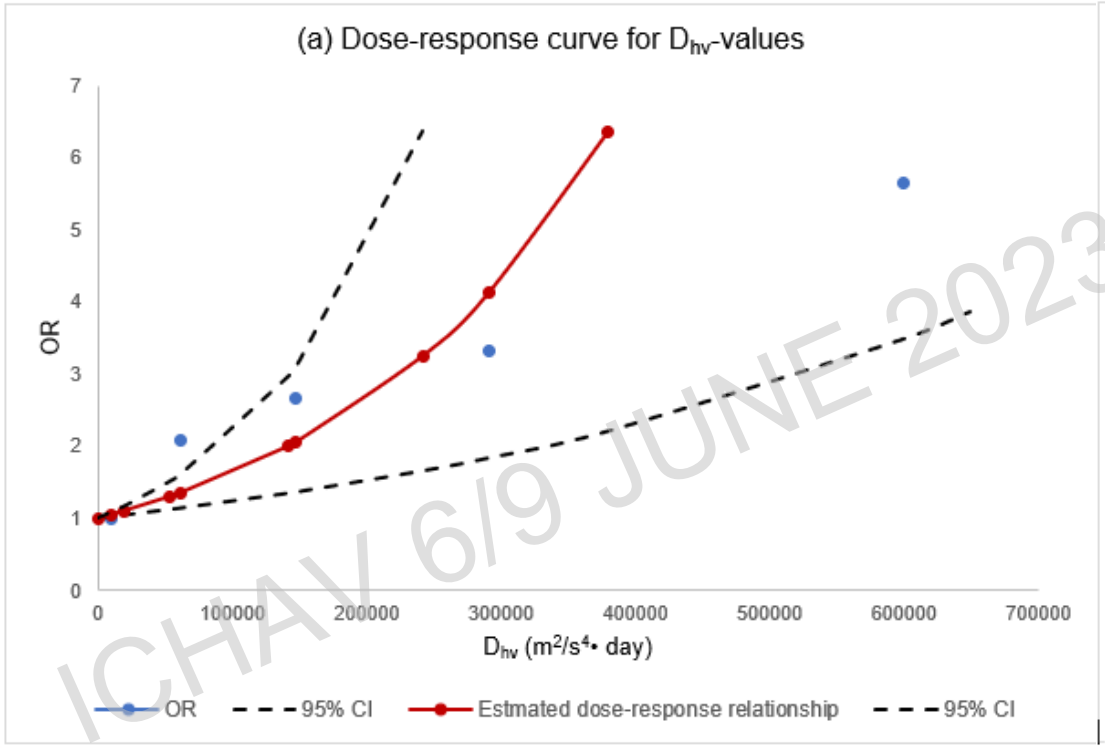


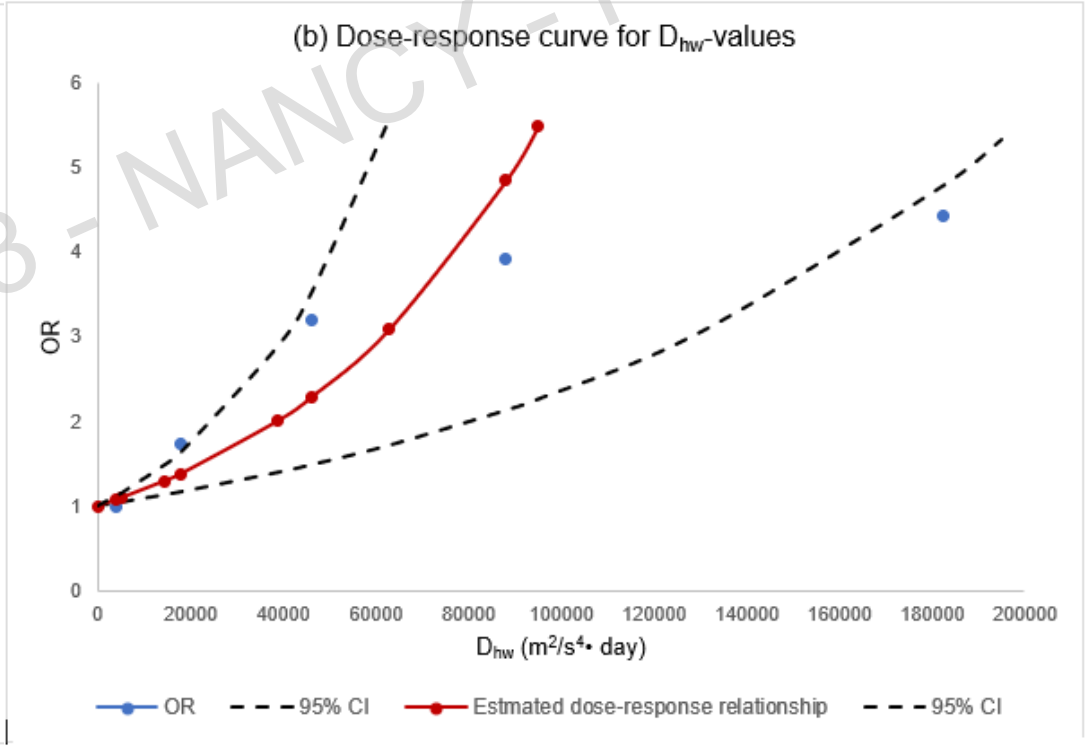


Quantification of dose-response relationship

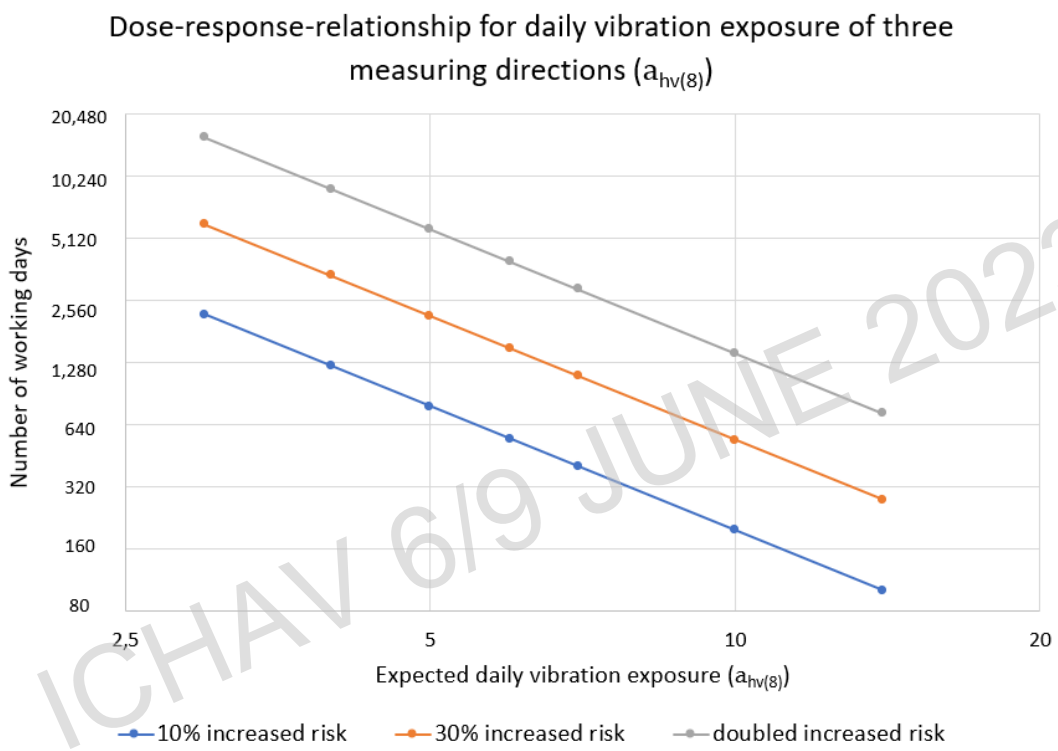
	Cases/N	Unadjusted		Adjusted	
		OR	95%CI	OR	95%CI
D_{hv} (m^2/s^4 •day)					
1. Quintile	20/165	1	–	1	–
2. Quintile	35/164	2.14	1.17 – 3.90	2.08	1.12 – 3.85
3. Quintile	46/165	3.10	1.72 – 5.59	2.66	1.45 – 4.88
4. Quintile	40/164	2.77	1.52 – 5.06	3.31	1.78 – 6.13
5. Quintile	68/165	5.03	2.83 – 8.93	5.65	3.06 – 10.42
Trend-test		P<0.0001		P<0.001	
100 m^2/s^4 •year increase		1.015	1.008–1.023	1.013	1.006–1.021
D_{hw} (m^2/s^4 •day)					
1. Quintile	16/165	1	–	1	–
2. Quintile	27/164	1.93	1.02–3.67	1.73	0.89 – 3.33
3. Quintile	44/165	3.57	1.92–6.62	3.19	1.70 – 6.01
4. Quintile	58/164	4.91	2.68–8.99	3.92	2.10 – 7.32
5. Quintile	64/165	5.08	2.80–9.22	4.43	2.39 – 8.21
Trend-test		P<0.0001		P<0.0001	
100 m^2/s^4 •year increase		1.036	1.015–1.058	1.028	1.006–1.050

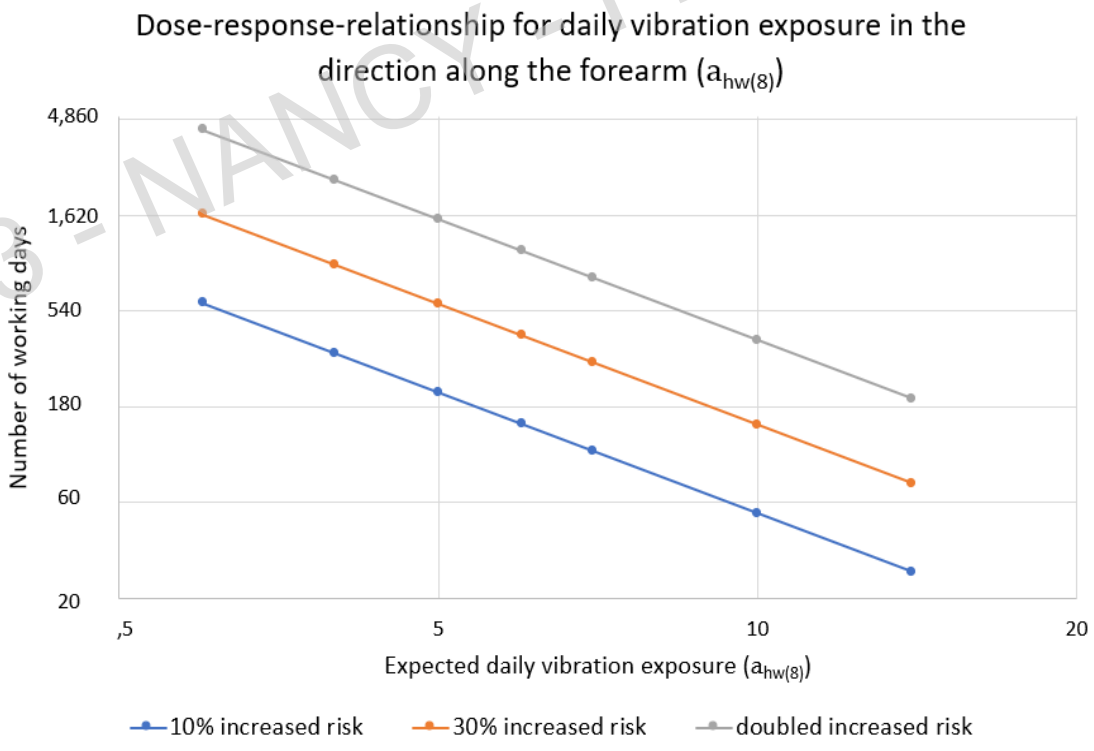
Estimated exposure-response-curve for D_{hv} and D_{hw}





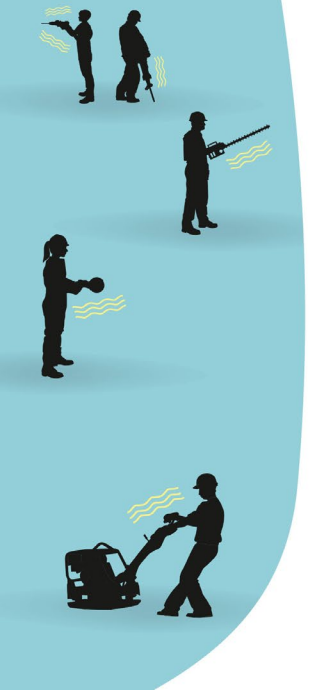
Expected 10%, 30% and doubled increased risk of musculoskeletal disorders





Summary

- One of the largest epidemiological studies on hand-arm-vibration (n=823) with higher methodological quality
- Object exposure assessment based on standardized industrial hygiene measurement database.
- Quantification of the exposure-response relationship between hand-arm-vibration and musculoskeletal disorders of the hand-arm-shoulder system
- The findings of this study provide useful guidelines in the prevention and compensation of work-related and vibration-induced musculoskeletal disorders of the upper limbs



Thank you very much for your attention!