# A LITERATURE REVIEW OF WORKPLACE INTERVENTIONS

## WITH RESPECT TO RISK MANAGEMENT MEASURES AND THEIR IMPACT ON OCCUPATIONAL EXPOSURE LEVELS TO HAZARDOUS SUBSTANCES

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## Background and Aims

In order to avoid or adequately reduce worker exposure to hazardous substances effective and appropriate risk management measures (RMMs) have to be implemented at the workplace. Intervention studies play an important role in supporting and complementing scientific validation of results of non-intervention assessments of the effectiveness of RMMs under controlled conditions.
This study reviewed existing scientific literature on workplace intervention studies with the aim to identify different types of interventions and evaluation approaches used to assess their effects on occupational exposure levels to hazardous substances. The work presented here gives an overview of a selection of 25 out of a total of 50 most relevant, published studies included in this review.

## Methods

Intervention studies published in English from the 1999 up to January 2017 were considered for inclusion. The selection was based on a systematic search of Pubmed.

Workplace interventions were defined as:

- events aimed at reducing occupational exposure to hazardous substances at the workplace or
- where reductions occurred as a side effect, e.g. due to changes in the production process.

## Discussion

Methods and findings varied considerably and hence limit the scope to directly compare results from the different studies and subsequently the effectiveness of the different interventions.

Opportunities to assess the full extent / all aspects of an intervention are not always given as this is dependent on data availability, available funding, etc..

Overall this review showed that the majority of the interventions, irrespective of their nature, have been successful at reducing exposure levels.

## Conclusions

There is evidence that decreases in workplace exposure levels to hazardous substances followed a variety of workplace interventions in a variety of industries underlining the benefits of implementing RMMs at workplaces.

However, a direct comparison of a specific RMM among different studies, even when focussing on one specific industry, remains difficult as the majority of studies assessed the implementation of a set of different RMMs; hence the quantification of the impact of individual interventions on exposure remains difficult due to the heterogeneity in methods.

| | Investigator | Intervention(s) | Study period | Exposure to | Exposure assessment by | Main findings |
|---|---|---|---|---|---|---|
| Metal industry | Grimsrud *et al.* 2000 | Nickel refineries, Norway: Abandonment of Hybinette method in 1978; technical changes with time | 1910 - 1994 | Ni compounds | Department-time-exposure-matrix | 1973 - 1994 (based on measurements): ↓ Ni by factor 5 in roasting, factor 6 in electrolyte purification, factor 8 in copper leaching department |
| | Sanderson *et al.* 2001 | Reading beryllium plant, U.S.: Major production changes btw. 1940's – 1970's | 1935 - 1992 | Be compounds | Job-Exposure-Matrix (JEM) | Estimates varied considerably btw. jobs; dramatic↓ Be btw. 1940's – 1970's for all jobs; selected example: Arc furnace workers: 1935-1960 vs.1981 - 1992: ↓ ~ 99% Be fume |
| | Doko Jelinić *et al.* 2005 | Aluminium production factory, Mostar, Bosnia and Herzegovina: After destruction in 1991/1992 rebuilding & modernisation | 1982 - 2004 | Dust; CO, $CO_2$, $SO_2$, HF, $NO_2$, difluoro sulphide, benzene, phenol, chlorine, butane, propane | Measurements prior & after rebuilding / modernization | Post-modernization: ↓ exposure: ↓ emission of harmful gases, primarily HF; pot modernization & modern devices for processing anode gases eliminated 96-99% of all pot emissions |
| | Lavoue *et al.* 2008 | 7 aluminium smelters, Quebec, Canada: Various control measures with time especially in Söderberg pot rooms and carbon plants | 1916 - 1999 | Coal tar pitch volatiles: BaP, benzene-soluble materials (BSM) | JEM | 1960 - 1980 major↓ exposure: Computerized control of smelting process, mechanization of tasks, alkaline scrubbing ventilation systems, >1980 ↓ at slower rate: Microenvironment machines; up to ~ ↓ 90% BSM and BaP comparing 1940/50's to 1990's |
| | Thomas *et al.* 2009 | Copper-beryllium alloy processing plant, U.S.: Targeted engineering controls etc. btw. 2000 - 2007 | 1995 - 2007 | Airborne Be | Survey to identify high-risk processes → 2000-2007 implementation phase | ~ ↓ 90% mean exposure after implementation; rod and wire processes: Highest air concentrations for all study periods → post-intervention: ↓by ~ 95 % (limited sample size) |
| | Winker *et al.* 2008 | Semiconductor plant, Germany: RMMs (technical & organisational) for workers with contact with open plasma etching systems in 1992 | 1991 & 2004 | Boron trifluoride and boron trichloride; biomonitoring (BM) | 2 surveys: Urinary excretion of fluoride; continuous air monitoring; micronucleus tests | Survey 1 & 2: air concentrations below detection limit; no difference in urinary fluoride; pre-intervention: Significantly ↑ mean level of micronuclei in exposed workers; post-intervention: ↓ 100% (to same range as controls) |
| | Couch *et al.* 2010 | Beryllium processing facility, Elmore, Ohio: Engineering & administrative controls with time | 1953 - 2006 | Airborne Be | JEM | Decade AM daily weighted average 2000's vs. 1950's: ↓76% airborne Be exposure for all jobs |
| | Sauni *et al.* 2010 | Kokkola cobalt plant, Finland: Production process change in 1987 | 1967 - 2003 | Dust, cobalt, Ni,$SO_2$, $H_2S$, $NH_3$ | Static & personal sampling; identification of asthma cases & confirmation: Bronchial challenge tests | Selected example: Sulphatizing roasting department: Highest $SO_2$ concentrations 1977-1986 → post-intervention: Mean cobalt sulphate: ↓ 100% → ↓ diagnosed asthma cases |
| | Søyseth *et al.* 2016 | 7 aluminium plants, Norway: Various control measures with time | 1986 - 1995 | Total dust, fluorides, PAH | JEM | Total dust, fluorides, and PAH ↓ p.a. by 9.2%, 11.7%, 14.9 %, respectively |
| | Beattie *et al.* 2017 | 53 electroplating companies, Great Britain: Repeat BM to drive sustainable improvements in exposure control | 2008 - 2011 | Cr & Ni | Multiple occasions over 3 yrs: Urine samples; hand wash sampling; surface wipe samples; personal air monitoring | General: Air conc. below exposure limits; +ve correlations btw. hand contamination & BM; company subset (more control deficiencies): BM Ni: ↓ 33% in Ni-electroplaters & ↓38% in other (directly exposed) Ni workers ; BM Cr: ↓23% in Cr-electroplaters & ↓ 27% in other Cr workers |
| Welding in construction | Meeker *et al.* 2007 | Pipefitters, U.S.: Effectiveness of commercially available portable LEV (experimental and field setting) | 2006 (?) | Mn; tTPs | Field scenario: Full-shift breathing zone samples, 8 days from 2 pipefitters | Field setting: LEV (compared to no LEV): GM ↓53% in Mn exposure; ↓ 10% in TPs |
| | Meeker *et al.* 2010 | Chromium-containing steel welders, experimental & field setting (boilermakers & pipefitters), U.S., Canada: Effectiveness of portable LEV | 2007 - 2008 | Cr(VI) | Examined data: OSHA compliance data; Welding Institute (TWI); field survey; controlled trials | General : No LEV → ↑ exposures; e.g. TWI data: LEV (compared to no LEV): Median ↓ 81 % Cr (VI); field surveys: All samples: GM for shifts: ↓ 40 % Cr (VI) |
| | Flynn & Susi 2010 | Welders' datasets, U.S., U.K., Canada: Influence of LEV, degree of confinement, sampler location | 1973 - 2008 | Metal fumes, including Mn, iron, TPs | Examined data by construction trade: TWI, Center for Construction Research and Training, OSHA compliance data | General: No LEV → ↑ exposures; greater degree of enclosure →↑ exposures<br>TWI data: LEV (compared to no LEV): Mean TP: ↓35%, iron:↓41%, Mn:↓31% |
| | Bowler *et al.* 2011 | 43 confined space welders, San Francisco-Oakland Bay Bridge, U.S.: Shift in welding process from automated to manual | 2005 - 2008 | Mn; BM | Blood Mn, status of mood, movement/neuromotor & cognitive function, & olfaction → GLM | Automated welding (associated with higher Mn exposure (Bowler et al. 2007)): 3-fold ↓; manual welding: 2.5-fold ↑; mean blood Mn concentration: ↓16 % |
| | Lehnert *et al.* 2014 | WELDOX study Germany: Improvements of exhaust ventilation and respiratory protection during flux-cored arc welding of stainless steel | 2008 - 2011 | Welding fume, Cr, Ni, Mn; BM | 243 welders from 23 companies: breathing zone & stationary sampling, post-shift: spot urine & blood | (i) ↓respirable particles by ~ 88%; ↓airborne metal compounds: Mn: 98%; ↓Cr: 97%; ↓Ni: 96%, most striking ↓ inside helmets with purified air supply; ↓urinary metal & mean Mn blood concentration |
| Dust in construction | Nij *et al.* 2002 | Construction industry, Netherlands: Control measures to ↓ quartz dust exposure : LEV, wet suppression, PPE | 1998 - 1999 | Respirable dust & quartz dust | Full-shift (n = 61) & short-term measurements & questionnaire (n=1335 workers) → mixed effect model | Controls not very strongly associated with full-shift estimates, but with short-term measurements [% dust reduction]: e.g. recess milling lime sandstone: LEV: >99%; sawing in lime sandstone: LEV: >99%; wet suppression: 81–92% |
| | Flanagan *et al.* 2003 | 9 large construction sites, U.S.: Control measures on silica dust exposure on 8 dust-producing construction tasks | 2000 - 2001 | Respirable dust | Task with vs. task without controls; 42 on-site days per site | Box fan in use (GMs ↓): Surface grinding: ↓ 57% ; floor sanding inside: ↓ 50%;<br>vacuum/shroud in use: Surface grinding outside : ↓ 71% |
| | Croteau *et al.* 2004 | 6 commercial construction sites, Seattle, WA: Commercially available LEV system during concrete surface grinding by cement masons | 2001 - 2002 | Respirable dust & crystalline silica | 28 paired personal samples (with & without LEV) | LEV: ↓ GM respirable dust exposure of 92% and of crystalline silica of 86.4% |
| | Deurssen *et al.* 2015 | 8 construction companies, Netherlands: Multidimensional intervention to ↓quartz exposure (engineering, organisational, behavioural) | 2011 - 2012 | Respirable dust & quartz | Randomized controlled trial (4 control, 4 intervention group); Bayesian hierarchical models | Substantial overall ↓ in quartz exposure baseline vs. follow-up: ↓ 73% in intervention vs. ↓ 40% in control group |
| Bakery | Meijster *et al.* 2009 | Flour processing industry , Netherlands: Intervention programme to ↓ flour dust and fungal α-amylase levels | 1993 - 2007 | Flour dust, fungal α-amylase contents | Surveys pre- (1993 & 2001) and post-intervention (2007); 638 personal exposure measurements | Annual trend: (i) Bakeries: Modest ↓ by 2% for flour dust & 8% for amylase; (ii) Flour mills: Flour dust ↓12%; no significant trend for amylase; (ii) Modest ↑ in use of control measures and proper work practices in most sectors, especially LEV |
| | Baatjies *et al.* 2014 | 30 bakeries of large supermarket chain store, South Africa: Interventions to ↓ flour dust | n.a. | Flour dust, wheat & rye allergens levels | Exposure measurements in 15 bakeries (intervention) vs. 15 controls | Overall 50% decrease in mean flour dust, wheat and rye allergen exposure; greatest reduction in flour dust due to use of mixer lid |
| Hospital | LaMontagne *et al.* 2004 | Hospitals, U.S.: Policy-level intervention (OSHA standards) on ethylene oxide (EtO) exposure over time | 1984 - 2001 | EtO | Personal samples from 2265 hospitals; random effect modelling | Exposure ↓ steadily after OSHA standards set; > 1996 ↑ in probability of exceeding short-term excursion limit → coincides with ↓ in enforcement; permissible exposure limit exceedances 1988 - 2001: ↓96% |
| | Vandenplas *et al.* 2009 | 88 hospitals, Belgium: Changes in glove policies: Substitution of natural rubber latex (NRL) with NRL-free gloves | 1980's - 2004 | NRL-induced occupational asthma (OA) cases | Retrospective review of OA claims; survey on glove policies | Overall ↓ usage of powdered NRL-gloves by ~ 80% from 1989 - 2004; parallel:↓ incident cases of NRL-induced OA |
| | Miyake *et al.* 2013 | Hospital, Japan: Effects of closed-system drug transfer device on surface contamination & exposure of pharmacists to cyclophosphamide (CP) | 2007 - 2009 | CP concentration; BM (urine) | Wipe tests for CP of compounding room before daily cleaning; 24-hr urine of 4 pharmacists | Post-intervention: ↓ of surface contamination to almost undetectable levels; ↓ pharmacists' mean urinary CP conc. by ~ 90% |
| | Zhang *et al.* 2016 | 2 hospitals, China: Effect of pharmacy intravenous admixture service on occupational antineoplastic drug (AD) exposure in female oncology nurses | 2009 - 2013 | BM: blood cell count; renal & liver BMs | 202 nurses in intervention hospital, 190 in control group; BM & self-reporting questionnaire | Post-intervention: Health risks to AD significantly alleviated in intervention group: significant restoration o blood cell counts & kidney function, ↓ adverse reproductive outcomes |

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