Potential hazards linked to the use of disinfectants in healthcare: Health and occupational health risks assessment

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Outline

I. Respiratory health effects of disinfectants and cleaning products (DCP)
   - Chronic respiratory diseases
   - DCP and asthma
   - DCP and COPD / lung function

II. Other potential health effects of DCP

III. Conclusion and pending questions
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Chronic respiratory diseases

Asthma

Definition / characteristics
• Chronic inflammatory disease of the airways
• Attacks of breathlessness with wheezing
• Chronic respiratory symptoms

Prevalence
• France: children 10-15%; adults 5-10%
• World: ~270 millions

Chronic Obstructive Pulmonary Disease (COPD)

Definition / characteristics
• Progressive and largely non-reversible airway obstruction leading to airflow limitation
• Diagnosed by lung function measurements

Prevalence
• France: Adults ≥45 years 5-10%
• World: ~300 millions, 3rd cause of mortality
15-20% of asthma and COPD cases attributable to occupational exposures (Blanc, AJRCCM, 2019)

In the past 2 decades: growing evidence for adverse respiratory effects of occupational exposure to disinfectants and cleaning products (DCP)

- (cleaning worker* OR cleaning product* OR cleaner* OR disinfect*) AND asthma
- (cleaning worker* OR cleaning product* OR cleaner* OR disinfect*) AND (COPD OR chronic obstructive pulmonary disease)
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DCP first identified as a risk factor for asthma

- **Surveillance data:** Industries/jobs accounting for a large part of occupational asthma cases:
  - Cleaners
  - **Healthcare**
    - USA: 16% (1\textsuperscript{st} industry)
    - France: 12% (2\textsuperscript{nd} industry)
    - **Hospital workers** - nurses, nursing aides, cleaners
  - DCP increasingly identified as causal agent


Siracusa, Allergy, 2013; Folletti, COACI, 2017
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- **Epidemiological studies**
  - Increased asthma risk (asthma development, asthma symptoms) among
    - Healthcare workers: nurses, nursing aides
    - Cleaners

Siracusa, Allergy, 2013; Folletti, COACI, 2017
Agents contained in DCP

Common cleaning / disinfection products

- Bleach
- Ammonia
- Acids (decalcifiers)
- Quats (quaternary ammonium compounds)
- Alcohol
- Perfumes

Products used in healthcare settings

- Aldehydes (formaldehyde, glutaraldehyde)
- Hydrogen peroxide (+ acids)
- Chlorhexidine
- Chloramine T
- Ethylene oxyde
- Enzymes (added to detergents)

Potential target(s) for prevention: which specific product(s)/agent(s)?
### Specific agents associated with asthma (epidemiological studies)

<table>
<thead>
<tr>
<th>Reference</th>
<th>Study design, country</th>
<th>Outcome</th>
<th>Agents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medina-Ramon, 2005</td>
<td>Spain, cleaners, n=195</td>
<td>Current asthma/ chronic bronchitis</td>
<td>Bleach, ammonia</td>
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<tr>
<td>Mirabelli, 2007</td>
<td>Europe, n=2813</td>
<td>New-onset asthma</td>
<td>BLEACH, ammonia</td>
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<tr>
<td>Vizcaya, 2011</td>
<td>Spain, cleaners, n=917</td>
<td>Current asthma, asthma symptoms</td>
<td>Hydrochloric acid, ammonia</td>
</tr>
<tr>
<td>Arif, 2012</td>
<td>USA, healthcare workers, n=3650</td>
<td>Work-related asthma / asthma symptoms</td>
<td>BLEACH, ammonia, chloramines, formaldehyde, glutaraldehyde/ ortho-phthalaldehyde, ethylene oxide</td>
</tr>
<tr>
<td>Dumas, 2012</td>
<td>France, n=724</td>
<td>Current asthma</td>
<td>Decalcifiers (acids), ammonia</td>
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<tr>
<td>Gonzalez, 2014</td>
<td>France, healthcare workers, n=543</td>
<td>Physician-diagnosed asthma</td>
<td>Quaternary ammonium compounds</td>
</tr>
<tr>
<td>Dumas, 2017</td>
<td>USA, female nurses with asthma, n=4102</td>
<td>Asthma control</td>
<td>BLEACH, hydrogen peroxide, enzymatic cleaners, formaldehyde, glutaraldehyde</td>
</tr>
<tr>
<td>Casey, 2017</td>
<td>USA, hospital workers, n=163</td>
<td>Current asthma</td>
<td>Disinfectant containing hydrogen peroxide, peracetic acid and acetic acid</td>
</tr>
<tr>
<td>Su, 2019</td>
<td>USA, healthcare workers, n=2030</td>
<td>Asthma clusters, e.g. “undiagnosed/ untreated asthma”, “asthma attacks/ exacerbations”</td>
<td>Alcohols, bleach, enzymatic cleaners</td>
</tr>
<tr>
<td>Brooks, 2020</td>
<td>New Zealand, 425 cleaners, 281 other workers</td>
<td>Current asthma, lung function</td>
<td>BLEACH, decalcifiers (acids)</td>
</tr>
</tbody>
</table>

*Results presented only for chemicals significantly associated with asthma outcomes. Products with mixed composition (e.g., “detergents”, “cleaning sprays”, “multipurpose products”) not reported in this table.*
Specific agents associated with asthma (epidemiological studies)

- **Bleach (chlorine) and ammonia**: first specific agents identified
- **Bleach** remains the most frequently reported

- High level disinfectants (healthcare settings):
  - Aldehydes (**formaldehyde, glutaraldehyde**) long known as causing agents for occupational asthma
  - High level disinfectants proposed as alternative to aldehydes (**hydrogen peroxide or hydrogen peroxide / peracetic acid mixtures**) also appear associated with asthma outcomes
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Working as cleaner and COPD: two European studies

**RHINE III** (Northern Europe): n=13,499 adults (mean age: 51.5) - Svanes, PlosOne, 2015

**UK Biobank**: n=228,614 adults (mean age: 52) – De Matteis, OEM, 2016

Results adjusted for sex, age, smoking, +education level, parents’ education level, body mass index
Working as cleaner and COPD mortality

Van den Borre et al, Int Arch Occup Environ Health 2018

- Linkage of Belgian census, register & death certificate data
  - Working population in 1991, ~2.5M adults
  - ~260,000 deaths from 1991 to 2011

- Cause specific mortality in death certificate:
  - ICD 9/10

- Current occupation recorded in 1991 census:
  - Comparison cleaners vs. non-manual workers (ref)

- Association with COPD mortality remained similar after adjustment for smoking (indirect) and education
- Working as cleaner also associated with mortality from lung cancer, pneumonia, ischemic heart diseases and cerebrovascular diseases with SMR range [1.10-1.50]
Working in healthcare and COPD: studies in the US

NHANES III - Hnizdo et al., AJE 2002 & AJIM 2004
• US, 1988-94
• n=9,823 adults aged 30-75 years
• Longest held job – healthcare industry

NHIS – Doney et al, JOEM 2014
• US, 2004-11
• Adults aged 40-70 years
• Current job – healthcare support

Results adjusted for sex, age, race/ethnicity, smoking, +education level/SES, body mass index
Association of exposure to specific disinfectants/cleaning products with COPD incidence

Exposure to specific agents
*High vs. low exposure level*

<table>
<thead>
<tr>
<th>Agent</th>
<th>HR (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formaldehyde</td>
<td>1.20</td>
</tr>
<tr>
<td>Glutaraldehyde</td>
<td>1.25</td>
</tr>
<tr>
<td>Hypochlorite bleach</td>
<td>1.36</td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>1.29</td>
</tr>
<tr>
<td>Alcohol</td>
<td>1.32</td>
</tr>
<tr>
<td>Quats</td>
<td>1.33</td>
</tr>
<tr>
<td>Enzymatic cleaners</td>
<td>1.05</td>
</tr>
</tbody>
</table>

n=582 incident COPD cases

- Female registered nurses from 15 US states
- Follow-up from 2009 to 2017
- 73,262 nurses (mean age: 54 years)

Results adjusted for age, race, ethnicity, smoking status and pack-years, and body mass index

*References*

Dumas et al., JAMA Network Open, 2019
ECRHS (Europe) – Svanes, AJRCCM 2018

- **n=6,235 adults** (mean age: 54 at end of follow-up)

- Lung function decline and airway obstruction:
  - Spirometry at each survey
  - Decline in FEV$_1$, FVC, FEV$_1$/FVC

- Cleaning exposures:
  - Cleaning at home (+ use of sprays)
  - Occupational cleaner

Results adjusted for age, height, smoking, education level, body mass index, spirometer model and study center
FEV1: forced expiratory volume in 1 second; FVC: forced vital capacity

Cleaning activities and lung function decline in women
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Other potential health hazards of occupational exposure to DCP

• Reproductive outcomes
  Use of sterilizing agents/disinfectants among female nurses associated with increased risk of:
  • Preterm birth - Lawson, AJOG 2009
  • Spontaneous abortions - Lawson, AJOG 2012
  • Reduced fecundity - Gaskins, SJWEH 2016

• Cardiovascular outcomes
  Long-term frequent use of household spray and scented products in older adult women associated with reduced Heart Rate Variability (suggests cardiovascular health hazards) - Mehta, EHP 2012

• Endocrine disruptors
  Disinfectants may contain endocrine disruptive chemicals used as preservative and antimicrobial agents (e.g., parabens, triclosan, triclocarban) – Dodson, EHP 2012
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Conclusion and pending questions

• Conclusions:
  – Strong evidence to support a link between DCP exposure and **asthma**
  – Evidence to support a link between DCP exposure and **COPD** is accumulating
  – Additional studies are needed to examine other potential health effects

• Pending questions:
  – Clarify the causative agents
    Crucial knowledge for the development of strategies for prevention, in particular in healthcare settings
  – Strategies for asthma and COPD prevention
    • Use of protective equipment, ventilation?
    • Limit use of sprays (likely to increase exposure by inhalation – Loven, Occup Env Hyg 2019)
    • Safer alternatives?
      – “Green products”? (need health safety evaluation) – Garza, AJIM 2015
      – Non-chemical disinfection? (UV light, heat) – Quinn, AJIC 2015
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