Occupational health in aquaculture – a review of the literature

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Outline

• Introduction

• Common hazards in aquaculture

• Occupational exposure assessment in aquaculture

• Epidemiology of occupational diseases in aquaculture

• Interventions to reduce hazards in aquaculture

• Conclusions
Introduction

• Aquaculture is one of the fastest growing food-producing sectors

• Fish farming is the second most high-risk occupation after being a fisherman (Norway)

• Little is known of the occupational exposures, risk factors and their associated diseases among aquaculture workers, particularly in developing countries where the activity predominates

• Aim: describe the occupational exposures and associated occupational diseases among aquaculture workers

• Google Scholar, MEDLINE and SCOPUS literature searches undertaken to identify relevant studies (1960-2017)
## Common occupational hazards in Aquaculture

<table>
<thead>
<tr>
<th>Hazard category</th>
<th>Causative agents/processes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Safety</strong></td>
<td>Slips and trips, falls, needle-sticks, unprotected machinery, electricity, diving, underwater entrapment, explosions, firearms, tractor power take-offs, confined spaces</td>
</tr>
<tr>
<td><strong>Physical</strong></td>
<td>Heat and cold, vibration, solar radiation, noise</td>
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<tr>
<td><strong>Chemical</strong></td>
<td>Sensitizers, irritants, antibiotics, toxic gases</td>
</tr>
<tr>
<td><strong>Biological</strong></td>
<td>Sharp teeth, spines, poisonous insects, snakes, allergens, microbes, fish feed, endotoxins</td>
</tr>
<tr>
<td><strong>Ergonomic</strong></td>
<td>Heavy lifting, prolonged standing, awkward postures, repetitive motion, overexertion, lack of visibility</td>
</tr>
<tr>
<td><strong>Psychosocial</strong></td>
<td>High demand-low control situations, shiftwork, remote locations and lone work, large fish kills, abusive social environment</td>
</tr>
</tbody>
</table>
Occupational exposure assessments studies in Aquaculture

• Very few occupational exposure characterisation studies that have quantified occupational exposures to hazards in aquaculture

• Hazards that have been quantified include noise, formaldehyde and microbial concentrations measured in different aquaculture operations
Noise

• Potential sources of excessive noise
  – Vehicles
  – Heavy equipment
  – Constant movement of water in intensive aquaculture operations

• Noise levels
  – Hatchery tank room: 36.1-73 dB
  – Salmon building: 43.2-77.5 dB
  – Rearing pavilion: 70.2-83.2 dB
  – Oyster farms: 58.2-88.5 dB

(Barnes et al, 2015; Voorhees et al, 2017; Guertler, 2017)
Formaldehyde

• Used for treating water damp mould and prevent parasitic infections

• Fish hatchery (Lee and Radtke, 1998)
  – Personal breathing zone: <0.19 - 0.8 ppm
  – Area measurements: <0.045 - 0.68 ppm

• Fish hatchery incubation stacks treated with 1,667 mg/L formalin for 15 min (Voorhees and Barnes, 2016)
  – Formalin Levels: 0.5 ppm (one stack) - >2.0 ppm (five stacks)
  – Opening incubation room door → lower levels
  – Recommendation: Hatchery workers to leave confined incubation locations or use appropriate PPE during formalin treatment
Microbes

• May arise from animal manure used to fertilize fish ponds

• *E. coli* levels in Vietnamese fish ponds
  – Irrigation water: $<10^3$ CFU)/100 mL
  – Fish pond water using animal manure: $<10^4$ CFU/100 mL
  – Tilapia skin:
    • Excreta-based systems: $<10^3$ CFU/100 cm
    • Feed-based systems: $<10^1$ CFU/100 cm

(Yajima and Kurokura, 2008)
Epidemiology of occupational diseases in Aquaculture

• Commonly encountered diseases reported in individual case reports or systematic epidemiological studies among workers in aquaculture:

  – musculoskeletal disorders
  – dermatitis, urticarial and skin infections
  – allergic respiratory disease
  – infections affecting other body systems
  – decompression illness
Musculoskeletal disorders (MSDs)

• Commonly reported MSDs
  – general body pain: 72%
  – lower back: 19-67%
  – shoulders: 63%
  – wrist/hands/fingers: 11-50%
  – neck: 48%
  – knees/hips: 9%
  – spinal cord, nerve or bone: 4%

• Risk factors for MSDs
  – Increased employment duration
    • Upper back pain: OR = 3.07 (CI: 1.17-8.04)
  – Tractor use
    • wrist/hand pain: OR = 2.89 (CI: 1.28-6.56)
    • low back pain: OR = 2.41 (CI: 1.03-5.67)

(Nonnenmann et al., 2010; Guertler et al., 2016; Fröcklin et al., 2012; Nuruzzaman et al, 2017; Viana, 2013; Thorvaldsen et al, 2017)
Dermatitis, urticaria and skin infections

• Commonly reported skin disorders
  – skin itching: 67%
  – whitlow finger infection: 41%
  – dermatitis: 6-7%
  – urticaria: 0.3-0.7%
  – fungal nail infection: 0.3-16%

• Risk factors for skin disorders
  – female gender: OR = 2.48 (CI: 1.06-5.76)
  – fish farming-related jobs: OR = 3.47 (CI: 1.27-9.50)
  – wastewater contact in the past 7 days: OR = 2.74 (CI: 1.29-5.82)
  – lack of protective measures: OR = 2.24 (CI: 1.21-4.12)
  – aquaculture work in the wet season: OR = 2.8 (CI: 1.02-7.6)

(Anh et al., 2007, 2009; Granslo et al., 2009; Trang et al., 2007; Oyediran et al., 2016)
Allergic respiratory disease

• Commonly reported allergic respiratory symptoms/diseases
  – sensitisation to Artemia (brine shrimp): 21-25%
  – rhinitis: 4%
  – dyspnoea and cough: 2-13%
  – work-related wheeze: 23%
  – work-related chest tightness: 20.2%
  – self-reported asthma: 0.7-17%
  – doctor diagnosed asthma: 4%

• Risk factors for work-related respiratory symptoms
  – Employment duration
    • 2-7 years: OR=2.29 (CI: 1.07-4.91)
    • >7 years: OR=3.72 (CI: 1.52-9.11)

(Granslo et al., 2009; Nuruzzaman et al., 2017; Fröcklin et al., 2012)
Other infections and skin trauma (needle sticks)

• British aquaculture workers: Leptospirosis incidence of 33/100,000 PYS (Gill et al., 1985)
  – incidence in the general adult male population: 0.137/100,000 PYS

• Tanzanian seaweed farm workers: Parasitic infection prevalence of 20% (Fröcklin et al., 2012)

• Needle stick injuries while vaccinating fish
  – risk in Norwegian salmon farmers: 5 self-injections/1,000,000 vaccinations (Dyrkorn et al., 1993)
Decompression illness

- Marine aquaculture is diving intensive - increased risk of decompression illness and barotrauma (leading to deafness) among divers

- Tasmanian marine aquaculture of salmon/trout:
  - incidence of decompression illness among divers: 0.57 cases/10,000 dives (1996/98)
  - declining from previous periods: 3.57 per 10,000 dives (1992-94) and 26.19 per 10,000 dives (1988-90)

- Reduction in incidence attributed to major improvements in safety training and procedures for divers
  
  (Smart et al., 2001)
Interventions to reduce occupational diseases

• Various measures have been identified to reduce the exposure to hazardous occupational agents among workers in the aquaculture industry

• These measures are designed to work most effectively:
  – At the source - removing or substituting a hazard
  – Along the path - occupational hygiene measures
  – At the level of the worker - administrative procedures and PPE usage

• Measures at the level of the worker are the least desirable as it relies on worker compliance
## Prevention at the source

<table>
<thead>
<tr>
<th>Type</th>
<th>Hazard</th>
<th>Specific intervention</th>
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</thead>
<tbody>
<tr>
<td>Removal/substitution of the hazard</td>
<td>Needlestick (while vaccinating fish)</td>
<td>Installation of <strong>automatic fish vaccination machine</strong></td>
</tr>
<tr>
<td></td>
<td>Heavy lifting</td>
<td>- Usage of <strong>pulley and rail or crane</strong> to raise fish nets from raceway&lt;br&gt;- Usage of fish pump to harvest fish</td>
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<tr>
<td></td>
<td>Work in confined spaces</td>
<td><strong>Redesign of pit for pump to prohibit human entry</strong></td>
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<tr>
<td></td>
<td>Solar radiation</td>
<td>Work in <strong>covered areas</strong></td>
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</tbody>
</table>
# Prevention along the path

<table>
<thead>
<tr>
<th>Type</th>
<th>Hazard</th>
<th>Specific intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational hygiene measures</td>
<td>Formalin</td>
<td>Local exhaust ventilation</td>
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<tr>
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<td>Local exhaust ventilation</td>
</tr>
<tr>
<td></td>
<td>Noise in fish rearing facilities</td>
<td>Enclosing tanks and standpipes</td>
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<tr>
<td></td>
<td>Formaldehyde in fish hatchery</td>
<td>Using a <strong>timer automated pump system</strong> to treat fish fingerlings or eggs when employees are not in area</td>
</tr>
<tr>
<td></td>
<td>Work in confined spaces</td>
<td>Placing <strong>railings</strong> as a barrier to entry of confined space</td>
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## Prevention at the Worker

<table>
<thead>
<tr>
<th>Type</th>
<th>Hazard</th>
<th>Specific Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory and eye protective devices, safer work practices, risk communication and training</td>
<td>Formalin (fish hatchery workers)</td>
<td>- Usage of appropriate safety equipment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Permitting workers to leave confined incubation locations</td>
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<tr>
<td></td>
<td>Safety hazards in diving</td>
<td>- Diver training</td>
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<tr>
<td></td>
<td></td>
<td>- Equipment maintenance</td>
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<tr>
<td></td>
<td></td>
<td>- Implementing safety procedures</td>
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<td>- Development of “mort cones” for capturing dead fish</td>
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</table>
Conclusions

- Aquaculture workers are at increased risk of developing adverse health outcomes that may be attributed to exposure to different hazards present in aquaculture environments.

- Levels of exposure to majority of the hazards have not been quantified in detail.

- Future studies should conduct improved exposure characterisation and epidemiological studies of workers exposed to key hazards so to identify important risk factors.

- Intervention programs aimed at reducing exposure to these hazards are likely to have a positive impact on the health of aquaculture workers since even basic measures are not in place in many developing countries.