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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

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

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

Type	Hazard	Specific intervention
Removal/ substitution of the hazard	Needlestick (while vaccinating fish)	Installation of automatic fish vaccination machine
	Heavy lifting	- Usage of pulley and rail or crane to raise fish nets from raceway - Usage of fish pump to harvest fish
	Work in confined spaces	Redesign of pit for pump to prohibit human entry
	Solar radiation	Work in covered areas

Prevention along the path

Type	Hazard	Specific intervention
Occupational hygiene measures	Formalin	Local exhaust ventilation
	Sodium metabisulfite	Local exhaust ventilation
	Noise in fish rearing facilities	Enclosing tanks and standpipes
	Formaldehyde in fish hatchery	Using a timer automated pump system to treat fish fingerlings or eggs when employees are not in area
	Work in confined spaces	Placing railings as a barrier to entry of confined space

Prevention at the worker

Type	Hazard	Specific intervention
Respiratory and eye protective devices, safer work practices, risk communication and training	Formalin (fish hatchery workers)	<ul style="list-style-type: none">- Usage of appropriate safety equipment- Permitting workers to leave confined incubation locations
	Safety hazards in diving	<ul style="list-style-type: none">- Diver training- Equipment maintenance- Implementing safety procedures- Development of “mort cones” for capturing dead fish

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