



# Occupational health, safety and work environments in Norwegian fish farming - employee perspective

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## ABSTRACT

**Background:** Aquaculture workers are exposed to several workplace hazards.

Norwegian fish farming has a high occupational injury rate. This article provides new knowledge about workers' perceptions of their health and work environment.

**Methods:** The study is based on data collected in a telephone survey with 447 participants and 35 qualitative interviews. The survey respondents were mainly personnel working at fish farms and on service vessels. The interviewees included personnel at fish farms as well as managers and staff. Data were analysed according to a model that included working conditions and exposures, health complaints and concerns, sickness absence, subjective health status and job satisfaction.

**Results:** The survey data show that physical and ergonomic exposures are the most common, and several workers report psychosocial exposures such as stress and lack of control in their workday. The most frequently reported health complaints were musculoskeletal (neck/shoulder/arm pain, back pain, hand/wrist pain, knee/hip pain). More than half of the respondents have concerns that their work environment may affect their health negatively. Work-related sickness absences related to strain and acute injuries are reported by 11.6% of respondents. Eighty-five per cent consider their health as good or very good, and 97% are satisfied at work always or most of the time. Interview data identify several work tasks that were perceived as particularly straining but also confirm the high level of job satisfaction in the industry.

**Discussion:** Hazards in the work environment need to be removed or mitigated to prevent unfavourable health exposures. Conflicting objectives in the production process may lead to work pressure for workers. Organisational factors that could improve individual work conditions are avoidance of long working hours and ensuring adequate rest between shifts. Workplace risk levels may be influenced by the design of fish farms and equipment, and hence occupational health and end user needs should be properly considered in technology development.

**Conclusion:** The prevalence of musculoskeletal diseases stands out as a challenge for workers' occupational health. Measures should be implemented at the individual, organisational and regulatory levels and included in technology design.

## 1. Introduction

Aquaculture workers worldwide are at increased risk when it comes to occupational diseases and injuries, and the risks are often under-reported (Ngajilo and Jeebhay, 2019). Hazards, injuries, diseases and the regulations to protect workers are diverse, reflecting different types of operations, scales of production and specific species farmed in different regions. A recent study calls for a global commitment to occupational safety and health issues in aquaculture (Cavalli et al., 2019).

The Norwegian aquaculture industry mainly consists of salmon fish farming (Holmen and Thorvaldsen, 2018). As a profitable producer of Atlantic salmon, the industry exports to a global market and creates great economic values and employment in fish farming companies and related industries (Johansen et al., 2019).

The injury and fatality rate is high compared to other industries, and common modes of injuries are falls, blows by objects, entanglement/crush and cuts (Holen et al., 2018a, 2018b). Surveys among workers and onshore management in a selection of Norwegian fish farming companies have shown that consideration to production is sometimes prioritised at the expense of workers' safety (Kongsvik et al., 2018b). Organisational challenges that may influence work conditions negatively are insufficient staffing, work pressure due to long work hours, lack of training, lack of involvement of employees when new procedures are designed and implemented, and insufficient time and resources for maintenance (Kongsvik et al., 2018a; Thorvaldsen et al., 2017).

Even though previous research has studied occupational safety in fish farming, there is inadequate knowledge regarding the causes of

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sickness absence in the industry. In addition, available national statistics do not identify if the sickness absences are work-related. However, musculoskeletal disorders (MSDs) are the main cause for sickness absence in Norway (Kinge et al., 2015). A recent review study found several ergonomic hazards that may increase the risk of MSDs in the aquaculture industry (Ngajilo and Jeebhay, 2019). In fish farming, unfavourable exposures such as heavy lifting, prolonged standing, awkward postures and repetitive work are common (Moreau and Neis, 2009).

There are no previous studies about how workers in the Norwegian fish farming industry experience their own health and how this relates to their work environment. The objective of this article is to provide knowledge about occupational health and the work environment by investigating workers' perceptions. Based on a telephone survey and qualitative interviews, new research-based knowledge about exposures, health complaints, concerns, sickness absence and perceptions of health status and job satisfaction is presented.

The findings presented here are part of the research project "Safer operations and workplaces in fish farming." Targeting sea-based fish farming, this project has also focused on physiological measurements of workers' workload and the influence of organisational factors and safety management on occupational health and safety (Kongsvik et al., 2019; Kongsvik et al., 2018a, b), as well as technology development and design as a key to good working conditions (Salomonsen et al., 2019). In the discussion, we draw on relevant findings from the project and literature to describe measures that could improve the working environment and reduce sickness absence and health complaints for workers in the fish farming industry.

## 2. Material and methods

The data presented in this article are based on a telephone survey including 447 participants, and in-depth interviews with 35 employees at different organisational levels.

All data have been handled according to the principles of the Norwegian Centre for Research Data (NSD, 2018). All survey and interview participants were informed about the purpose of the study, and that their participation was voluntary and anonymous. Informed consent was thus obtained from all participants.

### 2.1. Telephone survey

A survey was designed that included both closed and open-ended questions focused on self-reported health, health complaints, exposures and sickness absence. The survey included general questions about the participants' characteristics (age, position, etc.) as well as questions about health status, job satisfaction, work-related exposures, health complaints, sickness absence and concerns. Similar surveys from other industries such as offshore and fishing (Fenstad et al., 2016; Sønvisen et al., 2017) as well as public health surveys were studied for relevant questions.

According to figures from Statistics Norway, 5617 people were working in the Norwegian fish farming grow-out production in 2016 (Directorate of Fisheries, 2018). The same year, 165 companies were registered as salmon and trout producers (Directorate of Fisheries, 2019). The main production technology in Norwegian salmon farming involves sea-based fish farms and net cages with floating collars accessed by boat.

In the Norwegian context, employees or production workers at the fish farms include fish farmers, service vessel crew members and operational managers (here also referred to as workers). These workers were the target group for the survey. At any given fish farm, three to six fish farmers and an operational manager work to ensure the safety, welfare and growth of the fish. Fish farmers perform daily inspections at the fish farms, and operations such as parasite treatment or fish transfer. Boats and cranes are often used by both fish farmers and

service vessel crews. Service vessel crews travel between different fish farms and perform operations such as mooring and maintenance. Operational managers are the team managers at each fish farm. Along with being responsible for production at the fish farm, they may also participate in the work alongside the fish farmers.

Informants to the survey were recruited by contacting 40 different aquaculture companies at different geographical locations and of different sizes. Some of the researchers along with a professional polling company piloted the survey. No changes were considered necessary after the piloting, and the polling company proceeded with conducting the survey by telephone during the fall of 2016. Companies that shared employees' phone numbers received information about the purpose of the survey and were encouraged to share it with employees beforehand. In total, 735 employees were explicitly asked to participate, and 447 agreed while 288 declined, giving a response rate of 61%.

#### 2.1.1. Telephone survey respondents

The 447 participants were mainly personnel working at fish farms and vessels, including fish farmers (58%), operational managers (25%) and employees on board service vessels (13%). Some employees had other positions (4%) in the companies. The majority were male (96%). The age was evenly distributed, but the majority belonged to the age groups between 25 and 54 years old. A relatively large proportion had more than 15 years' experience in the aquaculture industry (38%). Most participants worked in companies with more than 200 employees (61%) and in the counties of Møre og Romsdal (21%), Hordaland (21%) and Trøndelag (20%). These counties were among the four counties with the highest number of licenses for grow-out production in 2016 (Directorate of Fisheries, 2019). Looking at the geographical location of the production sites in 2016, there are some differences regarding representativity. At the time of the survey, most fish farms were in Nordland (22%), Hordaland (18%) and Trøndelag (16%). Furthermore, only 9% of farms were in Møre og Romsdal (Directorate of Fisheries, 2019). These differences are related to the recruitment strategy as well as the response rate from companies that provided phone numbers and participants Table 1.

#### 2.2. Key informant interviews

Following the survey, in-depth, qualitative interviews with 35 employees were conducted from April to September 2017. The aim was to elaborate on and discuss topics and findings from the telephone survey. The interviews were semi-structured, based on an interview guide with open-ended questions, allowing the participants to talk freely about the topics at hand. Some minor changes in the guide were made after the first four interviews to make it more effectively targeted to the issues to be explored.

To recruit informants for the interviews, a selection of companies was approached through e-mail and telephone. Seven companies of different sizes and from different regions of Norway were selected. The participants for the follow-up interviews worked in three geographical regions (counties): Trøndelag (the middle region of Norway), Nordland and Finnmark (the northern region). Twenty-seven of the interviewees were fish farmers or operational managers, and eight worked in on-shore management or staff functions in the companies.

All interviews were conducted in person by one or two researchers. Most of the interviews were audio-recorded and transcribed. For the 17 interviews that were not audio-recorded, detailed notes were taken by a researcher not conducting the interviews. The interview data were analysed, and quotes used in the article were translated from Norwegian to English by the authors.

#### 2.3. Analysis

Regarding the telephone survey, the polling company registered the data continuously during the telephone interviews in a general format.

**Table 1**

The 447 participants in the telephone survey sorted by position, gender, age, experience, number of company employees and county.

		Percentage	Number
Position	Fish farmer	57.7	258
	Operational manager	24.6	110
	Service vessel crew	13.4	60
	Other	4.3	19
Gender	Male	95.5	427
	Female	4.5	20
Age	Below 25 years	11.2	50
	25–34 years	27.1	121
	35–44 years	23.7	106
	45–54 years	24.8	111
	55 and over	13.2	59
Experience	0–2 years	13.6	61
	3–6 years	23.9	107
	7–14 years	24.2	108
	15 years or more	38.3	171
Number of employees	Below 50	9.8	44
	50–200	22.8	102
	200 and over	60.9	272
	Did not know	6.5	29
County (as of 2017)	Møre og Romsdal	20.6	92
	Hordaland	20.6	92
	Sogn og Fjordane	11.6	52
	Nord-Trøndelag	10.7	48
	Sør-Trøndelag	9.2	41
	Rogaland	8.7	39
	Nordland	6.3	28
	Troms	5.6	25
	Finmark	4.3	19
	Other	2.5	11

At completion, data were exported to Statistical Package for the Social Sciences (SPSS). Descriptive analyses were performed in SPSS. The frequencies of work-related exposures, health complaints and concerns, sickness absence, self-reported health status and job satisfaction were obtained.

Five-point Likert scales were used for several variables. The respondents considered how often they experienced different work-related exposures. In order to estimate the prevalence of the different exposures, the two categories of *often* and *very often* were collapsed. Similarly, the respondents considered to what degree they had experienced different health complaints during the last 12 months. The categories of *large degree* and *very large degree* were collapsed in the analysis to estimate prevalence. The results are presented according to the model in Fig. 1.

The results were analysed for the total sample, and not broken down to different occupational categories etc. One reason for this was that fish farmers, operational managers and service vessel crews share much of the same working environment and health exposures. Also, in a preliminary analysis, we found only minor and non-significant differences between sub-groups in the sample. The low number of respondents in some sub-groups might have contributed to this.

The qualitative interviews were analysed according to the topics illustrated in Fig. 1. All interviews were manually coded in Word. The codes and the associated interview sections were then thematised according to the three main topics. Relevant findings from the interviews are presented in relation to the survey results on health and safety concerns, sickness absence, and health status, providing more in-depth

and nuanced data on these issues.

## 2.4. Data quality

In constructing the content of the survey questionnaire, previous questionnaires and public health surveys were used as a starting point. This should have contributed to the validity of the study. Still, additional health exposures might have been included, for example petroleum fumes, dust, veterinary products etc., which are of clear relevance in fish farming. Even so, there was a need to limit the length of the survey to avoid respondents from dropping out of the study.

A professional polling company conducted the survey. The use of a neutral agency with no association with the industry might have increased the respondents' trust in their own anonymity, and reduced a possible social desirability bias (Krumpal, 2013) and thus increased the validity of the study. The piloting completed by the researchers together with the polling company supports the study's reliability.

The response rate was 61%, which can be considered satisfactory/good (Baruch, 1999). Still, this does not exclude the possibility of response bias and a non-representative sample. An analysis of the characteristics of those who declined to participate would be preferable but was not feasible within the economic and time limits of the study. The sample is fairly representative when it comes to gender distribution. In the sample, 95.5% were men, while there are 82% men in the Norwegian aquaculture industry in general (Directorate of Fisheries, 2018). Land based, administrative positions and people working with fish processing were not included in the survey, which might explain the slightly overrepresentation of men in our sample. No public records exist on the distribution of other background variables in the population of fish farm employees, so how representative the sample is according to age, experience etc. cannot be assessed.

Future research in this area should seek to include a larger sample, as this can provide an opportunity to explore group differences statistically (e.g. between fish farmers, operational managers and service vessel crews).

The interview data was collected through personal interviews at the fish farms or onshore offices of the selected companies. Informants were ensured anonymity, and the general impression was that interview candidates were open about work environment challenges, and that interview data supported and elaborated findings from the telephone survey. When it came to exposures and health complaints, interview data had many similarities regardless of location and company size. The geographical location of the fish farms or size of the companies did thus not stand out as being of key importance in the findings presented here.

Overall, we consider the data quality to be satisfactory.

## 3. Results

### 3.1. Work-related exposures

The prevalence of work-related exposures and health complaints was studied through the survey data. Employees were asked to rate how often they were negatively exposed to 11 different aspects of their working environment during the last 12 months on a five-point scale: *never*, *seldom*, *sometimes*, *often* and *very often*. The figure below presents the combined percentage of answers in the categories of *often* and *very often* for exposures that relate to the physical work environment (F2)

Fig. 2



Fig. 1. Organisation of the results.

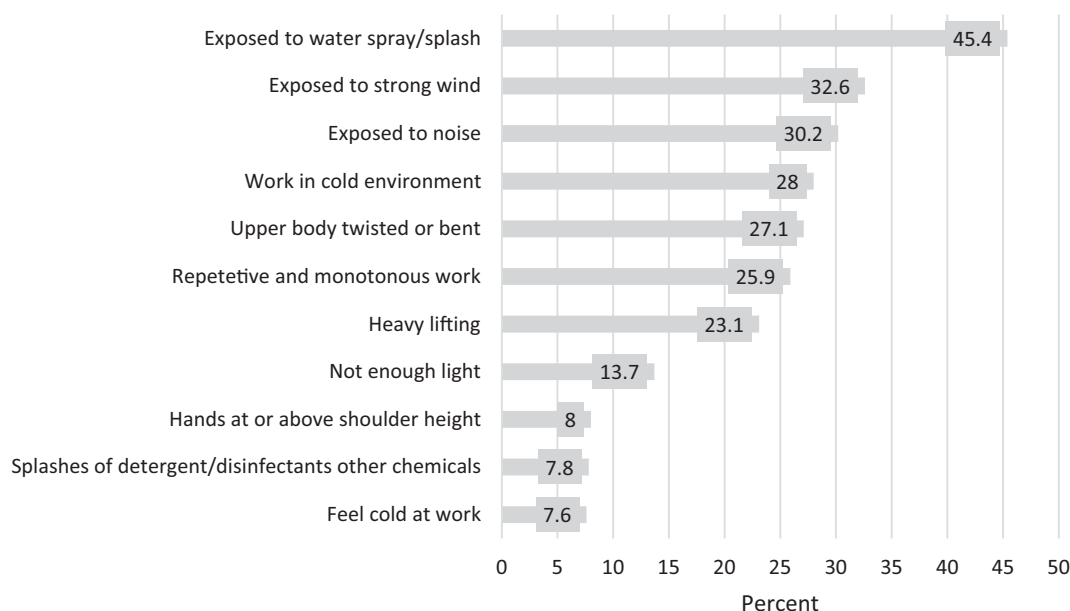


Fig. 2. Physical exposures experienced often or very often by the respondents (N = 447).

The most prevalent exposures were related to water spray/splash, strong wind and noise. Several of the exposures are connected to working outside. Sixty per cent of the service vessel crew work outside more than 80% of their workday. For fish farmers, 47% work outside more than 80% of the time, and 32% spend 50–80% of their time outdoors. Despite exposures to water splash, strong winds and a lot of time outdoors, relatively few workers feel cold at work (8%).

Ergonomic risk factors such as lifting with the upper body twisted or bent, repetitive and monotonous work operations and heavy lifting are experienced often or very often by significant portions of the participants.

Fig. 3 illustrates the prevalence of psychosocial work-related exposures (stress, lack of control, lack of rest and stressful working time arrangement). Regarding the psychosocial work environment, stress is most frequent, followed by lack of control (Fig. 3). In addition to the *often* and *very often* answers, the numbers for *sometimes* were high. Stress is sometimes experienced by 38%, 24% sometimes feel that they lack control in their workday, 23% sometimes find that they do not get adequate rest and 16% sometimes find that the working time arrangement is stressful.

These findings can be related to the organisation of work and work

hours in the industry. The cycle of fish production involves occasional work-demanding operations, such as parasite treatment or fish transfer, and the regularly low number of workers at the fish farm may in principle not be sufficient to cover the work hours needed during these busy periods. The question “How many hours and days do you work in busy periods (such as delousing)?” showed that 71.8% of fish farmers, operational managers and service vessel employees work between 9 and 12 or 13–16 continuous hours during busy periods (Fig. 4). Analysed by position, a lower percentage of the service vessel crew (28.3%) worked 9–12 h than the fish farmers (39.5%) and operational managers (38.2%). Furthermore, a higher percentage of the service vessel crews (40%) answered 13–16 than the fish farmers (34.1% and operational managers (33.6%). More service vessel crew members (18.3%) and operational managers (15.5%) than fish farmers (5.4%) worked 17–20 h.

For employees in the category “other”, most worked 9–12 h or did not know.

A normal workday (for shift workers) is 10.5 h. All participants were asked if they worked shifts. For the fish farmers, 204 out of 258 (79%) worked shifts and the most common system was 12 days of work and nine days off (68%), followed by one week on and one week off (24%). Although the majority worked shifts, most participants (78.5%) can

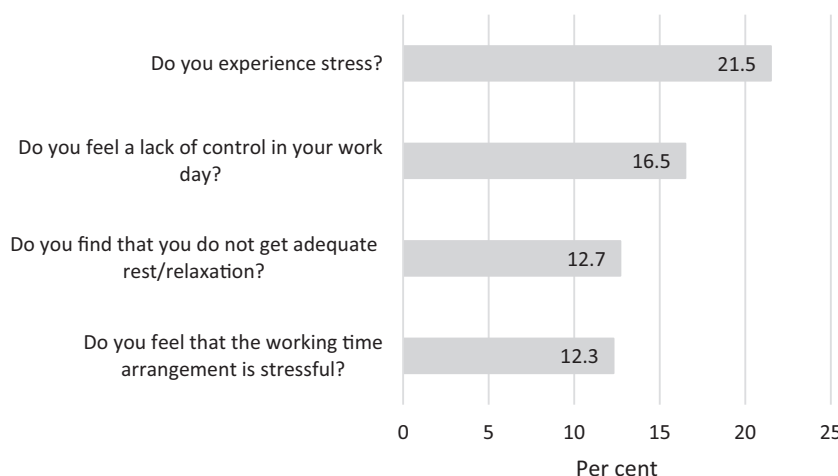


Fig. 3. Psychosocial work-related exposures experienced often or very often by the respondents (N = 447).

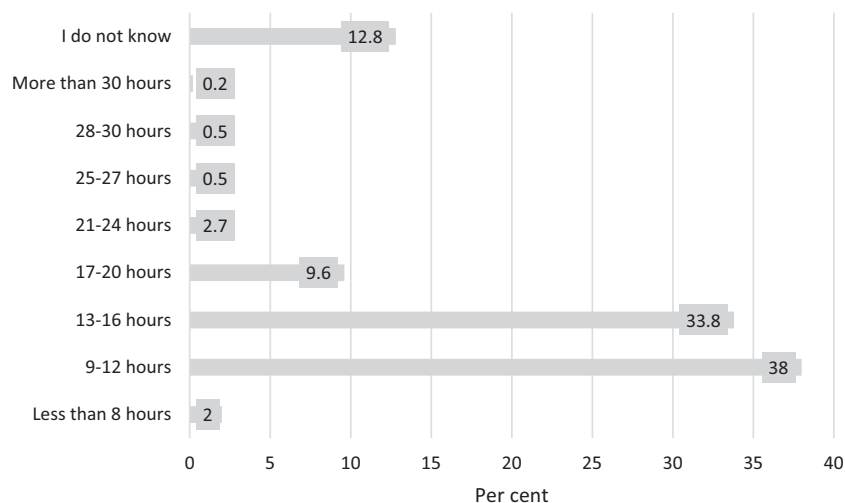


Fig. 4. Continuous hours worked in busy periods as reported by the respondents (N = 447).

spend the night at their own house, while 21% live farther away and must stay at the fish farm, on a land base nearby or on board a boat during their work periods.

### 3.2. Health complaints

All participants graded the prevalence of 15 different health complaints on a five-point scale from a *very small* to a *very large* degree: “To what degree have you, during the last 12 months, experienced the following health complaints?” Furthermore, they were asked to give examples of other complaints in an open category (“other”).

The most reported health complaints were musculoskeletal (Table 2). All employees who answered to a *large* or a *very large* degree were asked: “Do you think that this complaint is completely or partially caused by your work situation?” The findings show that the most common health complaint was neck/shoulder/arm pain (26.8%). Out of the total 447 participants, 23% related this complaint to their work. Looking at all musculoskeletal complaints (neck/shoulder/arm pain, back pain, hand/wrist pain, knee/hip pain), a total of 40% (179 respondents of 447) experienced one or more of these *often* or *very often*. Among these, there were 33.6% (150 respondents of 447) that

**Table 2**  
Prevalence of health complaints among the 447 participants in the telephone survey. The numbers are the percentage of respondents who reported a high or very high degree of the complaint, and who reported that they were work-related.

Health complaint	High/very high degree (percent of 447)	High/very high degree and work-related (percent of 447)
Neck/shoulder/arm pain	26.8	23.3
Back pain	19.0	15.4
Hand/wrist pain	11.5	10.5
Knee/hip pain	9.1	6.0
Tiredness	7.6	5.8
Headache	6.5	5.1
Sleep problems	5.8	2.9
Skin ailment (eczema, rash)	5.6	2.9
Respiratory ailment	4.2	1.6
Gastrointestinal disease	3.8	1.1
White fingers	2.4	2.0
Cardiovascular disease	2.2	0.2
Seasickness	2.2	1.6
Allergies	2.0	0.7
Mental sufferings	2.0	1.3
Other	1.4	0.9

indicated that these complaints were related to work.

### 3.3. Work-related health and safety concerns

To study work-related health and safety concerns, participants were asked: “Do you worry that aspects in your work environment may affect your health negatively now or in the future?” More than half of the participants answered *yes* or *sometimes* (26% and 27% respectively). Everyone who answered *yes* or *sometimes* was asked what aspects they worry about. Out of 239 participants who worried, the most common reasons for worry were strain injuries (20% of the total sample), accidents (13% of the total sample), other (e.g., specific work tasks, electrostatic charge in feeding tubes and driving boats) (7%), noise (4%) and bad weather/cold (3%).

In the survey, 76% of the participants said that they or their colleagues had experienced near accidents (incidents that may cause a person injury) during the last two years. Accidents were mentioned by 24% of the 239 who were worried. This finding also corresponds with results from another survey question: “Do you worry that you may be exposed to an accident at work?” Here, 8% responded *yes* and 24% responded *sometimes*. Thus, a total of 32% expressed worry about accidents at work.

The survey showed that workers were concerned about strain injuries and acute injuries. Concerns were also discussed in the interviews. A worry not directly addressed in the survey came up:

“I have thoughts about body vibrations [...]. It is something that is not talked about a lot. It wears on the skeleton. All boats give vibrations. You stand on deck, say, a few hours during the day. And vibrate. So, the question is how good the health will be in twenty years. One doesn't know. But other than that, I don't go around worrying.”

Another worker highlighted the development of the industry as well as the experience of the workers when he talked about his concerns:

“Some years ago, I was worried because we worked with moorings with a few people and boats that weren't in the best shape. One had to be experienced to do the work. If inexperienced workers participated, I was worried. It was so tough in the beginning that I often worried. The equipment was not adapted. Fish farmers did a lot of the work that employees at the service vessels do now.”

When asked about the fact that more workers worry about strain than accidents, an operational manager said that he had hurt himself several times, for instance experiencing torn ligaments or broken bones, but it was not something he thought about. Another worker said,



**Table 3**

The characteristics of sickness absence among the respondents in the telephone survey (numbers in per cent of 447 survey participants).

		Percent
Sickness absence (n = 447)	Yes, illness	26.4
	Yes, injury	16.3
	Total (of 447)	37.0
Sickness absence certified by a doctor (n = 165)	Yes	25.3
Duration of sickness absence (n = 165)	Less than one week	27.9
	One to two weeks	33.3
	Three to five weeks	14.5
	Six to eight weeks	7.3
	Eight or more weeks	15.8
Work-related? (n = 447)	Yes	11.6

“Personally, I do not worry about accidents. Perhaps one should, because accidents happen. But I don't. But I do worry a bit about strain.” Another fish farmer said, “I do not worry about getting a bad back when I am older, but I do not worry about crush injuries either. I think one can avoid strain injuries if one does things right.” In another interview a worker said he worried more about hurting someone else than he did about hurting himself.

### 3.4. Sickness absence

All participants were asked “Have you, during the last 12 months, had a sickness absence due to your own sickness or injury?” Participants with a sickness absence were asked if it was certified by a doctor, how long it lasted and if they perceived it as work-related.

Overall, 37% of the 447 participants had sickness absence(s) the last year, most due to illness. Most of the absences lasted less than two weeks (61%) (Table 3).

The findings reflect that most survey participants are sharp-end workers, exposed to several hazards at the fish farms and vessels. Out of the 52 participants who had work-related absences, 28 participants said strain/musculoskeletal injuries or complaints (back strain, wear and tear, inflammation) were the reason. For 21 of the 52 participants, acute injuries (crush/blow/cut, fractures and other injuries) were the reason. In addition, other injuries were mentioned by three participants.

During the follow-up interviews, several workers said that they experienced pain in their necks, shoulders, backs and arms. They said that many work tasks are physical, and one fish farmer stated that “almost everything that is done exposes the muscles and skeleton to strain.” Work tasks demand lifting and pulling on a moving working deck where wind and weather may add to the workload, as illustrated by this quote from another fish farmer: “Ten hours on the fish farm in winter waters is tiresome. You are physically active all day.”

The interviewees were asked to describe tasks that were particularly straining. Here, daily inspections and the removal of dead fish, changing heavy batteries, hauling the netting, cleaning the nets and counting sea lice were mentioned.

The removal of dead fish requires pulling to get the fish out from the bottom of the net cage, and it is heavy, monotonous and hard on the shoulders. Some semi-automatic solutions exist, but the procedure still requires manual work. This operation may take up to 4–5 h each day, depending on the amount of dead fish, according to one of the interviewees.

Another example of straining work was the changing of the batteries for cameras that are used in the net cages, which need to be changed every other day. They weigh 10–12 k, and fish farmers must move them manually when they are to be changed. It is heavy work that may also increase the risk for slipping and falling to avoid losing the battery at sea.

Hauling the netting is a manual operation that precedes operations such as the delousing and slaughtering of the fish. It entails pulling up part of the netting to help reduce the volume of the net cage and crowding of the fish. Many employees found it straining, but some said it was less heavy now due to better cleaning of the nets that reduces the weight. This is related to the fact that biofouling may increase the weight of the net considerably. To lessen the strain, workers said that experience was an advantage for doing the work efficiently. They also said sufficient staffing to do this type of work was important.

Staffing also came up in relation to work hours and shifts. Delousing and slaughter are examples of operations that require extra workers, where workers may work long hours for several consecutive days. One fish farmer said that overall, the staffing was good. But due to a lack of personnel, they would sometimes have to work shifts of 12 h rather than the preferred three 8-h shifts per 24 h. This was also related to other actors participating in the operations, such as well boats:

“When a well boat comes to the fish farm, we want to finish before it has to go to the next farm. So, sometimes we would have liked to have more people at the fish farm during those operations.”

Workers are not necessarily opposed to demanding work. One fish farmer said that his impression was that the workers found it acceptable to make an extra effort, because it did not happen very often. Some employees also stated that physical work may be good for the body. One fish farmer said:

“.. . when you perform physical work a lot, it is mainly positive, it is important to use one's body. There is no doubt about that. But of course, the price to pay is that one, to a larger degree perhaps than other occupations. .. that one is more exposed, you know, for lifting the wrong way, and that one gets some back pains and problems.”

The interviews showed some changes for the better for workers' health. One fish farmer said their company performed health checks of employees to identify and prevent health complaints, and several companies highlighted technological solutions that helped reduce strain, such as cranes or netting haulers used for hauling the netting.

### 3.5. Self-reported health status and job satisfaction

All survey participants were asked to evaluate their health status and job satisfaction. When asked: “How do you evaluate your own health in general?” 85% considered their own health to be *good* or *very good*, on a five-point scale ranging from *very poor* to *very good*. None of the participants considered their own health as *poor*.

Job satisfaction was studied by asking: “Are you satisfied at work?” On a five-point scale from *seldom* to *always*, 97% answered *always* or *most of the time*. When asked what contributed to job satisfaction (an open question where several answers were possible), the most frequent answers belonged to four main categories, defined by the researchers; work environment/good colleagues (81%), varied work (25%), meaningful work (25%) and working outdoors/in nature (17%).

Furthermore, 78% of participants thought they will have the same job in five years, 12% did not, and 10% did not know. A total of 97% were positive about recommending work in the aquaculture industry to others, three said they were neutral and less than 1% (three respondents) were negative.

Interviews confirmed the high level of job satisfaction found in the survey. One fish farmer said, “It is the best job I ever had,” and another said, “I couldn't picture anything else, couldn't picture any other job.” A fish farmer explained what he liked about his job:

“I feel, for me, I love the sea very much. I knew I loved the sea before, but I had not worked at sea. To come out here and work on the fish farm, I thought it was very cool. And I will without a doubt have this kind of job probably for the rest of my life. I think it is incredibly rewarding. It's varied. You do some work inside; you do a lot of work outside. It's different people you work with, and very many external, good people come by too. So, it's new things. It's very

dynamic.”

While he acknowledged the fact that some of the work was tough, that there was a lot of bad weather at some sites, and that the work is not for everyone, he still saw his occupation as a job one could grow old in.

#### 4. Discussion

This study provides both quantitative and qualitative data on aquaculture workers' perception of their own health and work environment. The findings show that workers report good health and high job satisfaction, which is attributed to their work environment and colleagues. Still, several exposures and health complaints, possibly leading to sickness absence and concerns, were identified.

MSDs stand out as an important area where measures are needed. For the general working population in Norway, MSDs are the most common cause of sickness absence overall. The prevalence of MSDs in Norway in 2012 was estimated at 18% among men and 27% among women (Kinge et al., 2015). In this study, 40% experienced MSDs, and 34% related these to work exposures.

In this section, measures aimed at better health and work environment in fish farming are discussed. The discussion reflects an approach that includes the individual, organisational and regulatory levels. Furthermore, the relevance of technology development and design for the working environment is described.

##### 4.1. Worker level

The findings from Norwegian fish farming reported in this article confirm the prevalence of ergonomic hazards, musculoskeletal complaints, diseases and injuries reported from other national contexts (Fry et al., 2019; Kaustell et al., 2019; Mitchell and Lystad, 2019; Moreau and Neis, 2009; Myers, 2010; Ngajilo and Jeebhay, 2019). The survey data show that pains in the neck/shoulder/arms and back are the most common health complaints. Many workers relate these complaints to their working environment, and ergonomic risk factors such as lifting with the upper body twisted or bent, repetitive and monotonous work operations and heavy lifting are common (for instance when hauling the netting). In addition to this, the survey found that strain/musculoskeletal injuries were the main reasons for work-related sick leave as well as concern.

Measurements support these findings. As a part of the project, the monitoring of heart rate and core temperature to measure work strain found great fluctuations during a working day depending on the work tasks performed (Sandsund et al., unpublished results). According to the literature, limit values for acceptable levels of strain at work are between 33 and 50% of maximal oxygen uptake for an 8-h shift (Preisser et al., 2019; Åstrand et al., 2003). In our study, several work tasks showed periods of higher work strain than these recommended limits (Sandsund et al., unpublished results). Depending on the number and length of rest periods shorter or longer work periods require higher or lower acceptable limits (Preisser et al. 2019) and a standardized work-rest schedule is recommended for activities that result in prolonged periods of dynamic work (Åstrand et al. 2003). Furthermore, repetitive work at low intensity in cold environments (5 °C) has also been shown to have a negative effect on muscle function and fatigue (Oksa et al., 2002).

These findings underline the importance of reducing the work strain for the individual worker. Some measures may be implemented at the individual level, for instance providing workers with knowledge of how to work ergonomically. Prevention of MSDs must also involve strategies that focus on controlling hazards at the source through removing or substituting them (Myers et al., 2012), for example aiming to reduce manual tasks involving heavy lifting and awkward postures (Mitchell and Lystad, 2019). Furthermore, considering factors related to the

organisation of work and improving the design of equipment, vessels and fish farms are important to reduce the workload of individual workers.

##### 4.2. Organisational factors

The relevance of organisational factors to workplace health issues, including MSDs, is highlighted by several authors within ergonomics (Bentley and Tappin, 2010; Golubovich et al., 2014; Hernandez and Peterson, 2012). Organisational factors have also been extensively explored over several decades as the root causes for accidents and as pivotal for workplace safety (Hale and Hovden, 1998; Hollnagel, 2018; J. Reason, 1997). Such factors include time and work pressure, training, rules and procedures, management, worker involvement, communication, etc. (Rosness and Sikkerhet, 2010).

The high numbers of work-related sickness absences and MSDs among fish farmers found in this study may be related to organisational conditions and safety management. The current study underscores that fish farm personnel work long hours. Especially in operations such as delousing, some work up to 20 h for several days in a row. Some also experience stress, feel a lack of control over their workday and do not get adequate rest.

Another study among fish farmers showed some challenges related to goal conflicts; sometimes considerations to production are prioritised at the expense of safety, maintenance and employee participation (Thorvaldsen et al., 2017; Kongsvik et al., 2018a). A study focusing on contributing factors to fish escape has pointed to insufficient staffing, work hours and training (Thorvaldsen et al., 2015).

It is well-known that conflicting objectives and work pressure can lead to stress, which could be negative for mental and physical health (Smith et al., 2006) and for personnel safety (Reason, 2013). As with most operational personnel, the personnel at fish farms must perform their work thoroughly, often with limited resources in terms of material or personnel, and at the same time maintain their health and safety. However, fish farm personnel also have to take care of the fish, which potentially can lead personnel to make efforts that are not optimal for their own health or safety (Størkersen, 2012). The biological nature of the product, combined with the weather exposure, lead to many situations where heavy operations must be performed in a hurry.

A survey among 135 employees in aquaculture company management and staff (Kongsvik et al., 2018b) found that 70% agreed that more training could reduce the number of personal injuries, 36% that production demands sometimes led to workers breaking safety rules, and 48% that more time for maintenance would reduce the number of personal injuries.

Further analysis also showed that self-reported health complaints (musculoskeletal pain, headaches and fatigue) may be influenced by work pressure and a lack of involvement in safety decisions (Kongsvik et al., 2019).

##### 4.3. Regulation, technology and design

Occupational health and safety regulations, inspection and enforcement varies in different regions (Cavalli et al., 2019). A global scoping project states that Norway's tripartite approach in which industry, workers and regulators work together is the best global approach currently available for improving occupational health and safety (Watterson et al., 2019). In this approach the trade unions are important. There are two main trade unions, one representing the employees (Fellesforbundet) and the other the employers (Sjømat Norge). Together with the regulators, they cooperate to increase awareness about OHS challenges and solutions. In the Norwegian context, occupational health and safety regulations are statutory by the Working Environment Act (Norwegian Ministry of Labour and Social Affairs, 2005), enforced by the Norwegian Labour Inspection Authority. This is one out of five different major authorities regulating the Norwegian

aquaculture industry (Holmen et al., 2018). Other regulations aim to reduce the escape of fish, ensure fish welfare, keep the prevalence of sea lice low and protect the environment. These risks often compete for attention regarding how they influence the design of the farms and the equipment the employees must operate.

This study shows that aquaculture production systems and the technologies used affect occupational health and safety. While aquaculture systems have increased in size, the technologies are gradually more complex, and operating in more exposed areas may pose new risks for workers. However, compliance with occupational health and safety regulations at the fish farms does not ensure that occupational health and safety are maintained in the design of systems and technologies. The mandatory technical standard in the Norwegian fish farming industry, NS 9415 (Standard Norway, 2009), focuses on the structural integrity of the fish farms and not on occupational health and safety. The objective of this standard is to reduce the risk of fish escape due to technical failures and operational errors. The standard includes requirements for site surveys, risk assessments, dimensioning and load calculations, as well as maintenance and operations. NS 9415 also contains an informative annex on personal safety which unfortunately is not mandatory. However, there are regulatory requirements statutory by the Working Environment Act (Norwegian Ministry of Labour and Social Affairs, 2005) which applies to Norwegian fish farms. The Act sets a standard equal to or above the ISO 45001:2018 (ISO, 2018). The requirements are quite general and mandatory for all industries under the authority of the Labour Inspection Agency, which are mainly on-shore industries. The regulations describe desired safety levels and do not spell out detailed safety measures or design requirements. These are to be developed, documented and implemented by each company or manufacturer. This study indicates that there is a potential for improving the design of the fish farm components and equipment to ensure a healthy working environment and support safe operations. Today's technology has been developed with a main focus on production efficiency, prevention of fish escape and fish welfare (Bjelland et al., 2015). Workers' health and safety should be a priority in the development of new technologies because human performance is significant for the safety outcome of operations (Hetherington et al., 2006).

A study of hazard control in aquaculture work (Myers et al., 2012) described several farmer-generated innovations designed to eliminate the risk of injuries and illness and called for design engineers to design inherently safer technologies through eliminating, guarding and warning against hazards. As the introduction or adaptation of technologies might have far-reaching effects on the work environment, systematic design methods that include workers' health and safety are needed. Conducted as a part of the project this article is based on, a survey of design practices among technology suppliers to the Norwegian aquaculture industry showed that improvements in workers' conditions can be made by properly regarding end-user needs and involving users in the design process and procurement phase (Salomonsen et al., 2019). The survey also documented that in terms of priorities, suppliers are particularly concerned with fish health, welfare and the quality and prices of products/services. However, suppliers are also concerned about how they can contribute to a safe working environment in the aquaculture industry. The study presented in this paper thus also provides valuable knowledge to the technology manufacturers.

## 5. Conclusions

Workers in Norwegian fish farming report good health and high job satisfaction. Still, work-related sickness absences and health worries are common. This is mainly related to musculoskeletal complaints and acute injuries, and interviews show examples of work tasks that are particularly straining. In order to improve employees' health and reduce work-related sickness absences, the fish farming companies, technology suppliers and authorities must prioritise measures aimed at preventing

acute injuries and musculoskeletal strain. At the fish farms, identifying work tasks where improvements for workers' occupational health can be made is key. Organising the work in a way that ensures safe and healthy conditions for workers is also highly important. For technology suppliers, including occupational health in technology development may contribute to reduced risk and strain. This may be achieved through systematic design methods and user involvement. Authorities play a key role, enforcing the regulations as well as performing inspections at the fish farms. Finally, the tripartite approach found in Norwegian work life provides a solid foundation for improving occupational health and safety in the fish farming industry.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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