Agriculture in transition: New strategies for the promotion of occupational health and safety

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Abstract. It is well documented that farming is a high-risk industry in terms of fatalities and injuries, and with numerous risk factors associated with operating the farm. It has also proved difficult to find evidence for the effectiveness of interventions. Moreover, farming is in transition, with ongoing technological transformations as well becoming increasingly more globalized. Thus, new perspectives that allow for more systemic understandings in the management and promotion of occupational health and safety (OHS) are needed. Our main objective is to present an integrated theoretical understanding of the farm as an enterprise and an integrated element in the political-economic agricultural system. The main question is how can farmers organize and manage the farm, in order to simultaneously improve efficiency, quality and OHS based on systemic models for OHS and a systemic understanding of the political-economical system of Norwegian agriculture? The framework is adapted to the Norwegian agricultural context, with ongoing transformations both technologically and organizationally, including visions and plans set by Norwegian agriculture itself. However, the framework can be applied irrespective of national context.

Keywords: agriculture, occupational health and safety, system theory, technological change

1 Introduction

1.1 Agriculture – a risk prone industry

It is well documented that farming is a high-risk industry in terms of fatalities and injuries [1, 2]. Numerous risk factors are associated with the operation of farms, and studies have shown that handling animals, tractors and other machinery are the most frequent causes of non-fatal injuries [3-9]. Other injury risk factors are gender, age, physical health and conditions of employment [8,10,11]. Moreover, studies of organizational aspects and OHS risks show that injury risk is correlated with being a full-time farmer and/or farm owner [1], the number of employees [12,13], two-operators and operators with fellows [9], and cooperation with other farmers [5]. Correlations between injuries and higher income levels, greater field size, and occupational health services membership is also found [10]. An increasingly more industrialized and competitive agriculture may therefore increase OHS risks. Despite a well-documented risk picture, it has proven difficult to find evidence for the effectiveness of interventions for the prevention of injuries, shown in several systematic reviews, when restricting the reviews to a rigid design [14,15].

1.2 Agriculture in transformation

Agriculture is in a state of transformation. Drivers for this include globalization, trade liberalization, population growth, urbanization, income increases, policy change, shifts in food consumption patterns, technological changes, and environmental changes [16]. Globalization is claimed to be one of the most significant drivers for this transformation due to a global market, lacking protectionist borders and trade across countries (ibid). In the case of Norway, farmers have become part of a globalized labor market, and dependent on labor supply across national borders [17] with an increasingly larger group of foreign, temporary, and seasonal workers [18]. Norwegian farmers face stronger competition in domestic markets, and increased interest from international capital [19]. Globalization represents complex and interconnected problems, thus calling for new management strategies at different levels [16].

Digitalization is a another driver, and a central aspect of the so-called “fourth agricultural revolution” [20].Various labels such as smart farming, digital farming, and agriculture 4.0 have been suggested, but the overall implication is that farm managers and organizations in the value chain can make more precise decisions based on different kinds of “big data” [21]. Data may be gathered by sensors, machines, drones and satellites monitoring animals, plants, water, and soils, as well as humans (ibid). The development has been characterized as a change from *process driven farming* combining past data, experience, and naked-eye observations, to *data driven farming* using “big data” and situational awareness [22]. Charatsari et al. argue that this shift from so-called physical-social systems to cyber-physical-social systems transforms farming regarding to both labor and related organizations [22].

Various OHS risk factors may be eliminated or reduced by new technologies. Norwegian dairy farmers who implemented automated milking systems (AMS) experienced reduced physical strain and more efficient production [23, 24, 25]. They were also more satisfied with safety and the working environment [26]. However, increased cognitive demands due to 24/7 system operation, including production of large amounts of data is requiring new competencies [25]. New technologies and smart farming may require new capabilities that potentially disrupt established ways of processing knowledge and thus contribute to the loss of tacit knowledge [20]. Moreover, social consequences may include new actors and alterations of power relations between different stakeholders in existing value chains [27] In sum, the technological transformation changes both work practices and the management of the farm and expand the interplay with actors in the surroundings of the farm.

1.3 The need for new perspectives

Safety research has been criticized for focusing mainly on local failures and exposure of individual workers [28]. This critic has been repeated specifically for research in the construction industry, calling for the use of systemic approaches to understand hazards and OHS risks [29]. We believe this also holds for agriculture. A recent study among Norwegian farmers finds the most significant injury risk factors associated to workplace design, organization of work and production form, these risk factors highly interrelated in the work system and difficult to separate from each other [30]. The finding is novel and points to how we need to raise awareness regarding work system dynamics. Taking into consideration agriculture being globalized, even more connected through technology and smart farming, this underpins our point of organizational complexity calling for sociotechnical understanding.

Underpinning this point is critics raised for scientific evaluations and systematic reviews of OHS interventions, including interventions in agriculture [31]. The success or failure of interventions are suggested to be influenced by larger social systems in which interventions are embedded, including infrastructural (ex: politics, public support), institutional (ex: culture), interpersonal (ex: communication, learning environment, relationships) and individual factors [32]. Irrespective of studying OHS risk or OHS interventions, system perspectives increasing the understanding of the surroundings the farm and farmers are embedded within, and interplay of actors is therefore important.

We should therefore also pay attention to the political level. Due to "agricultural exceptionalism" [33], in most countries farming is more regulated by political authorities than other industries. Norway differ from other countries, were both regulations and economic support are settled through yearly corporatist negotiations between central government and the two Norwegian farmers associations. If the parties agree, the Parliament normally accepts the outcome of the negotiations. If they do not agree, the Parliament may play a more active role, depending on the parliamentary situation [34, 35].

Adding a practical perspective, we know that OHS is often seen as an "*occupational health and safety sidecar*" [36] associated with legislation [37], a finding echoed amongst Norwegian farmers [31]. Dul and Neumann [37] therefore suggest the integrating of OHS in overall management strategies. We believe this is a fruitful approach to reach farmers, hence trying to identify strategies that resonate well with how farmers manage the farm regarding production and income.

Based on this, the main objective is to present a systemic and integrated theoretical framework that can be further developed to improve our understandings of the organization of future agriculture in which OHS is embedded. This framework address' the farm and the farmer's role as a manager, while considering the structures surrounding the farm. Moreover, we seek to develop this framework in order to be used as a bottom-up practical action framework that can facilitate systemic learning and knowledge exchange between researchers, farmers and other actors and based on this develop new strategies and tools for the promotion of OHS.

2 An integrated framework for understanding and promoting occupational health and safety in agriculture

2.1 A starting point

Sociotechnical system theory is our point of departure. Several sociotechnical models are in use, serving different purposes [e,g., 38, 39, 40]. All of them acknowledge that organizations and work systems depend on the environment by which they are regulated and otherwise influenced [30]. We believe that the concentric circle model by Carayon et al. [28] is the most appropriate model for understanding the farm as an organization due to placing the worker in the center of the work system. The model consists of three circles, where the two inner layers are shown to the left in figure 1. The inner circle depicts the work system (the local context), where daily decisions are made and practical work is performed. Elements in the work system (technology, tasks, the individual, organization, and environment) are interdependent, so that changes in one of them will affect one or more of the others. However, the local context is embedded in a larger sociotechnical context, involving organizational structural elements (the second layer) and the external environment including regulatory regimes (the third layer) [28]. The work system is therefore not isolated from the world outside and decisions made in the farm enterprise are heavily influenced by constraints and policies made in the outer layers. In other industries, operators in the "sharp end" may have to work according to rigid procedures set by people far away in the organization. Much more influence is associated with being a worker in the center of the work system [28], which underscores the suitability of this model in agriculture, where a focus on day-to-day practice and the handling of unpredictability is essential.

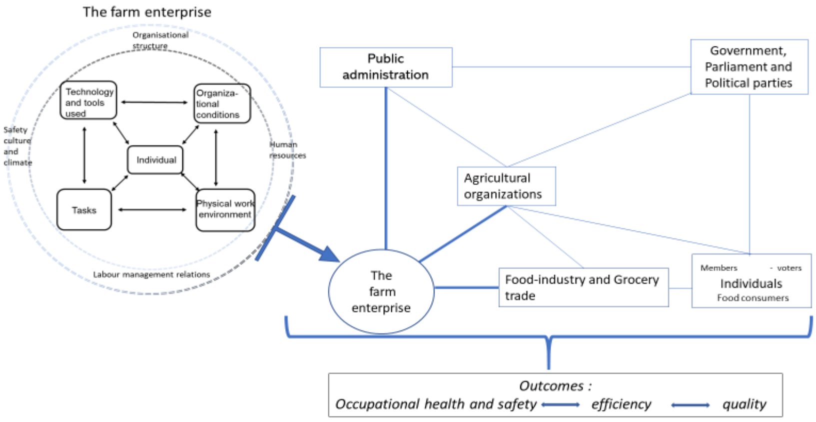

Fig 1. Our framework based on Carayon et al [28] and Rommetvedt [34]

The second layer in the circular model includes organizational structure elements, culture, etc. Agriculture in Norway and many other countries consists of small enterprises with few employees, often family members. Hence, the second layer points to organizational structures, which to a low degree is present in agriculture. An implication of this is that the third layer in the model, the external environment (regulation, market, industry standards) [28], directly impacts the local work system at the farm. In our framework (Fig. 1) this layer is replaced with the specified actors in the political-economical system of Norwegian agriculture [34], comprising the economic value chain (processing the food before it reaches the consumer) and the parliamentary chain of government where decisions on regulations are made politically and administratively. In addition, the framework includes organizations of which the farmers are members or involved in. Changing power relations and elections may change the political situation, thus influencing farmers [41], while the economic value chain may be influenced by global trends [42].

Dul and Neumann [37] suggest the integrating of OHS in overall management strategies, hence simultaneously improving efficiency, quality and OHS as a way forward to improve OHS. A Norwegian study found that farmers' high well-being and low level of stress was positively associated with animal welfare indicators [43]. Thus, correlations are indicated across several outcomes in agriculture, demonstrating the potential in simultaneous improvements across efficiency, quality and OHS.

2.2 Hypotheses emerging from the theoretical approach

Based on the presented framework, three overall hypotheses are developed to guide future research on OHS:

- This framework stimulates for going beyond the individual and local causes for injuries, hence improving the understanding of latent conditions and work system dynamics' impact on farm injuries.
- This framework will reveal the system drivers for facilitating or inhibiting farm management across several outcomes: OHS, efficiency, and quality. This allows for identifying system conflicts and weaknesses that may entail dilemmas in managing and prioritizing efforts at the farm.
- Increased understanding of system conflicts and management dilemmas will improve our understanding of how we change system dynamics to stimulate and support farmers' efforts to improve OHS through improving efficiency and quality.

2.3 Application of the model

To show the analytical and practical application of the framework we will use implementation of AMS as an example. Starting with the innermost circle, *the local work system* [28] was used as an analytical tool in a paper studying AMS and new occupational health and safety risks [25]. The study found AMS altering the whole dynamic within the local work system. AMS is completely changing the *physical work environment*, due to loose housing. Moreover, the *task design* also changes, reducing both physical demands and animal contact, while at the same time introducing new cognitive demands and data driven routines. In the *organizational domain*, AMS alters working hours because the robot operates 24/7. The loose housing entails new considerations regarding breed and affects strategic decisions, through the potential for utilizing the data produced by the robot. The study demonstrates that AMS changes the work system in a way that may expand the focus on management, organization, social life, and culture. Dairy production is embedded in the wider political-economic system illustrated by Figure 1. To uphold scarcely populated districts, Norwegian agricultural policy restrains the size of farms by regulating the production volume through milk quotas. Investments in AMS requires higher income, hence also milk volume, which is solved by exploiting the marked for available milk quotas. From an economic and supply chain perspective, the farm is integrated both in terms of physical products and additional supporting relations, like advisory service and flow of data. In the example of AMS, utilization and access to data from the milking robot involve several actors (supplier, dairy company, advisors, accountants, etc.). These relations are examples of how the system is intertwined with farm management, also improving effectiveness and the quality of production, to increase competitiveness.

3 Conclusion

By combining sociotechnical system theory [28] and an established model of the political-economical system of Norwegian agriculture [34], we have established a framework opening for new approaches in agricultural research and in practice. System mechanisms' impact on farm management is essential, and higher levels of understanding may improve efficiency, quality and OHS.

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