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Farm operators' experiences of advanced technology and automation in Swedish agriculture: a pilot study

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ABSTRACT
This pilot study investigated how farm operators use and experience working with advanced farm technology and automated systems. The study participants included 10 farm operators at 4 modern and technically well-equipped arable and dairy farms. The informants reported that the technology allowed for more accuracy and efficiency in daily work, made the work less physically strenuous, and gave more time for leisure. The challenges lay in systems and programs not being compatible and difficulties in interpreting generated data. At times, the technology was considered complex or difficult to handle and operate. It was also considered mentally stressful when it did not work as expected. Nightly alarms causing disturbed sleep and work time, and tasks losing some of their clear and natural starts and ends were the most challenging issues on dairy farms. Malfunctions disturbed the daily work, especially when spare parts or service technicians were unavailable. The informants concluded that advanced farm technology and automated systems had both positive and negative sides. They reported no consistent mental strain caused by the technology and considered it a necessity for their future work. However, technology and automated systems must be functional, user-friendly, and reliable to avoid imposing potential mental strain.

KEYWORDS
Agriculture; automation; farmer; interview; stress; technology

Introduction

Swedish agriculture has experienced significant structural and technological development during recent decades. Farms have become fewer, but larger, with each unit including more animals and a larger area to manage.[1,2] Technical aids and automation are a necessity if large farms are to be managed with few employees. With modern technology and automation, farm work still includes physically demanding labour but also monitoring and analysis of data from automatic processes.

It is well known that agricultural work is physically demanding and associated with several occupational injuries, diseases, and disorders mainly caused by animals, handling of chemicals, and machines.[2–9] Besides being physically demanding, working in agriculture can also be mentally demanding. Farmers and farm workers may face high workload, time pressure, machinery breakdown, difficulties understanding new technology, and hazardous working conditions on a daily basis which may affect their health and safety.[3,10–14]

Modern arable farms today use technologically advanced tractors, harvesting machines, and equipment with devices that physically control the machines.[15] Likewise, on many dairy farms, conventional pipeline and parlour milking has been replaced by automatic milking systems (AMS) and the records for the cows are made in computer programs. Vacation and time away from the farm is limited, especially on livestock farms.[3,5,10] However, some studies have shown that AMS implementations on dairies may reduce daily workloads, physical burden, and exposures to injury risks.[16–18]

Advanced technology and automated systems may enhance farm operators' experience of control and flexibility in their daily work.[16,19] However, it

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may also be mentally straining for farm operators to learn, manage, and handle advanced technology and automated systems and deal with possible technical failures. In brief, technologically advanced equipment and machinery, as well as advanced computer-controlled automated systems, may pose possibilities as well as challenges for farm operators, and rather than being an efficient tool, even pose a potential stress factor.

The overall aim of this pilot study was to investigate how farm operators use and experience working with advanced farm technology and automated (ATA) systems and to identify possibilities and challenges related to ATA. Furthermore, this work aimed to present suggestions and recommendations for farm operators, advisors, and manufacturers in order to improve operators' work efficiency and flexibility using ATA, without introducing new stressors.

Material and methods

Study design and ethical aspects

In this pilot study, semi-structured interviews and transect walks were used to assess farm operators' subjective experiences of working with ATA.[20] These methods provide comparable and reliable data and at the same time maintain a fairly open framework to follow up leads.[21] The type and content of the interview questions required no application to Swedish Ethical Board. However, current national legislation and guidelines based on the Helsinki Declaration[22] concerning research ethics, anonymity, voluntariness, confidentiality, and retention of data were considered and fulfilled.

Selection of informants

The target group for this study were farm owners, managers, and employees (farm operators) working with ATA on large arable farms and dairy farms. Lists of farms using ATA were identified with help of manufacturers of AMS and agricultural management solutions. Criteria for selection were that the farms possessed new ATA and that they had used these for at least 6 months prior to the study. Demographic descriptions of the participating farms and interviewed farm operators are presented in the 'Results' section.

Interviews and transect walks

The interviews consisted mainly of open-ended questions, which were developed based on literature and the researchers' knowledge of the sector. Besides demographic information on the informants (age, gender) and their farms (farm and herd size, number of employees), the questions targeted the following issues:

- Available ATA on the farm
- How and to what degree ATA was used
- Subjective experience of working with ATA
- Challenges and possibilities working with ATA
- Contentment or discontentment with the ATA
- Effect of ATA on the daily work
- How did farm operators view the future regarding ATA

The interviews were conducted on the farm, lasted approximately one hour, and, with the consent of the informant, were recorded to support the researchers' notes. A one-hour transect walk was also conducted around the farm premises. The purpose of the transect walks was to observe, describe, and, together with the farm's interviewees, discuss the availability and use, as well as possibilities and challenges, of the farm resources, machinery, equipment, and animals. The reason for using interviews and transect walks was to obtain a more nuanced picture and deeper understanding of the informants' perceptions and experiences compared with the use of questionnaires.

Data analysis

Thematisation was chosen as a qualitative phenomenological method, according to Brinkmann and Kvale.[23] The data were anonymised and transcribed. After transcription, the text was read repeatedly to gain familiarity with the content. Reflections concerning the following issues were considered in the texts. (1) What is the content of the text? (2) What does the interviewee say? (3) What is important for the informants? (4) How should the experiences and statements of the informants be interpreted?

Themes related to the main issues that concerned the informants were identified. The identified themes were named, and summaries and quotes that described the informants' responses were formulated according to the procedure described by Brinkmann and Kvale.[23]

Results

Demographic description of farms and informants

A total of 10 informants on 2 arable and 2 dairy farms located in southern Sweden were recruited for the study (Table 1).

Arable farms

Arable farm 1 had about 2,500 acres of arable land (Table 1). The machinery consisted of tractors, combines, automotive beet harvesters, and different equipment for crop management. The farm was run by a manager and three employees. The manager and one employee were interviewed. The manager was 35–40 years of age, male, had attended agricultural education, had practical experience from previous agricultural work, and had been employed on the farm for about 6 years. The employee was 25–30 years old, male, had a different professional training than farming but had a few years of previous agricultural experience.

Arable farm 2 had about 1,200 acres of arable land and conducted additional extensive subcontracting work for other farmers. The machinery consisted of tractors, combine harvesters, beet harvesters, loaders, and a variety of implements for crop management. The manager and one employee were interviewed. The manager was 40–45 years old, male, had attended agricultural education, and had many years of practical experience in crop production and as a manager. The employee was 20–25 years of age, male, had agricultural education, and had a few years of practical farming experience.

Dairy farms

Dairy farms 1 and 2 both had more than 300 dairy cows, had more than 3 automatic milking units, and had used the AMS for more than a year (Table 1). Two owners at dairy farm 1 were interviewed. They had clearly divided work tasks and responsibilities, although both were involved in daily work in the dairy barn. They were 40–50 years of age, had theoretical and practical training in agriculture, and were born and raised on farms.

At dairy farm 2, one female and one male owner, and two male employees were interviewed. The two owners were 50–55 years of age and had an educational background other than agriculture.

Table 1. Demographics of arable and dairy farms, farm owners, managers, and farm workers.

Arable farm 1 (2,500 acres)	Gender	Years of age	Theoretical agricultural education	Practical agricultural education	Work experience (age)
Manager	Male	35–40	Yes	Yes	>6
Employee	Male	25–30	No	Yes	>2
Arable farm 2 (1,200 acres)					
Manager	Male	40–45	Yes	Yes	>10
Employee	Male	20–25	Yes	Yes	>2
Dairy farm 1 (>300 cows and AMS)					
Owner 1	Male	40–50	Yes	Yes	>10
Owner 2	Male	40–50	Yes	Yes	>10
Dairy farm 2 (>300 cows and AMS)					
Owner 1	Male	50–55	No	Yes	>10
Owner 2	Female	50–55	No (born on a farm)	Yes	>10
Employee 1	Male	25	Yes	Yes	>3
Employee 2	Male	25	Yes	Yes	>3

The two employees interviewed were about 25 years of age, male, had agricultural education, and had several years of practical experience in farming.

Themes identified from the arable farms

The analysis of arable farms revealed four separate themes: (1) farm technology and functions used, (2) administrative systems, (3) new technologies – learning and education, and (4) reliability of the ATA.

Farm technology and functions used

In general, the farms studied utilised, to a large degree, but not fully, the available advanced technology and automated systems in the farm machines, implements, and administrative systems (Figures 1 and 2).

The introduction of Global Positioning System (GPS) on tractors and combines was reported by the informants to be the most useful and important technological development. Complementary use of the system involved more operator focus on supervision of the machine and the process than on operating the machine. One participant stated that GPS has revolutionised agriculture. It is more accurate and you have better control over the machine and the process.

On the farm with subcontracting operations, the GPS was efficiently used for area measurement and constituted the basis for invoicing customers.

Figure 1. High-tech machines with computer surveillance equipment in tractors.

Figure 2. High-tech machines with camera surveillance, GPS monitor screen and implement control, data boxes, and joysticks.

The other farm used the GPS technology for following controlled traffic farming in the field and for automated part-width section control when sowing and spraying pesticides, as well as for calculation and adjustment of seed and fertiliser rate.

In many modern tractors, the operator can control the engine and transmission separately. The informants were very pleased that they were able to control the engine speed and machine velocity independently to obtain the lowest fuel consumption.

Some modern harvesting machines have surveillance cameras installed to provide the operator with an improved field of vision from the machine and implement. These cameras, and especially the possibility to adjust the camera from inside the machine cab, were highly appreciated by the informants. The arable farms did not fully use the technology and automated systems in the machines and implements, but they felt that they took advantage of it and used what they needed. One participant stated that they used only one fifth of the technology and automated system capacity; meanwhile, 80% of the positioning (GPS) and auto-steering functions. Another participant expanded further to note that due to the technical development and increased capacity of the combine harvester, he had become a supervisor instead of a machine operator and was able to work longer hours without getting fatigued.

Administrative systems

Participants commented that the electronic communication between the different data boxes in the machines, implements, and administrative systems did not always work properly. In general, the systems were not always compatible with one another. Thus, using pencil and paper was often chosen as the most efficient method of documentation:

> Basically, we have all the required records regarding pesticide spraying in the yield mapping computer system, but the transfer to the crop production computer programme is not working well. The systems need to be synchronised! Now it is easier to write on paper, scan the documents and send them by fax or email to e.g. the client and the municipality – much faster and easier. (male farm manager)

Computerised programs for crop management were used and these were linked to the farmers' smartphones. With their phones, they were able to record and check documentation on the amount of pesticides and fertilisers applied and even the crop management plan for subsidy applications.

New technologies – learning and education

Adapting new technology, e.g. from previous partly mechanised combines or tractors to today's fully computerised models, may involve difficulties for operators. The technology of the machines and implements is important for the quality of work and in this the experience of the operator plays a major role:

> Due to my age and years of experience I´m able to figure out how it (the machine, technology, or computer) works and I'm not afraid of trying. If I can´t make it work, I just call the colleague who usually operates the machine. (male farm employee)

The informants had received a half or one day of an introduction or practical training on how to operate the new machines and assistance in adapting the technology to the needs and requirements of the farm. The introduction, assistance in the event of breakdown or malfunction, and answering the farmers' questions were usually provided by the manufacturer. Although support and assistance services are always possible to improve, the informants were satisfied with the support and assistance team and reported that they were competent, fast-working, and efficient. Due to the advanced computer technology in the machines and implements, it was even possible for the repair team to guide and assist the operator from a distance:

> The computer in the new combine harvester can be connected to the computer in the farm repair workshop or the service centre. The service manager doesn´t have to be physically at the scene... he will be able to monitor and identify the error code from the farm workshop or service centre computer. (male farm manager)

Technological competence and skills among staff was raised as an important topic among the informants. Even though the employees had recently graduated from agricultural college and had some experience and practice in operating agricultural machines and implements, their acquired knowledge and skills were often not up-to-date regarding the latest technology. However, irrespective of the level of knowledge and skills among staff, acquisition of new technology and equipment always involves necessary introductory training provided by the manufacturer, scrutiny of the instruction manual, and, above all, practical testing, driving, and familiarising themselves with the different features in order to learn properly.

The operators claimed that remembering how the machines and technology work could be difficult, especially due to their limited seasonal use. Easily accessible and concise information, such as a quick guide on 'How to run this machine' on the data box monitor, would be a valuable innovation according to the operators. The informants stated that despite training, demonstrations, courses, instruction manuals, and help from the support service, learning new techniques and gaining an understanding of how the advanced and modern machines function was complicated.

There are various ways to learn and instruction manuals may not always be the obvious and preferred learning tool. The informants often chose practical instructions and testing and learning-by-doing principles, rather than theoretical learning. Several of the informants reported that younger machine operators seem to learn and adapt to new technology more easily and faster than older machine operators who were not so familiar with computerisation and advanced technology. One possible explanation given by the informants was that the younger generation in general is 'born and raised' with computers, tablets, and smartphones, and already has experience from working with computerised equipment and technology and therefore finds it easier.

Reliability of the ATA

The technology and automation of the machines and implements were considered very reliable. The informants did not report any stress related to the ATA, except for minor irritations and frustration due to machine or implement breakdowns, which often had a negative effect on workflow. In the case of a breakdown, it was often possible to identify the problem and need for spare parts on the spot using a smartphone. Simultaneously, decision was made whether it was possible to repair the machine in the field or at the farm workshop. Due to faster response, breakdowns were considered less stressful than earlier.

Themes identified from the dairy farms

Five themes were identified in the dairy farm interviews: (1) technology and functions – problems and challenges, (2) data and information, (3) practical training and technical support, (4) operational alarms, and (5) the work has changed.

Technology and functions – problems and challenges

The dairy farms used the available technology to a large degree. Besides AMS, the farms had automatic manure scrapers and used fully automated feed mixers and feeding wagons programmed to distribute feed several times a day. The operators claimed that introducing AMS on a dairy farm requires a holistic perspective on farm management and farm logistics, also involving feeding and manure handling, rather than a focus solely on milking. Further, the AMS was regarded as the most essential function on the farm, but logistics such as cow traffic, feeding, and manure handling must work as intended to obtain good utilisation of the AMS and good profitability during the 24 hours of milking:

> When you have an AMS it operates 24 hours a day, 365 days per year and it needs to run without too many breakdowns. Manure removal, feeding, and milking are interrelated and if one of these stops, then the cow traffic doesn't work; so manure handling and feeding is as important as milking. (male farm owner)

Operational reliability of the AMS, manure handling, and feeding were identified as very important and caused serious problems if they did not work properly. The participating farms usually had an extensive inventory of spare parts to avoid long downtime. Some informants also mentioned the importance of having technically knowledgeable personnel with an interest in digital systems which was usually related to the younger generation.

Introduction of the technology in the dairy barn constitutes challenges for the animals, the technology, and the workers. The AMS works also as a management tool with digitalised and computerised functions for milking the cows (Figure 3), collecting data on milk quality and quantity, and individual details of the cows exported to the farm database (Figure 4).

The informants frequently used data on milk performance and in some cases even data on somatic cell counts, conductivity, and early mas-

Figure 3. Cow no 6212 being milked in the automatic milking system (AMS).

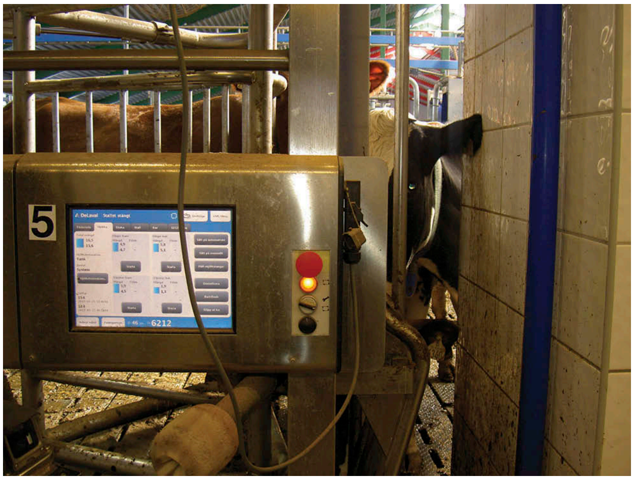

Figure 4. During the milking process, the operator can see the cow data on the screen.

titis warning. They were satisfied with the functions of the AMS, but reported often having to make adjustments. This was because the pre-programmed settings for identifying the teats or level of mastitis did not always match the udder structure or production status of individual cows:

> The milk yield and quality for each udder quarter are shown directly on the screen. We measure conductivity and find the information very valuable for early detection of mastitis. But as cows are different so is their milk, and often we have to adjust the value for mastitis indication on individual cow level. You need to adjust manually to avoid incorrect separation of milk in the AMS. (female farm manager)

Data and information

The AMS generates large amount of data which the operator must analyse and address. The informants also said that it was difficult and time-consuming to learn how the computer system works and how to interpret the data. Several informants reported that they had to develop routines for when to check the data lists. Although data lists were occasionally difficult to interpret, the informants unanimously agreed that they were helpful, but did not replace the daily surveillance tasks in the dairy barn.

The informants raised the critical issue that sector organisations, government agencies, and advisory services use different software programs which are not compatible with each other. This involved extra work and frustration among the informants, as the information could not be exported from one software to another.

Practical training and technical support

It is time-consuming to learn new technology and to get all technical functions and settings to work together – a common issue stated by the operators interviewed. In particular, the start-up period for the AMS was described as difficult, demanding, frustrating, and stressful. After the staff and the cows became accustomed to the AMS, it worked well. Before and during installation of the AMS, the informants participated in on-farm training courses arranged by the manufacturer. Once installed, they had access to round-the-clock support.

There was disagreement among the informants concerning the adequacy of the training and support services provided for AMS. While the education and training courses provided were considered satisfactory, the informants spent much time testing and practised learning-by-doing. Some had become AMS experts and had even provided new knowledge and solutions of value to the manufacturer. However, the majority felt they still had much to learn.

Operational alarms

The AMS is equipped with an alarm system in case of malfunction or other technical failure during milking. Malfunction may be caused by a variety of factors, e.g. the milking cluster being kicked off by the cow during milking. The type and seriousness of the malfunctions determines whether an alarm is sent to the operator's mobile phone for immediate action. Less serious malfunctions are registered on an alert list for later action. Informants felt it should be possible to set limits or change the pre-programmed settings of the alarm system. Alarms from the AMS were frequent and especially during night-time the informants experienced the alarms as stressful, with disturbed sleep and fatigue during the following day.

> It's tough until you learn not to get stressed by the alarms; nowadays, at night we just accept stop-alarm

> calls for immediate action and several of the alarms you can fix from home via the internet. (male farm owner)

The work has changed

The informants reported that AMS is a major achievement. The task of milking has been replaced with monitoring, controlling, and observing the cows in the barn and analysis of data lists in the office. Some felt that there is a lot to keep track of concerning the AMS (including much time at the computer) compared with manual milking. Work with the AMS made them mentally, rather than physically, tired:

> It is more mentally tiring now, and you are more tired in your head after a working day. In the past, people worked more physically and now you need to be more administrative. (male farm owner)

Another issue raised by the informants was that previously, with conventional milking, the working day had a clear and natural 'start' and 'end', but with the AMS there are no specific working hours. The informants claimed that they are working longer hours now than before. They are never really done after a working day as there is always something more to be done in the dairy barn, and they believe that this is not particularly a good thing. However, the employees had fixed working hours, which the managers regarded as an important work-welfare issue.

Discussion

Main findings

This pilot study investigated how farm operators used, experienced, and viewed possibilities and challenges working with ATA in agriculture. Further, the study also focused on farm operators' suggestions for improvement of ATA and if ATA could constitute stress instead of support for farm operators. The study included interviews with owners, managers, and employees on large arable and dairy farms.

The informants on the four farms focused on similar themes: (1) technology and functions considered problematic and challenging, (2) administrative systems not being compatible, (3) large amount of data generated by the technology, (4) the art and the difficulty of learning new technologies, (5) the availability of training and support, (6) the value of reliability and the problem of continuous operational alarms, and (7) a change in work time.

In general, the farm operators used a large part of the available advanced technology and automated systems. All informants considered technical and computerised development a necessity for future profitability, survival, and expansion of the farms. They also believed that investments in ATA required a holistic perspective on the farm.

Several studies have shown that well-functioning management systems become even more important as more technology and automation are introduced on farms.[24–26] Farmers' incentive for investing in ATA is usually to achieve high production efficiency and save labour, but studies in Denmark have shown that it can be difficult to recover the investment costs through reduced labour costs.[27]

The informants regarded the ATA as good, effective, and necessary tools in their daily work. The general view was that more of the available functions of the technology and computer programs could be learned and used. The reliability of the ATA was an important parameter to obtain efficient production, work flow, and profitability. ATA not performing as expected could cause irritation and mental strain.

Several of the informants reported that younger operators seemed to learn and adapt to ATA more easily and faster than older operators who were not so familiar with computerisation and advanced technology. Studies have shown that farmers' willingness to introduce new technology depends on its complexity and that they avoid technology that is perceived as complex and difficult to manage.[28,29] New technologies may affect individuals in different ways, e.g. depending on age and educational level. It might be that younger and presumably well-educated farm operators appreciate and are motivated by ATA, while older and presumably less well-educated operators experience inadequacy towards new technology. Learning new technology can be overwhelming and challenging, and older operators may not want to learn and choose to resign and conduct their work task as usual.

The informants felt that the comprehensive data generated by the computerised systems required a lot of time, knowledge, and patience to analyse. They often found it difficult to interpret or export data to other administrative systems. The operators often found that despite attending introductory training courses, they had to spend a lot of time learning the ATA and testing and adjusting pre-programmed settings. Instead of using manuals, most operators preferred using non-technical skills (help, support, and discussion with colleagues and managers) to learn the technique and improve their work performance.[30] However, the majority of the informants considered the technology a major achievement and a major transformation of daily work, especially in dairy farming which also have been found in other studies.[31,32]

Challenges and possibilities utilising ATA

Technology allows for more accuracy and efficiency in farmers' daily work.[33,34] The results of this study indicated that ATA on arable and dairy farms were regarded as both a possibility and a challenge for the operators. For example, AMS makes dairy farming physically less straining and allows more spare time, freedom from farm work, and more time for leisure compared with conventional milking systems. However, the technology can also constitute a challenge and is periodically mentally straining for the operators, as earlier studies have shown.[4,10,16] A study of dairy farmers in New Zealand showed, however, no correlation between introduction of new technology and stress, but indicated an increased level of stress with age related to new technology.[19]

The most stressful factor reported by dairy operators was the nightly alarms generated by the AMS, as also shown in a recent study.[16] No obvious stressors were identified on the arable farms studied. However, both arable and dairy farm operators indicated that downtime due to, e.g., technological malfunction always disturb. Stressful situations may also arise owing to unfavourable weather during harvest. International research on injuries in agriculture has shown that work under stress and time pressure is often a major contributing cause of serious and fatal injuries,[4,10,35,36] and stressful situations can increase the risk for mental ill health.[37–39] With few exceptions, the operators did not perceive ATA as stressful and considered them a necessity in the future. However, importantly stated by all the operators: 'such systems must be functional, user-friendly, and reliable, since otherwise they represent a potential stress factor for users'.

Suggestions and recommendations for improvements of ATA

The informants had suggestions for advisors, manufacturers, and other farmers to improve farm operators' work efficiency and flexibility using ATA, and to prevent ATA being a potential stressor:

For both arable and dairy farms:

- ✓ The technology must be simple and functional; the more advanced and complex the technology, the more the manufacturers need to consider usability and ease of understanding and operation by users.
- ✓ Training and support can be improved, possibly with short courses available on the Internet or computer simulators.
- ✓ Transfer of data between different systems must be made easier.

Specifically for arable farms:

- ✓ It is important that the farm manager is supportive of operators during the learning process for new technology.
- ✓ Data boxes and computer programs inmachines, regardless of manufacturer or advisory organisation, must be able to communicate with each other.
- ✓ Suppliers should develop an accessible and concise quick guide 'How to operate this machine', incorporated in the data box of the machine.
- ✓ Agricultural students must be provided with up-to-date training on technologically advanced equipment.

Specifically for dairy farms:

- ✓ Suppliers should develop hand-held devices for operators giving them easy access to the cow management system.
- ✓ Suppliers should improve the possibility for operators to adjust pre-programmed settings regarding type of information initiating an alarm or adding it to an alert list.
- ✓ Suppliers should develop manuals on how to analyse and interpret data generated by the AMS.
- ✓ Managers should develop work routines for operators on when to process and analyse data.
- ✓ Managers should decide when they want to 'start' and 'end' their working day. Some tasks could just as well be performed on the next day.
- ✓ A rotating standby system (from 10 pm to 6 am) could be developed among farms or round-the-clock staffing could be introduced on large dairy farms.

Strengths and limitations

This pilot study involved a limited number of interviews and the results cannot necessarily be generalised to the entire sector. However, the results highlight important key issues to address and they provide valuable insights into the reasoning of large-scale arable and dairy farms concerning the use of ATA.

A further limitation in the study was few interviews with female or older operators. Several farm managers indicated that older machine operators had more difficulties learning new technology than younger operators. It would have been interesting to get the perspective of older operators, but unfortunately older farmers that were contacted were not interested in participating.

In future research, a more profound focus on the themes identified is recommended. In addition, issues related to quality of life changes and occupational safety should be addressed. Furthermore, interviewing influencers such as farm advisors and manufacturers of farm machinery, technology, and software may unveil new insights and lines of research.

Conclusions

This pilot study found that participant operators regarded ATA as beneficial, but also challenging. The farm operators identified several challenges concerning, e.g., non-compatible computerised administrative systems, learning new technology, and the reliability of the ATA. Furthermore, they also identified training and support during installation and start-up, large amount of data and, in the case of dairy farms, frequent alarms generated by AMS and the effect of AMS on daily work and leisure time as challenging. ATA were not identified as obvious stress factors among farm operators except for the nightly AMS alarms and downtime due to breakdowns or malfunctions disrupting typical workflows.

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