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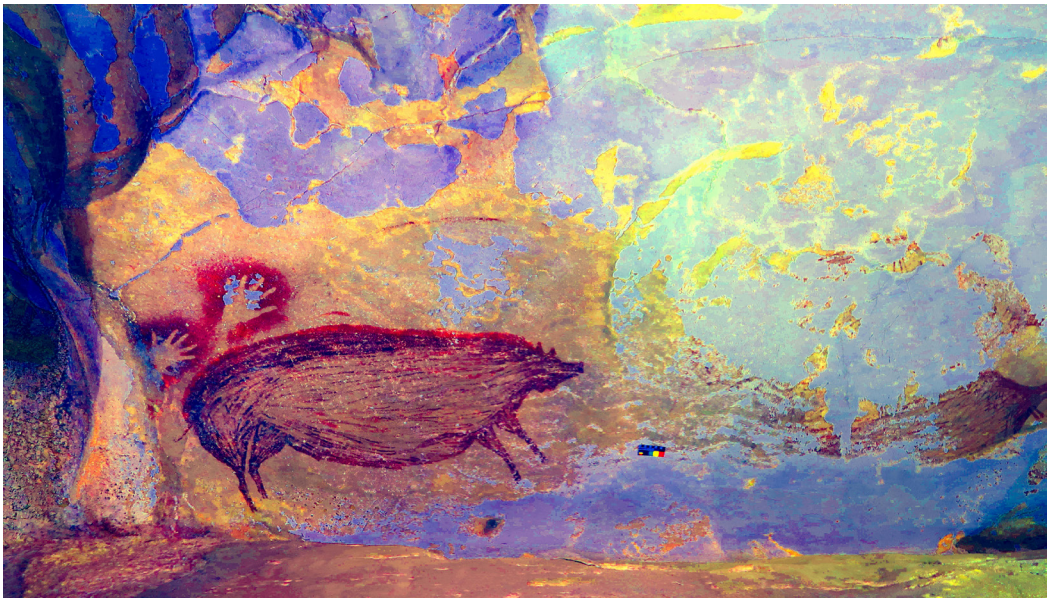
There's no time to rush!

Pigs' and transport drivers' welfare and interactions during slaughter transport

Sofia Wilhelmsson



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Cover: Rock art panel dated 45 000 years old, at Leang Tedongnge, Sulawesi, Indonesia
(Photo credit: A.A. Oktaviana, courtesy of Professor A. Brumm)

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Abstract

Loading at slaughter transport is one of the most stressful situations for pigs. Animal transport drivers require a broad set of skills and knowledge on *e.g.* pig handling. Finding successful ways to train stockpeople in the food production industry is critical in ensuring farm animal welfare, but transport drivers have received very little scientific attention. This thesis investigated Swedish pig transport drivers' working conditions and interactions between drivers and pigs during loading at slaughter transport, and evaluated the effect of a training intervention on transport drivers' attitudes, handling methods, physical workload and time efficiency. A broad research approach was applied, with data collected using questionnaires, measurements of physical workload, behavioural observations, workshops and interviews. The results indicated that Swedish pig transport drivers have a physically and psychosocially demanding work, despite high work satisfaction, and that handling behaviours vary between drivers. Loading, unloading and cleaning the trailer were found to lead to high load on the shoulders and poor on-farm loading area design posed risks to driver wellbeing and pig welfare. Associations were found between negative driver behaviours and stress-related pig behaviours, and between positive driver behaviours and relaxed/explorative pig behaviours. After training, transport drivers showed a tendency for improved attitudes to pig handling and negative driver behaviours decreased while positive behaviours increased. In conclusion, pig transport drivers have good work satisfaction but their physical workload varies, with occasional high load on the shoulders. There is a reciprocal relationship between driver and pig behaviour during slaughter transport loading, and transport drivers' handling of pigs can be improved through training.

Keywords: anthrozoology, behaviour, handling, pig, transport driver, training, interaction, slaughter transport, workload, working environment

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Vi har inte tid att stressa! Grisars och transportförares välfärd och interaktioner vid slakttransport

Sammanfattning

Lastning vid slakttransport är en av de mest stressfulla situationerna för grisar. Djurtransportörer behöver en bred kompetens och kunskap vad gäller t.ex. hantering av grisar. Att hitta framgångsrika sätt att utbilda människor som arbetar med djur i livsmedelssektorn är viktigt för att säkerställa lantbruksdjurens välfärd. Djurtransportörer har tidigare fått väldigt lite vetenskaplig uppmärksamhet. I denna avhandling undersöktes svenska gristransportörers arbetsförhållanden, interaktionerna mellan föraren och grisarna under pålastning i samband med slakttransport, och effekten av en utbildningsintervention på förarnas attityder, hanteringsmetoder, samt fysisk belastning och tidseffektivitet. En bred forskningsansats användes och data samlades in genom frågeformulär, mätningar av fysisk belastning, beteendeobservationer, workshops och intervjuer. Resultaten indikerar att svenska gristransportörer har ett fysiskt och psykosocialt krävande arbete, trots god arbetstillfredsställelse, och att hanteringsmetoderna varierar mellan förare. Lastning, lossning och tvätt av fordon innebar arbete med hög belastning på axlarna och dålig utformning av utlastningsutrymmen riskerar såväl transportörens välbefinnande som grisarnas välfärd. Samband hittades mellan hanteringsmetoder av negativ karaktär och stressrelaterade grisbeteende, och mellan hanteringsmetoder av positiv karaktär och avslappnat/undersökande grisbeteende. Efter utbildningen fanns en tendens till förbättrade attityder hos förarna, och hanteringsmetoder av negativ karaktär minskade medan positiva ökade. Sammanfattningsvis har förarna god arbetstillfredsställelse, men deras fysiska arbetsbelastning varierar med en ibland hög belastning på axlarna. Det finns samband mellan förares och grisars beteende vid lastning i samband med slakttransport, och det är möjligt att förbättra förarnas hantering av grisar genom en utbildning.

Nyckelord: antrozoologi, arbetsbelastning, arbetsmiljö, beteende, djurtransportör, gris, hanteringsmetod, interaktion, slakttransport, utbildning

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Dedication

To all beings involved in the raging march of agricultural intensification.

Out beyond ideas of wrongdoing and rightdoing, there is a field.
I'll meet you there.
Mewlana Jalaluddin Rumi

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This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I. Wilhelmsson, S., Andersson, M., Arvidsson, I., Dahlqvist, C., Hemsworth, P.H., Yngvesson, J. & Hultgren, J. (2021). Physical workload and psychosocial working conditions in Swedish pig transport drivers. *International Journal of Industrial Ergonomics* 83, 103124.

II. Wilhelmsson, S., Andersson, M., Hemsworth, P.H., Yngvesson, J. & Hultgren, J. Human-animal interactions during on-farm truck loading of finishing pigs for slaughter transport (manuscript).

III. Wilhelmsson, S., Hemsworth, P.H., Andersson, M., Yngvesson, J., Hemsworth, L.M. & Hultgren, J. Training of transport drivers improves their attitudes and handling of pigs during loading for slaughter transport (manuscript).

IV. Wilhelmsson, S., Arvidsson, I., Hemsworth, P.H., Andersson, M., Yngvesson, J. & Hultgren, J. Effects of a training intervention for Swedish pig transport drivers on physical workload and time efficiency during loading (submitted manuscript).

The contribution of Sofia Wilhelmsson to the papers included in this thesis was as follows:

I. Conceptualisation, investigation, formal analysis, project administration, writing (original draft, reviewing & editing).

II. Conceptualisation, investigation, project administration, writing (original draft, reviewing & editing).

III. Conceptualisation, investigation, project administration, writing (reviewing & editing).

IV. Data curation, investigation, methodology, project administration, resources, writing (original draft, reviewing & editing).

1. Introduction

An estimated 7.9 billion human beings currently inhabit planet Earth, and approximately 1.5 billion pigs are being slaughtered for human consumption annually (FAOSTAT, 2021). Domestication of wild boars (*Sus scrofa*), the ancestor of most domestic pigs (*Sus scrofa domesticus*), is believed to have started ~9000 years ago (Giuffra *et al*., 2000). Selection for production traits started ~200 years ago, and has in the recent decades focused primarily on growth rate, leanness and large litter sizes, resulting in phenotypical changes (Ekesbo & Gunnarsson, 2018). Despite this, the behavioural patterns of the wild boar persist, and domestic pigs are highly motivated to explore their surroundings, spending 75% of the daylight period investigating their environment and foraging if given the opportunity (Stolba & Wood-Gush, 1989).

The vast number of pigs and humans on Earth and similarities between the species provide many possibilities to interact. Most people have some sort of relationship to pigs, either indirectly as food or directly as production animals on the farm. However, only a small proportion of the human population have more than glanced at a living pig. In most developed countries, the majority of all pigs reared for pork are kept in intensive indoor production systems and are transported from farms to slaughter facilities at about six months of age, when they have reached an economically profitable weight of about 100 kg. The 2.6 million pigs reared annually on around 900 farms in Sweden are transported by approximately 100 professional pig transport drivers (TDs), involving approximately 14,000 journeys (A. Falk, Swedish Association of Road Transport Companies, pers. comm. 18 June 2020). Transportation and related handling is one of the most stressful situations for pigs, and although TDs comprise a relatively small occupational group, they meet and interact with a large number of pigs.

A broad, holistic approach to animal welfare research, also including environmental impacts and human health, has been called for (Buller *et al*., 2018). The link between human wellbeing and animal welfare is central to the concept of 'One Welfare' (Tarazona *et al*., 2019; García-Pinillos *et al*., 2016). For example, if the working environment imposes a risk of physical or psychological stress in stockpeople, this is also likely to affect the animals in their care (Anneberg & Sandoe, 2019). The research field of anthrozoology studies the human-non-human animal interactions and relationships, and often involves collaboration between scientists from different disciplines and stakeholders or pet-owners.

The research reported in this thesis examined TDs overall working conditions and the human-pig interactions during on-farm truck loading. It was carried out in collaboration with researchers at the University of Melbourne, Australia, and Lund University, Sweden.

2. Background

2.1 Interactions between humans and pigs

Pigs and humans are similar when it comes to socialising, often maintaining close relationships with relatives. Both are omnivores, and both usually sleep for 8-9 hours at night and spend a similar amount of time active during the day (Jensen, 1993). Both species are also well-known for prominent cognitive capacities such as quickly learning new things. Compared to other domesticated species, relatively little research has been done on pig psychology; however, pigs' learning abilities are similar to that of dogs and chimpanzees (Marino & Colvin, 2015). Comparing cognitive abilities between species from a human-centered (anthropocentric) viewpoint risks leading to overrating the importance of human-like abilities (Brauer *et al*., 2020). The current situation necessitates a humble stance regarding what we do not know about pig learning and cognition.

2.1.1 Communication pathways

Humans and pigs share many sensory capacities that enable a large variety of possible interactions (Tallet *et al*., 2018). To recognise conspecifics, pigs use olfactory (Kristensen *et al*., 2001; Mendl *et al*., 2002), auditory and visual cues (Shillito Walser, 1986). When identifying individual humans, pigs combine these senses (Tanida & Nagano, 1998). Communication between pigs is based on visual and physical contact (Jensen, 1993), and on vocal and olfactory cues (Houpt, 2018). Pigs' well-developed social cognition allows them to discriminate between, and develop social relationships with, both individual pigs and humans (Graves, 1984). This provides the possibility for positive inter-species interactions, such as belly-

rubbing by a human (Rault *et al*., 2019), potentially leading to a release of the hormone oxytocin, which is important for social bonding (Rault, 2016; Reimert *et al*., 2015). By using visual cues, pigs can discriminate between different attentive states amongst conspecifics (Nawroth *et al*., 2019), and tend to be more fearful of humans who approach them in an erect posture compared with a crouched position (Hemsworth *et al*., 1986; Miura *et al*., 1996). Pigs' social-cognitive capacities also entail social facilitation, *i.e.* the behaviour of one pig can be influenced by observing the behaviour of other pigs, and they can understand communicative cues from humans (Nawroth *et al*., 2019). Research on communication between humans and pigs often focuses on how the pig responds to a specific human interaction or human characteristic, *e.g.* it has been shown that pigs are able to understand human-given cues in the form of pointing gestures (Nawroth *et al*., 2014). If and how pigs use communicative behaviours towards humans, has been less well explored.

Two-way communication between humans and pigs can be argued to be restricted to the overlap of the sensory abilities of the species. Pigs can clearly hear the human voice, as they are sensitive for sound frequencies below 1.5 kHz (Signoret *et al*., 1975), and can identify people they know by the sound of their voice. Bensoussan *et al.* (2019) recently investigated how piglets responded to the human voice and found that they are attentive to the human voice and able to distinguish rhythm and pitch. Pigs also possess a comprehensive vocal repertoire with a broad and varied field of application (Tallet *et al*., 2013). Pigs have an excellent sense of smell and are able to detect pheromones excreted in the urine and saliva of other pigs, making it possible for them to avoid areas where previous aversive events have occurred (Vieuille-Thomas & Signoret, 1992). The eyesight of pigs is restricted by a relatively narrow binocular field of vision (35-50 degrees) and a poor visual depth perception, but they have a wide monocular field of vision that allows detection of movements behind them (Grandin, 1982) (Figure 1). The most effective ways for humans communicate actively with pigs are hence by visual, auditory and tactile cues. A more indirect way to communicate might be through chemosignals, as human chemosignals have previously been found to result in physiological and behavioural responses in dogs and horses (Semin *et al*., 2019). However, it is unknown whether pigs can detect and process information transmitted via human chemosignals.

2.1.2 Handling of pigs

Pigs are social animals and are easily stressed when separated from the group. When moving pigs from one place to another, it is important to utilise their natural instinct to follow one another, which increases the opportunities for synchronisation and social facilitation of behaviours such as walking and running. By using strategic positioning, it is possible to make pigs go in a specific direction with minimal effort. Moving into pigs' flight zone encourages them to move away, but being too close risks triggering panic responses, including escape behaviours such as running back to a familiar place, screaming and/or, freezing (Broom, 2019). Standing outside of the flight zone decreases the pressure and limits potential unwanted responses (Grandin, 2017). Positioning behind or in front of the shoulder of the pig, *i.e.* the point of balance, encourages either forward or reverse motion. Standing in the blind spot immediately behind the pig should be avoided, since it inhibits forward motion in the pig (Figure 1). However, these handling strategies only work if there is enough space for the pig and the stockperson, and if the pig is not completely tame, *i.e.* if it shows a flight response when approached by a human.

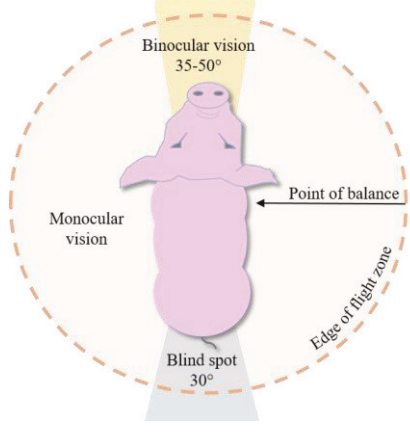

Figure 1. Field of vision, flight zone and point of balance of the pig.

The quality of a human-animal relationship is affected by many factors, including genetic selection, husbandry practices, previous experiences and the nature of the human contact. A high-quality relationship between the stockperson and the animal is important to reduce animal stress and facilitate handling (Hemsworth, 2019). In farmers, improved attitudes to pigs have

been found to be positively correlated with improved behaviours towards pigs, and possibly also increase job satisfaction, motivation to learn about pigs and overall work motivation (Coleman *et al*., 1998) (Figure 2).

Rough human contact, *e.g.* slaps, kicks or shouting, increase pigs' fear of humans, making them difficult to handle (Hemsworth *et al*., 1986b; Hemsworth, 2019). Gentle contact, on the other hand, reduces fear of humans (Tallet *et al*., 2014; Hayes *et al*., 2021). Although pigs can distinguish between aversive and gentle handlers, they tend to generalise the sum of previous experiences when interacting with unknown humans (Tallet *et al*., 2018; Hemsworth, 2019). Hence the quality and quantity of previous interactions with humans determine the level of fearfulness and pigs' behavioural response (Hemsworth *et al*., 1994a). Human behaviours that reduce fearfulness in pigs, and hence enable the use of positive human interactions, include stroking, resting a hand on the back of the pig and speaking softly (Hemsworth, 2019; Hayes *et al*., 2021). Withdrawal and avoidance of humans reflect a high level of fear, whereas proximity and investigation reflect a low level of fear (Acharya *et al*., 2022). Moreover, limited human contact leads to increased fear to the same extent as previous negative experiences (Hemsworth *et al*., 1986b). In addition to the quality and quantity of human interactions, stressful or even severely painful procedures included in routine farm management, such as weaning or castration, are likely to exacerbate fear of humans in pigs (Tallet *et al*., 2018).

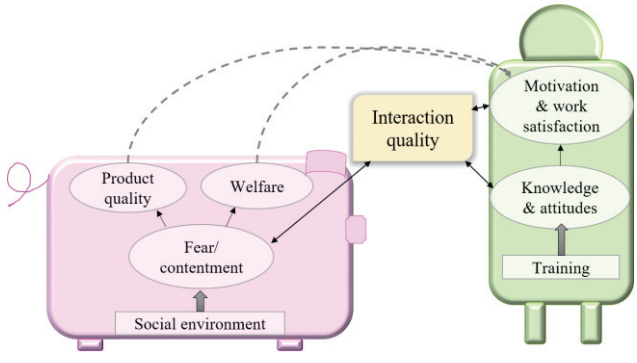

Figure 2. Quality of interactions between humans and pigs, determined by the nature of the stockperson behaviour (affected by for example attitudes, which can be improved by training), and pigs' fear level of humans (affected by their social environment including previous experience of human contact). Greater awareness of the effects of pigs' fear of humans on animal welfare and production traits can increase motivation in stockpeople to improve handling (Ajzen, 1985; Hemsworth *et al*., 1986b; Hemsworth *et al*., 1994b).

2.2 Slaughter transportation of pigs

2.2.1 Sector intensification

Since the 1950s, the term 'animal husbandry' has been gradually replaced by 'animal production' with the introduction of new, more effective rearing methods in industrialised countries (Ekesbo, 1991). The intensive rationalisation of animal production, enabling larger numbers of animals to be kept on one site, has reduced the time spent on each individual animal (Rushen *et al.,* 1999), and has increased the overall pace of work in the agricultural sector (Pinzke *et al.,* 2018). Within pig production, this intensification has come with technical advances, with positive outcomes for the working environment, pig welfare and the natural environment. However, implementation of modern 'factory-style' management techniques has also been criticised for coming at the cost of loss of farmer identity and of human-animal relationships (Werkheiser, 2018).

During the past 30 years, the average size of finishing pig herds in Sweden has increased almost 10-fold, while the number of farms with finishing pigs has decreased 10-fold. In the same period, the number of Swedish abattoirs slaughtering >1000 pigs yearly has decreased from 25 to 15 (SBA, 2019) (Figure 3). This change towards fewer farms with larger herds and fewer abattoirs with increased capacity has had great consequences for pig production, including work organisation, and the number of pigs handled during each slaughter transport has increased. The associated limited attention to each individual pig's physiological and behavioural needs is a risk factor for poor welfare (Webster, 2005).

The modern trailers commonly used for commercial transportation of pigs to slaughter in Sweden are equipped with hydraulic systems to hoist the internal decks. The greater number of decks in modern trailers, and hence their greater total capacity, may be problematic. The common practice is to load pigs onto animal transport trailers with three or four decks and a total capacity of about 200-300 pigs. These vehicles thus have a high centre of gravity which, combined with an unsecured load, increases the risk of on-road instability. Moreover, it is difficult for the TD to access the interior of the trailer and attend to individual pigs during road transport, and there are severe consequences in the event of a road accident due to the large number of pigs. Altogether, this development in transport technology emphasises the importance of the skill set of TDs in terms of technical skills, driving skills

and the ability to handle hundreds of pigs appropriately and ensure their welfare.

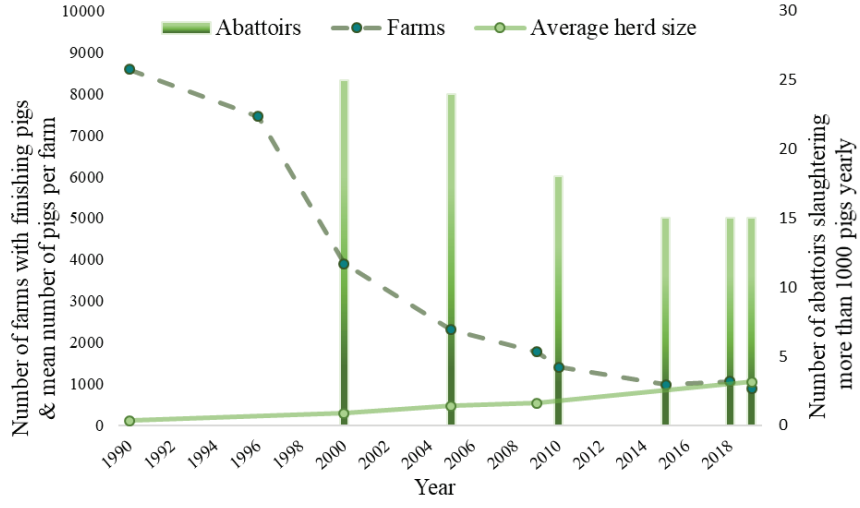

Figure 3. Changes in the Swedish pig production sector 1990-2019. Finishing pigs are defined as pigs reared for fattening, weighing 20 kg or more.

2.2.2 Pig welfare

Animal protection can be defined as human actions and obligations towards animals to protect their welfare, mostly manifested in preventative regulations, while *animal welfare* itself is about how the animal feels and experiences a situation (Blokhuis *et al*., 2008). The animal welfare research field has expanded to cover intersecting themes of animal health, emotions and behaviour (Keeling *et al*., 2011). One commonly used definition of animal welfare refers to how well an animal is able to cope with its environment, where stress is taken as a sign of poor welfare due to failure to cope (Broom, 1996). According to the 'Five Domains' model (Mellor, 2017), the overall welfare of an animal is determined by a combination of its nutrition, environment, health, behavioural state and mental state. This model was recently reconfigured to also include human-animal interactions, and animal transport drivers in particular have been recognised as a group whose interactions are likely to generate negative affective experiences in animals (Mellor *et al*., 2020).

Reduced fear responses and reactivity to novelty are generally considered to be among the main effects of domestication (Zeder, 2012), although

stimulus-specific fear behaviour prevails in pigs (Hemsworth *et al*., 1996). Fear has been defined as a reaction to the perception of danger (Boissy, 1998), and animals (including humans) respond to fear with physiological and behavioural reactions. The word 'stress' is commonly used to describe the reactions of animals to harmful stimuli, and when attempting to measure stress the optimal approach is to combine physiological indices with behavioural observations (Jensen & Toates, 1997). Pre-slaughter handling and transportation is known to be one of the most stressful situations for pigs, potentially leading to major welfare problems (McGlone *et al*., 2014; Bench *et al*., 2008) and reduced meat quality. Several factors influence how pigs cope with pre-slaughter handling. Mixing of pigs (Dreissen *et al.*, 2020), high loading density (Gerritzen *et al*., 2013), large pig groups during loading (Gesing *et al*., 2011) and poor vehicle design involving cold and heat stress (Brown *et al*., 2011; Costa *et al*., 2007) are among the factors reported to have a negative impact on pig welfare and meat quality. Exposure of pigs to novel environments, low or high ambient outdoor temperatures, bright sunlight and wind during loading may cause stress (Grandin, 2019) and behavioural responses such as baulking or backing away which are indicative of aversion (Broom, 2019). According to Faucitano and Goumon (2018), use of shipping rooms and moving pigs in group sizes suited to the alley and ramp size reduce the workload and the time required for loading. Events occurring before the pre-slaughter phase are also important, as pigs reared in barren environments have been found to be more difficult to handle than pigs reared in more enriched environments, possibly due to inability to cope with unknown situations (de Jong *et al*., 2000). A short training session that involves subjecting pigs to alleys and ramps can result in improved handling ease and time efficiency, and reduced stress responses (Lewis *et al*., 2008).

Pigs that are fearful of humans show stress-related behaviours such as high-pitched vocalisations, crowding or attempting to flee back to a known place. These behaviours make pigs more difficult to handle (Hemsworth, 2019). Stress in pigs prior to slaughter, caused by *e.g.* aversive handling, creates a risk of decreased meat quality, such as pale soft exudative (PSE) meat (Hemsworth *et al*., 2002; Van de Perre, 2010). In the pre-slaughter stage, there are several stressful events for pigs, *e.g.* farm staff mark pigs with a number on the shoulders using a tattoo hammer, to enable traceability at slaughter. Moreover, pigs that have reached the optimal slaughter weight are commonly sorted out directly prior to loading or, if all pigs are large

enough, the pig house section is emptied. Pigs show aggressive behaviours when establishing dominance relationships, *e.g.* when unfamiliar pigs are mixed (McGlone, 1985). Mixing is common at several stages of rearing, including at transportation to slaughter, and "mixing aggression" is a major welfare issue (Dreissen *et al*., 2020). Each of the compartments inside the pig trailer usually hold 12 to 20 pigs, so to fill all compartments mixing of pigs occurs at loading and unloading. Mixing occurs again inside the slaughterhouse, where the waiting pens are even larger. Pigs are usually fasted for a couple of hours prior to loading, which is believed to decrease pig mortality during transport. Fasting has also been suggested to make handling easier (Saucier *et al*., 2007; Kelley *et al*., 1980). However Dalla Costa *et al*. (2016) and Acevedo-Giraldo *et al*. (2020) found that on-farm fasting of pigs (18 and 8 hours, respectively), compared with no fasting, led to pigs turning around, backing and stopping more often during loading. In the worst case, cumulative stress due to inability to cope and limited possibilities to recover can lead to non-ambulatory pigs, collapse or even stress-induced death (Benjamin, 2005).

2.3 Working with animal transportation

2.3.1 Regulations

In many countries, including Sweden, intensive farming techniques and live animal transportation has become a growing concern for the general public (Alonso *et al*., 2020; Vanhonacker *et al*., 2009). This concern is reflected in the fact that educational institutions, authorities and others have worked for and developed stakeholder guidelines with advice on management procedures and conditions for humane transportation, and quality assurance schemes to assess and monitor animal stress and welfare (von Borell & Schäffer, 2005). However, there is no statutory obligation for actors to apply these recommendations and guidelines.

During loading, the responsibility for ensuring pig welfare, including ensuring that only pigs fit for transport are loaded, is shared between the farmer and the TD (SBA, 2016). Pigs that are not sufficiently healthy, for instance those with an open wound, a hernia with diameter over 20 cm or poor general condition, may not be transported (SBA, 2016). Once loaded, the TD is responsible for pig welfare until the pigs are unloaded at the

slaughter facility. Under Swedish regulations (SJVFS 2012:27, L22), the animals must be handled calmly during moving and handling tools (rattle paddles and driving boards (Figure 4)) may only be used for directing the animals. Electric goads may only be used in exceptional cases and only on adult pigs, and thus not on six-month-old finishing pigs. In the European Union, Council Regulation (EC) No. 1/2005 governs the protection of animals during transportation and related operations associated with economic activity. The regulation prohibit hitting, kicking and use of violence on animals and ban any method likely to cause unnecessary injury or suffering in animals. However, interpretation and application of the regulation are hampered by a lack of definitions on *e.g.* "hitting". Moreover, all staff who handle animals must be trained appropriately for this purpose. Swedish animal welfare regulations state that road journeys exceeding 8 hours, with time for loading and unloading included, are prohibited. Animals should be controlled every other hour and it is not allowed to leave them in the trailer without surveillance.

European Union Council Regulation (EC) 561/2006, on working conditions and road safety, limits the driving time to 4.5 h before taking a break of at least 45 consecutive min, or split into 15 plus 30 min. The TD is not permitted to carry out any type of work during the break and must be able to dispose of the time freely. Violations can lead to financial penalties for the haulage company. A specific licence is needed in order to handle and transport animals ((EC) 1/2005), and a small number of organisations in Sweden offer a course to obtain the compulsory certificate of competence. The course covers theoretical training for drivers on *e.g.* road safety and regulations, but only a very small amount of information is provided on pig behaviour, handling and welfare. Practical training for TDs is instead generally provided by the haulage company after employment.

Figure 4. Rattle paddles (containing beads which make a rattling sound when shaken) and driving boards are recommended handling tools in Swedish animal welfare legislation, and are commonly used for pig handling in Sweden. Photo: Sofia Wilhelmsson.

2.3.2 Working conditions

There is a lack of knowledge about TDs' working strategies and overall working conditions, including potential physical and psychological stress. Swedish animal haulage companies are commonly subcontractors for slaughter companies, and TDs collect pigs on the farms that rear them. Farmers tend to choose a slaughter facility depending on pricing, and thus do not necessarily choose the closest facility. Therefore, individual farmers and TDs do not actively choose to work with each other. Moreover, the subcontractor situation can lead to poor worker safety management (Valluru *et al*., 2017), such as violating best work practices. In a recent study, Danish drivers transporting sows reported sometimes having to violate the regulations on mandatory driver rest stops to ensure sow welfare and perceived stationary periods during transportation as an animal welfare concern (Thodberg *et al.*, 2020). Dairy cow drivers in Denmark have previously reported loading cows that were unfit for transportation, with one reason cited for this being perceived pressure from the farmer (Herskin *et al*., 2017).

In general, truck driving is a hazardous work. The majority of reported occupational accidents to truck drivers occur while loading or unloading goods (Shibuya *et al*., 2010), and are caused by several contributing factors, *e.g.* slippery flooring in the loading area (Reiman *et al*., 2018). Harsh weather conditions, working alone and a tight time schedule are other risk factors that

contribute to an increased risk of accidents (Reiman, 2021). In addition, musculoskeletal pain and discomfort, especially in the lower back, are frequently reported by truck drivers and increase with increased driving time on a weekly basis (Senthanar & Bigelow, 2018). Training in work safety has previously been found to increase measures to prevent injuries in agricultural work settings (Pinzke *et al*., 2018) and in timber truck drivers, if combined with individual feedback (Smidt *et al*., 2021). Farmers are another occupational group known for safety risks and over-representation in statistics on work-related injuries and accidents. Handling of large animals in connection with transportation is the main reason for physical injury in livestock farmers (Langley & Morrow, 2010). However, statistics on occupational injuries in the agricultural sector are uncertain, due to lack of reporting (Pinzke & Lundqvist, 2007).

Repetitive work and awkward working positions have been found to be related to high prevalence of musculoskeletal disorders in the neck and lower back amongst dairy and pig farmers on large-scale farms (Kolstrup *et al*., 2006). Job stress has been defined as "harmful physical and emotional responses that occur when the requirements of the job do not match the capabilities, resources, or needs of the worker…" (NIOSH, 1999). When evaluating work stress, it is important to simultaneously consider psycho-social and ergonomics-related causes (Carayon *et al*., 1999). Studies on physical workload often involve self-assessment questionnaires, visual observations or technical recordings of physical load (Winkel & Mathiassen, 1994; van der Beek & Frings-Dresen, 1998).

There are exposure-response relationships between the physical workload and musculoskeletal disorders (Balogh *et al*., 2019). Physical exposure can be assessed by technical methods for both individual tasks and exposures throughout the day (Hansson *et al*., 2010), *e.g.* by use of triaxial accelerometers for recordings of angular velocities and postures of the head, neck, back and upper arms (Hansson *et al*., 2001). For example, in studies within the meat-cutting industry, carpal tunnel syndrome has been associated with rapid movements of the upper arms and wrists (Arvidsson *et al*., 2012). Action levels for whole-day values of velocity and elevation of the upper arms (medians of 60°/s and 30°, respectively, and 60° elevation in the 90th percentile) have been established as a tool to prevent muscle pain (myalgia) and musculoskeletal disorders such as rotator cuff syndrome (Arvidsson *et al*., 2021).

The key role that stockpeople play in animal welfare brings a responsibility to learn and improve the quality of human-animal interactions in all parts of the production chain, especially during activities linked to poor animal and human welfare. While pig production has made significant progress concerning technical aids, best-practice pig handling is less well recognised and implemented. To safeguard the welfare of pigs and TDs during slaughter transport, there is a need to identify factors that influence the quality of human-animal interactions and potential opportunities for improvements. Adequate training of stockpeople is key to ensuring animal welfare (Langley & Morrow, 2010; Coleman *et al*., 2014).

2.4 Training of stockpeople

2.4.1 Theoretical framework

According to Hemsworth and Coleman (2011), the work performance of a stockperson relies on three main factors: *capacity* (ability, health, skills, knowledge), *willingness* (attitude, motivation, job satisfaction) and *opportunity* (working conditions, actions of co-workers, policies and rules). Technical and cognitive-behavioural training is needed to improve the motivation of a stockperson to learn and implement new skills (Hemsworth, 2018). A small study on Swedish TDs showed that they used the rattle paddle with varying frequency when unloading pigs at a slaughter facility, with some using it very frequently and forcefully (Bornhede, 2014), indicating a need for training. However, there is a lack of research on the potential of training to improve TDs' handling of pigs, and consequently improve ease of handling and reduce pig stress. A need for training of cattle and sheep transport drivers has also been highlighted by Herskin *et al.* (2017) and Burnard *et al.* (2015).

There is a growing body of evidence that the interactions between farm animals and the stockpeople who handle them affect the behaviour, welfare and productivity of the animals (Hemsworth & Coleman, 2011). Essentially, stockpeoples' attitudes towards the animals, their beliefs about other people's expectations of them and their beliefs about the extent to which they have control over their ability to interact appropriately with the animals determine the nature of their interactions. Underlying this relationship between human attitudes and behaviour is the Theory of Planned Behaviour

(Figure 5), which was developed to deal with behaviours under the control of the individual, *i.e.* volitional behaviours.

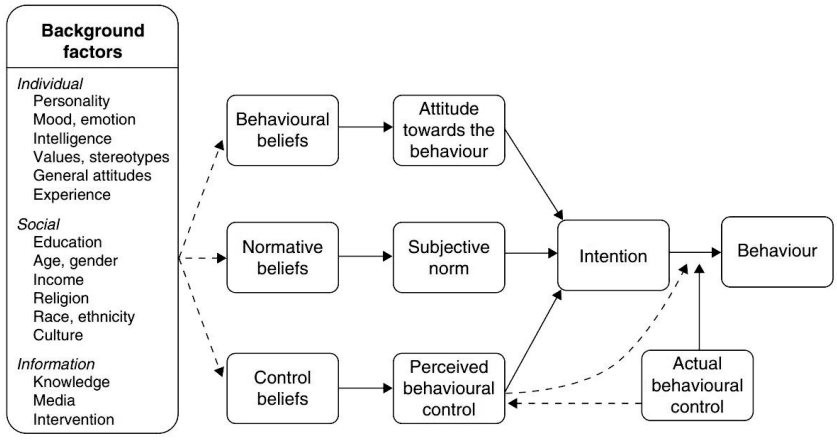

Figure 5. Model of the Theory of Reasoned Action and Planned Behaviour (adapted from Albarracin *et al*. (2014) by Hemsworth & Coleman (2011)).

The Theory of Planned Behaviour proposes that the immediate cause of a person's behavioural intent, and subsequent behaviour, is their relevant beliefs and associated attitudes to the behaviour, and the beliefs about others' expectations as well as the perceived behavioural control. In other words, if there are no physical constraints, such as an inability to perform a behaviour, then a person is likely to do what he or she intends. This framework is useful in understanding TD-pig relationships and their outcomes for both the TD and the pig. Underlying beliefs about a specific animal species and handling of the species can be modified by increased knowledge about that species and about handling behaviours (Hemsworth & Coleman, 2011), which in turn leads to improved quality of interactions.

2.4.2 Training in practice

A training programme (ProHand Pigs®) that builds on the Theory of Planned Behaviour has been used successfully by Australian and New Zealand pig farmers for several decades. In short, the programme aims to increase knowledge about pig behaviour, the consequences of pigs' fear of humans (*e.g.* pig stress, and associated reduced profitability and handling difficulties) and possibilities and consequences of improving human-pig interactions.

This process of inducing behavioural change is a comprehensive procedure in which all personal and external factors that are relevant to the behavioural situation are explicitly addressed. This includes addressing common perceived barriers to change, addressing defensiveness about previous behaviour, changing habits, providing follow-up sessions to reinforce changes and changing relevant attitudes and behaviours. The programme typically uses group discussions, individual feedback, posters and guidelines as training tools (Coleman *et al*., 2000). Several studies show that this type of cognitive behavioural intervention can in fact improve animal handling in practice and result in less aversive handling, and that this improvement has subsequent positive effects on welfare and productivity in pigs (Coleman *et al*., 2000; Hemsworth *et al*., 1989). However, studies to date have mainly focused on farmers, animal owners or other stockpeople who care for animals during a long rearing period, which provides the possibility to evaluate possible changes in the behaviour of individual animals after an intervention. Whether similar secondary training can be successful in stockpeople who briefly encounter a large number of animals has been less well investigated. Perceived behavioural control, including *e.g.* perceived time constraints and the effect of poor facilities, and inappropriate beliefs about arousing livestock have been found to be associated with aversive handling by stockpeople at cattle and sheep abattoirs (Coleman *et al*., 2012).

A common method to elucidate beliefs that underlie specific behaviours, and potential changes in these after training, is to use questionnaires with statements about animals and handling of animals, to which the respondents can agree or disagree. In this way, it is possible to assess the attitudes of stockpeople by examining the individual's beliefs about their own behaviour and that of their animals (Coleman & Hemsworth, 2014). Such data are able to predict behaviour better than information about personality (for example empathic abilities) and more general job-related variables (Coleman *et al*., 1998). Changes in attitudes, and in actual handling behaviours, are the primary outcomes when evaluating the effects of training. Changes in the animals' response to handling, reflecting improvement in the quality of the interaction from the animal's perspective, can be assessed by both behavioural observations and physiological measurements, and may be interpreted as secondary outcomes of the training.

2.5 Applying a broad research approach

There is a lack of research done on the working environment of TDs, their behaviour when handling pigs during slaughter transport loading, the behavioural response of the pigs and the potential effects of a training intervention. In order to obtain as much information as possible about this previous overlooked topic, a holistic approach was applied in this thesis and several research methods were used in an effort to gain applicable information and address problems and potential causes. The complexity of this topic, with many potential influencing factors, means that research can likely gain from engaging stakeholders (Peterson, 2013). Cross-disciplinary research has been proven to be useful for solving societal inquiries. However, problems with cross-disciplinary research have been raised by Lele & Norgaard (2005), e.g. regarding barriers caused by researchers' insufficient understanding of their own biases and prejudices, and by Felt *et al.* (2012), who point out that early-stage researchers sometimes struggle to establish a stable foundation for a future academic career. Due to the infinite number of different types of collaborations between scientific fields and the fact that applied research questions often emerge from pressing societal issues (Jahn & Keil, 2015), there is no 'gold standard' for how cross-disciplinary research should be conducted (Mobjork, 2010; Pohl & Hirsch Hadorn, 2008). Conventional single-discipline approaches rely on *e.g.* repeatable, validated methodologies in quantitative research or thoroughly described theoretical perspectives in qualitative research, whereas the success of cross-disciplinary research often relies on the ability of individual researchers to take risks, be inquisitive and be humble (Augsburg, 2014).

3. Aims of the Thesis

The main aims of this thesis were to investigate Swedish pig transport drivers' working conditions, determine the effects on pig behaviour of different handling behaviours during loading of finishing pigs at slaughter transport, and evaluate the effect of training on transport drivers' attitudes, handling methods, physical workload and time efficiency.

Specific objectives were to:

- In study 1: describe Swedish pig transport drivers' physical and psychosocial working conditions during a typical working day, and map interactions between driver and pig behaviours during transport loading (Papers I and II)

- In study 2: investigate the effects of a training intervention on Swedish pig transport drivers' attitudes and behaviours towards pigs, physical workload and time efficiency during transport loading (Papers III and IV).

4. Materials and Methods

A combination of explorative, observational and interventional research methods were used in this thesis. The analysis built on data collected from February 2018 to March 2021 (Figure 6). Field work was conducted during normal working practices for Swedish pig transport drivers (TDs). A total of 4721 finishing pigs at 37 loadings on 34 Swedish conventional pig farms were included in the observations. The pigs were approximately six months of age at the time of slaughter transportation. The number of pigs per loading varied from 49 to 265 (median 110). For detailed description of the methodologies, see Papers I-IV.

4.1 Ethical statement

The work was approved by the Regional Ethical Review Board of Gothenburg (ref. 070-18) for human research subjects, and by the Animal Ethics Committee of Gothenburg (Dnr 5.8.18-12650/2018) for animal research. All human participation was voluntary and TDs gave their informed consent in writing. Permission for data collection was obtained from farmers and slaughter facility managers. Data were collected, stored and processed in accordance with Regulation (EU) 2016/679 (General Data Protection Regulation).

4.2 Study 1 (Papers I and II)

Data were collected through observations and measurements of physical workload during TDs' work, *i.e.* during loading of pigs on farm, truck driving, and unloading and cleaning of vehicles at the slaughterhouse. Information about psychosocial factors and musculoskeletal discomfort in TDs was collected through questionnaires. Observations were made of TD and pig behaviours during loading.

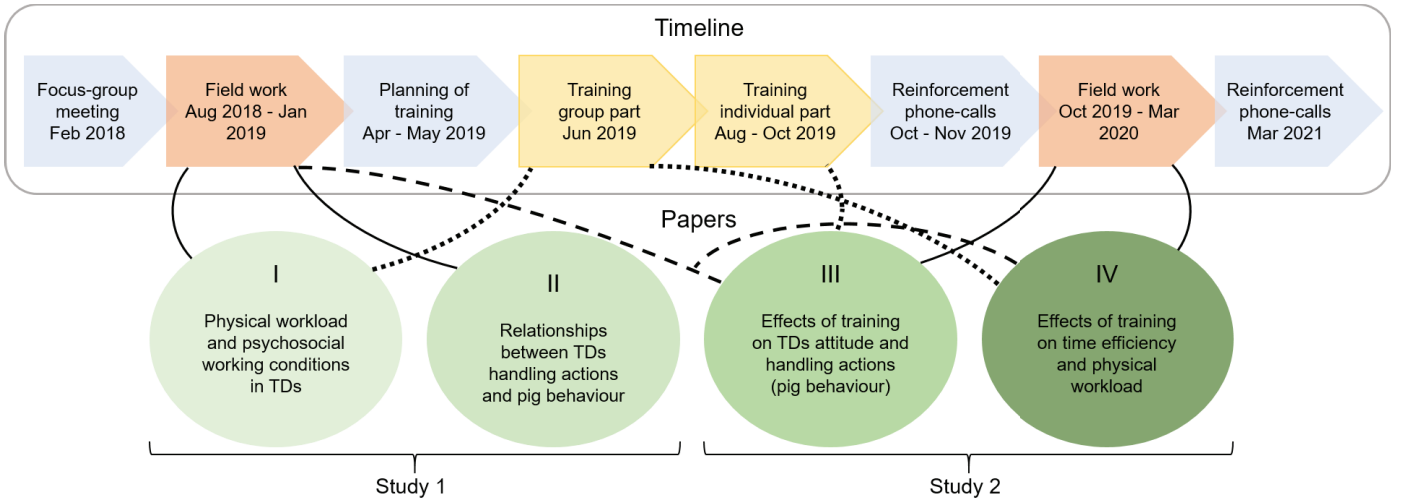

Figure 6. Timeline of the different study parts, and use of information in the four papers included in the thesis. Light blue blocks denote preparation of questionnaire content, planning and reinforcement phone-calls. Dark orange blocks denote field work, including measurements of physical workload, distribution of questionnaires and behavioural observations. Yellow blocks (outlined) denote TD training. Green circles summarise work in Papers I-IV and lines show flow of information to these papers. Solid lines represent data on TD physical workload, working conditions, health, attitudes and/or TD and pig behaviour. Dashed lines represent pre-training data used to analyse effects of training. Dotted lines represent information from training sessions, including for example description of training, workshop notes and evaluation.

4.2.1 Transport drivers, farmers and slaughter facilities

Slaughter facilities in Sweden were asked to provide contact details for their contracted hauliers. Haulier managers in turn were asked to provide contact details for the TDs they employ. In total, four slaughter facilities, four haulage companies and 18 TDs and farms agreed to participate. One slaughter facility, one haulier and approximately 10 farmers declined to participate. At the time of the study, the TDs (2 females, 16 males; aged 20-54 years) were operating in the south, south-west and centre-north of Sweden, and all had at least six months of experience of pig transportation. Together, they constituted approximately 10-15% of a total of around 100 TDs operating in Sweden at the time (A. Falk, Swedish Association of Road Transport Companies, pers. comm. 18 June 2020).

4.2.2 Physical workload and time allocation

Measurements of physical workload were made during one sequence from start of loading on-farm to end of vehicle cleaning after unloading at the slaughterhouse. Angular velocity and posture of the head, upper back and upper arms were recorded with triaxial accelerometers (inclinometers) and angular velocity and posture of wrist positions (flexion/extension) were recorded with biaxial flexible electro-goniometers. Application of the equipment and reference position were set as described by Dahlqvist *et al.* (2016) and Simonsen *et al.* (2018). Workload was expressed in terms of angular velocity (expressed in °/s) and forward or backward angle for head, back, and wrists, or any angle direction for arms (expressed in °). TDs' activities, including type and length of tasks, were continuously logged during field observations.

4.2.3 Transport driver and pig interactions

Each TD was observed at one loading. TDs and pigs were filmed by an elevated video camera covering the loading area, including the vehicle ramp. The observed part of the loading area included the trailer ramp and the TDs working space in front of the ramp, limited to video coverage. TD behaviour and pig behaviours, and number of pigs located within 2 m half-radius in front of the TD, were recorded by two trained researchers with continuous or one-zero sampling at 5-s intervals. Description of different categories of

TD behaviour (three categories) and pig behaviour (four categories) are presented in Table 1.

Ambient air temperature and presence of persistent wind, rain or sunlight were measured in or near the loading area prior to and immediately after loading and unloading. Width, length and general design (presence of roof, walls, doorways, corners, height above ground level, floor/ ground material, type of litter substrate etc.) of the loading area were recorded. Ramp length and height were converted to a gradient (expressed in degrees).

Table 1. Categories, examples and description of transport driver (TD) behaviour and pig behaviour

Category	Example	Description
Mildly negative TD behaviour	Light physical contact[1]	Light physical interaction with rattle paddle or driving board while pig stands still or moves towards or away from truck
Moderately-strongly negative TD behaviour	Hard physical contact[1]	Moderately hard to hard physical interaction with hand, rattle paddle or driving board while pig stands still or moves towards or away from truck
	Loud noise[2]	Shouting or making loud noise with tools
	Knee[2]	Knee or leg in physical contact with pig
Positive TD behaviour	Loose hand[1]	Gentle touch of hand, including light tapping, while pig stands still or moves towards or away from truck
	Talk[2]	Talking or whistling in conversational tone or softer
	Visual interaction (active/passive)[2]	Active: movement of body or tool without physical interaction. Passive: not moving for minimum of 3 s
Stress-related pig behaviour	HPV[1]	High-pitched vocalization: squealing or screaming
	Attentive[1]	Head higher than shoulders and ears turned back
	Freeze[1]	Standing still reluctant to move without blocking ahead, minimum 3 s
	Crowding[1]	Standing still, blocked from moving by pigs ahead, minimum three pigs
Slow flow-related pig behaviour	Backing[1]	Backing one or several steps away from truck
	Turn to other[1]	Turning away from truck
	Stopping[1]	Stops without crowding, not recorded simultaneously with relaxing
Flow-related pig behaviour	Turn to truck[1]	Turning towards truck
	Walking[1]	One or several steps in walking motion
Relaxed pig behaviour	Relaxing/ exploring[1]	Standing still including investigating, nosing or chewing, gentle social interactions, relaxed and not tense posture

[1]Number of occurrences per 5-s interval.
[2]1/0 registration (occurring or not) per 5-s interval.

4.2.4 Working conditions and attitudes

To support development of the questionnaire, a focus group meeting was organised and participating pig farmers, slaughter facility staff and former animal transport drivers (in total 10 participants) were asked to reflect on TDs' work environment and pig welfare during slaughter transportation, and give feedback on a draft questionnaire. Questions about TD background, working conditions, and attitudes to the pigs and pig handling were included in the final questionnaire that was handed out to TDs after cleaning the vehicle at the slaughterhouse.

The questionnaire was divided into two documents with a total of 141 questions, all with multiple choice answers. Document 1 comprised 82 questions about TD background and operating procedures, pig handling methods and statements about pigs and pig handling (reflecting beliefs) based on a previously validated questionnaire (Coleman *et al*., 2012), but modified to fit pig TDs (further explained in study 2, Paper III). Document 2 comprised 59 questions about work conditions (for example role expectations, controllability, commitment and satisfaction), psychosocial workload, and physical workload and discomfort, based on the QPS Nordic Questionnaire (Kuorinka *et al*., 1987) and the Copenhagen Psychosocial Questionnaire (Kristensen *et al*., 2005).

4.2.5 Statistical analysis

Measurements of physical workload for one TD were lost due to technical problems. Data for the remaining 17 TDs were processed according to Hansson *et al*. (2003) and Dahlqvist *et al*. (2016). Measures of median and peak load (50^{th} and 90^{th} percentile) of head and upper back inclination and upper arm elevation, and median load of the angular velocity of head, upper back, wrists and upper arms were summarised for the total workday and for specific tasks (Paper I).

Mixed-effects logistic models of TD behaviour and pig behaviour were constructed, introducing loading occasion as a random effect. Stress-related and slow flow-related pig behaviour were analysed using either 'moderately-strongly negative' TD behaviour or 'any negative' TD behaviour ('mildly negative' and 'moderately-strongly negative' combined) as the studied predictor. 'Moderately-strongly negative' and 'any negative' TD behaviour were estimated using stress-related and slow flow-related pig behaviours as studied predictors. A model of 'relaxed' pig behaviour was estimated using

'positive' TD behaviour as the studied predictor. Confounding variables and variables that contributed significantly to each model ($p \leq 0.05$) were included in the final models (Paper II).

For questionnaire data on work conditions and musculoskeletal complaints, scores were rescaled to a range of 0 to 1 and means for six dimensions ('work demands', 'role expectations', 'work control', 'mastery of work', 'work commitment and satisfaction' and 'psychosocial workload') were calculated (Paper I).

4.3 Training intervention (Papers I, III and IV)

The 18 TDs that had been included in study 1 and their managers were asked to contribute to planning the training intervention. In total, 23 people were contacted via telephone, of which 18 responded. In the phone-calls, eight respondents made spontaneous comments related to pig handling methods, for example:

> I want to know more about what handling method to use depending on external factors, weather, wind...

Five wanted information about attritional wear and five commented on issues related to their psychosocial working environment, for example:

> How to avoid attritional wear on knees, shoulders, lower back… Knees become worn when moving pigs when you are crawling

> It's difficult to be rigid towards farmers because they may get angry, a dilemma that you risk being either yelled at by the farmer or reported by the veterinarian…

Altogether, their comments reflected a desire for training content on how to adapt to the working environment and remain a resilient worker, and on understanding pigs better and improving handling methods in challenging situations. The final training activity was designed based on these comments, in combination with a remodelled version of a previously validated cognitive

behavioural training programme (ProHand pigs®) (Hemsworth & Coleman, 2011).

In total, 11 TDs participated in the training activity, which included a group session in order to enable participants to exchange experiences and raise problems with their peers and to provide opportunities for participants to further encourage ambivalent participants to accept key advice during discussions. Thereafter, individual sessions were held to provide a safe environment to evaluate individual handling methods, attitudes and physical workload. Participants were able to evaluate the training activities both orally and anonymously in writing (questionnaire with open-ended questions about content) after each session.

The group session was held during two consecutive days (a weekend) in June 2019. Both days consisted of short lectures with subsequent discussions. On the first day, workload, working environment, legislation and practical aspects of different loading facility designs were addressed. Each subject was followed by a workshop with discussions on what was outside the control of TDs' and what the TDs could do themselves to improve their work. Participating TDs met with an experienced official veterinarian from the Swedish Food Agency and were allowed to express concerns and ask questions about sensitive issues related to official inspections. On the second day, the cognitive behavioural training programme was applied. It included information about pig behaviour, handling methods and human behaviour. Minimising the force in physical interactions was highlighted as important in order to reduce workload and stress in pigs. Participants were again able to express their own concerns and experiences regarding handling methods, and a joint discussion followed on how to simultaneously decrease workload and pig stress and increase work efficiency. Finally, guidelines for professional handling of pigs at slaughter (adapted from the training programme Prohand Pig®) were reworked together with the TDs.

Individual sessions were held two to three months after the group session, and lasted for approximately 3 hours per TD. Each participant was initially asked about reflections emerging after the group session, followed by repetition of essential parts from the group session. Individual workload results were discussed in terms of how to prevent future injury and decrease workload. Each TD was then shown short video clips of him/herself while loading and unloading pigs, and encouraged to reflect and comment on what they thought they had done well and what could be improved. Finally, a

discussion was held on the interconnectedness of pig welfare, work efficiency and workload. The TD also received a course certificate, a cap and a sticker for the truck with the project logo printed on it and a pocket folder with the 10 previously elaborated recommendations for professional pig handling. The TDs were encouraged to read the folder and to talk to colleagues about experiences from the training.

Two to four weeks after the individual session, reinforcement phone-calls were made to all TDs in which they were asked about changes in working methods and thereafter reminded about essential parts of the training. Three questions were asked, in the following order:

1. Do you have any reflections or questions concerning the training content?
2. Have you made any changes to the way you work? If the TD mentioned changes in handling behaviour, the following question was added:
   - Have you noticed differences in how the pigs react to you?
3. Have you used the folder with guidelines and professional advice on pig handling, the cap and the sticker?

The interviews were repeated again approximately 1.5 years later, in March 2021.

4.3.1 Statistical analysis

Notes from the workshop on working environment were compiled and key concepts were identified and described (Paper I).

The TDs' reflections during training and reinforcement phone-calls were transcribed verbatim, answers for each question were compiled and quotes relevant to training content selected. Examples of typical participant comments are presented in results, following free translation from Swedish to English (not in paper).

4.4 Study 2 (Papers III and IV)

In study 2, recordings were made from 50 to 160 (median 80) days after the individual training session. Recordings of TD behaviour, pig behaviour, work duration, physical workload, environmental factors and design of loading facilities followed the methodology described in study 1, however

only during loading of pigs. The questionnaire on TD attitudes (document 1, see Section 4.2.4) was handed out.

For behavioural observations, 10 TDs contributed with one loading each before training and 1-2 loadings each after training (in total 28 loadings). In total, 20 TDs completed the questionnaire before training, including the 10 who participated in the training, and eight responded to the questionnaire post-training (Paper III). For physical workload measurements and time efficiency data, 17 TDs contributed with one loading each before training, seven contributed with one or two loadings within 90 days after training, and four with one or two loadings more than 90 days after training (in total 37 loadings) (Paper IV).

4.4.1 Statistical analysis

The effect of the training intervention on TDs' attitudes was analysed by factor analysis and principal component analysis (PCA) utilising the 20 pre-training responses. In total, 32 statements reflecting attitudes or beliefs about pig handling were reduced to two sets of beliefs; 'Ways to move pigs' and 'Rapid pig moving'. In each set, three components with Eigenvalues >1 were subjectively labelled based on semantic content. These were 'force', 'design', and 'fear' for handling strategies, and 'quick', 'floor', and 'contact' for rapid pig moving. Composite scores were calculated for each component as the mean response of items with PCA loadings >0.4. Effects of training on the six composite scores were analysed by paired t-test based on the eight TDs who contributed with data from before and after training (Paper III).

The effect of the training intervention on TDs' handling behaviour was analysed by multivariable mixed-effect logistic regression models of 'moderately-strongly negative', 'mildly negative' and 'positive' handling behaviours in a 5-s interval. A categorical predictor with two levels, expressing the timing in relation to training as 'before' or 'after', was used. Variables expressing TD background (age and haulage company) and environmental factors (recorder, hour of day, number of pigs, ramp slope, ramp length, outdoor temperature, pig rearing time, season, farm staff interference and length and width of loading area) were considered to varying degrees in the final models. Predictive margins of effects of training were calculated (Paper III).

The effects of the training intervention on physical workload and time efficiency were analysed by linear mixed regression. Physical workload was

expressed by the 90th percentile of upper arm elevation and velocity. Time efficiency was expressed as mean active loading time per pig, *i.e*. the total loading time excluding the time TDs waited for pigs to enter from the farm building. A categorical predictor with three levels, expressing the timing in relation to training as 'before', '≤90 days after' or '>90 days after', was used. Variables expressing TD background (gender, age, height and body weight) and environmental factors (number of pigs, age of pigs, sorting of pigs and number of trailer decks) were considered as fixed effects in the models. Predictive margins of effects of training were calculated. Linear relationships between the dependent variables were checked with Spearman rank correlation (Paper IV).

5. Summary of results

A summary of the results obtained in Study 1 and 2 are presented in this chapter. In addition, descriptive results from the training intervention and designs of loading areas are presented. Detailed descriptions of the results can be found in Papers I-IV.

5.1 Study 1 (Papers I and II)

5.1.1 Physical workload, time allocation and working conditions (Paper I)

The TDs reported spending about 1-3 h per day loading and unloading pigs, and collected pigs from 1-3 farms during a normal work-day, depending on farm size and the distance to the slaughterhouse. The 'loading-to-cleaning' sequences included in field work took on average 369 min, with a minimum of 177 and a maximum of 566 min depending on the number of stops and the distance between farms and slaughterhouse. Time spent on the different tasks varied between TDs (Figure 7).

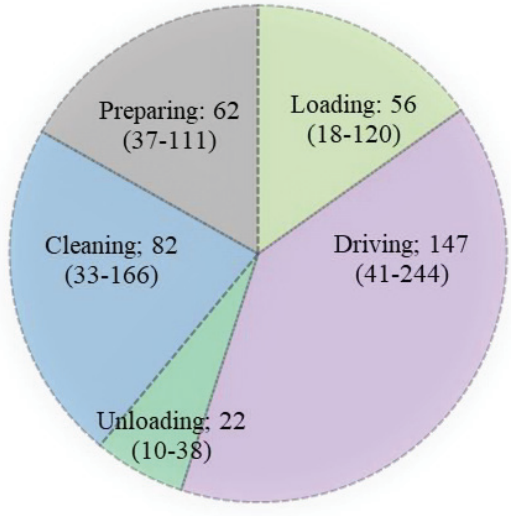

Figure 7. Time allocation (minutes) to different work tasks carried out by Swedish pig transport drivers (n=18) studied in 2019. Mean (min.-max.) minutes during one 'loading-to-cleaning' sequence (one loading, one unloading, one cleaning event) per driver.

Group means of upper right arm elevation (median 41° (50th percentile), 66° in peak load (90th percentile)) during a whole loading-to-cleaning sequence exceeded action levels (30° and 60°, respectively) suggested by Arvidsson *et al*. (2021). Elevation in the upper arm and neck and back flexion (forward motion) varied between tasks. Peak load of upper arm elevation was highest during vehicle cleaning, and median load was highest during driving however with arms supported by the driving wheel. Steep forward inclination of the back (peak load) during unloading likely reflected extreme crouching postures when working in the lowest level of the vehicle (Figure 8).

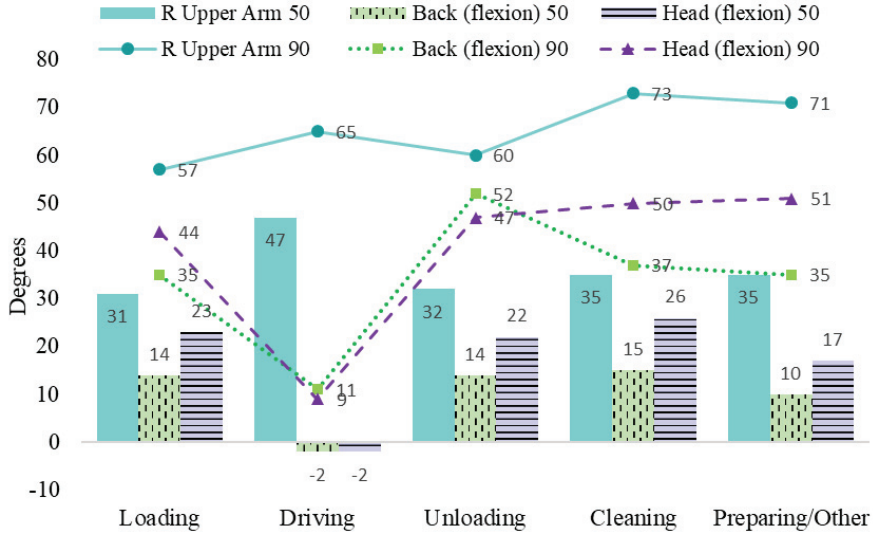

Figure 8. Group means of right upper arm elevations and neck and back flexion (°) in the 50th percentile (median load) and 90th percentile (peak load) for Swedish pig transport drivers (n=17) during four different tasks: loading of pigs, driving the vehicle, unloading of pigs, cleaning the vehicle and work performed in between those tasks denoted as preparing/other, 2018-2019.

Rapid angular velocities were recorded in upper arms when unloading pigs and cleaning the vehicle, and in wrists during cleaning, but whole-day recordings did not exceed the action levels (60 and 20 °/s, respectively) suggested by Arvidsson *et al.* (2021). There were large variations in velocities between the TDs during loading and cleaning (Table 2).

Table 2. Group means (standard deviations) of angular velocities (°/s) in the 50th percentile (median load) of head, back and right upper arm wrist in Swedish pig transport drivers (n=17) during one 'loading-to-cleaning' sequence and different tasks: loading of pigs, driving the vehicle, unloading of pigs, cleaning the vehicle, and preparing/other, 2018-2019

Area	Whole day	Loading	Driving	Unload-ing	Cleaning	Prepar-ing/other
Head flexion	15 (2.7)	21 (8.9)	11 (2.3)	25 (4.1)	22 (7.4)	19 (4.9)
Back flexion	12 (2.4)	17 (9.6)	8 (1.9)	22 (4.5)	20 (6.8)	15 (3.8)
Upper arm, right	30 (8.6)	49 (26.8)	16 (3.7)	63 (11.4)	67 (23.8)	44 (11.4)
Wrist flexion, right	11 (5.5)	12 (7.5)	5 (2.2)	18 (4.2)	20 (5.2)	17 (4.1)

In total, 20 TDs, of which 16 participated in physical workload measurements and four were not included in other parts of the study, responded to the questionnaire. These TDs reported being personally engaged and satisfied with their own work quality, with a good ability to cope with work demands. The TDs also perceived demands in making difficult decisions, with a high risk to safety and economic outcomes in the case of mistakes. Stakeholder pressure (from farmers or official veterinarians) and lack of control over working conditions were perceived as moderately strong. A large proportion of the TDs reported discomfort in the lower back (60%), knees (50%) or neck or shoulders (30%).

During the training workshop, the TDs identified issues that negatively affected their work, including: poor loading area design; conflict with farmers, e.g. due to differing opinions on pig fitness; fear of being reported by official veterinarians; inappropriate equipment for cleaning the vehicle; limited work space in multi-deck vehicles (see Figure 9); and time limitations and complex regulations, leading to a risk of violating one regulation while complying with another. They also mentioned that work-related injuries were not always reported, due to limited possibilities to be assigned less physically demanding tasks. The TDs emphasised that poor on-farm loading area design considerably increased their physical workload and made it difficult to detect whether pigs were unfit for transportation. For example,

poor lighting or lack of protection from wind and sunlight, or too large or too small a driveway, made pigs more difficult to handle and increased the risk of pain in TDs' knees when pushing against the driving board. Some examples of TDs' statements on these matters are given below (with clarification in square brackets):

> [Physical symptoms] are work-related… when you have to push them out [of the farm building], that's when problems with knees occur, we can't influence this, just point it out.

> If it is a good farm, it is almost enough just to stand and watch; there are large differences between farms.

> All of a sudden, a pig I did not want to load is there [in the loading area] anyway.

> With a proper loading room you can observe all pigs and load in your own pace.

> They [official veterinarians] stand there and inspect you without saying anything for years and then report you all of a sudden.

Some of the issues mentioned were connected to the increased efficiency in the pig production chain, for example:

> You need to keep count [of pigs] and do several practical things simultaneously.

> We are constantly trying to increase speed, and at some farms the speed is too high.

> [There is] pressure from the abattoir to load more animals, but the veterinarian say it's no business of theirs.

> You crawl when shutting gates inside the vehicle… worse with the four-decked trucks that are being used increasingly.

Figure 9. Pigs being loaded in to the lowest deck in a three-decked trailer, Sweden 2019 (the author, height 172 cm, is shown in the pictures). Photo: Lina Göransson.

5.1.2 Transport driver and pig interactions (Paper II)

Out of the 18 TDs included in Study 1, 13 used both a rattle paddle and a driving board during the observed loadings and five used only a driving board. Ramp slope varied from 5 to 22 degrees. The average number of pigs within 2 m in front of the TD in one 5-s interval, as observed from video recordings, varied from 1.8 to 5.2 (median 2.2). 'Positive' TD behaviour was observed in 53% of the successive 5-s intervals (n=2,033), followed by 'mildly negative' (30%), and 'moderately-strongly negative' (25%) behaviour. 'Flow-related' pig behaviour was recorded in 69% of the 5-s intervals, followed by 'stress-related' (38%), 'relaxed' (31%) and 'slow flow-related' (28%) pig behaviour. There were large variations between loadings and TDs in the mean number of TD behaviours and pig behaviours recorded per 5-s interval (Figures 10 and 11).

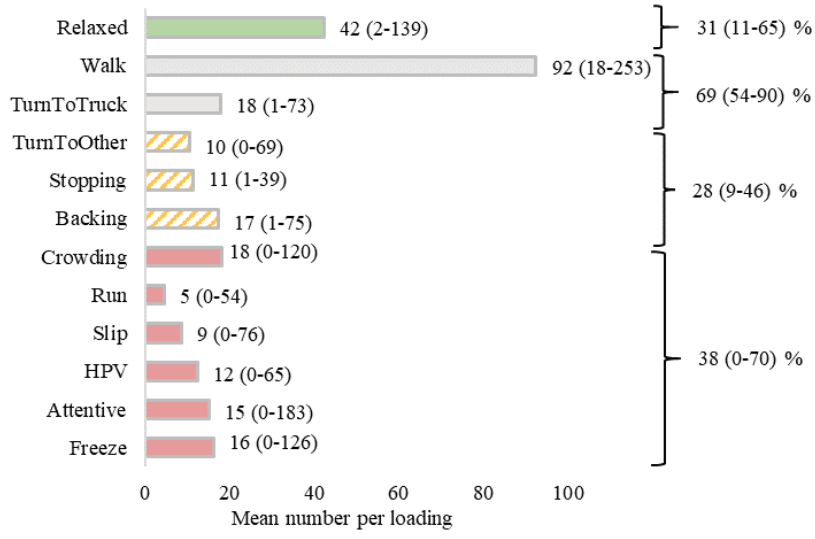

Figure 10. Incidence of relaxed behaviour (green), flow-related (light grey), slow flow-related (cross-hatched) and stress-related (red) pig behaviours observed during 18 transport loadings (49-258 pigs per loading). Mean (min-max) number of recorded behaviours (numbers on bars), and mean (min-max) proportion of 5-s intervals with the recorded behaviour category (right margin), per loading, Sweden 2018-2019.

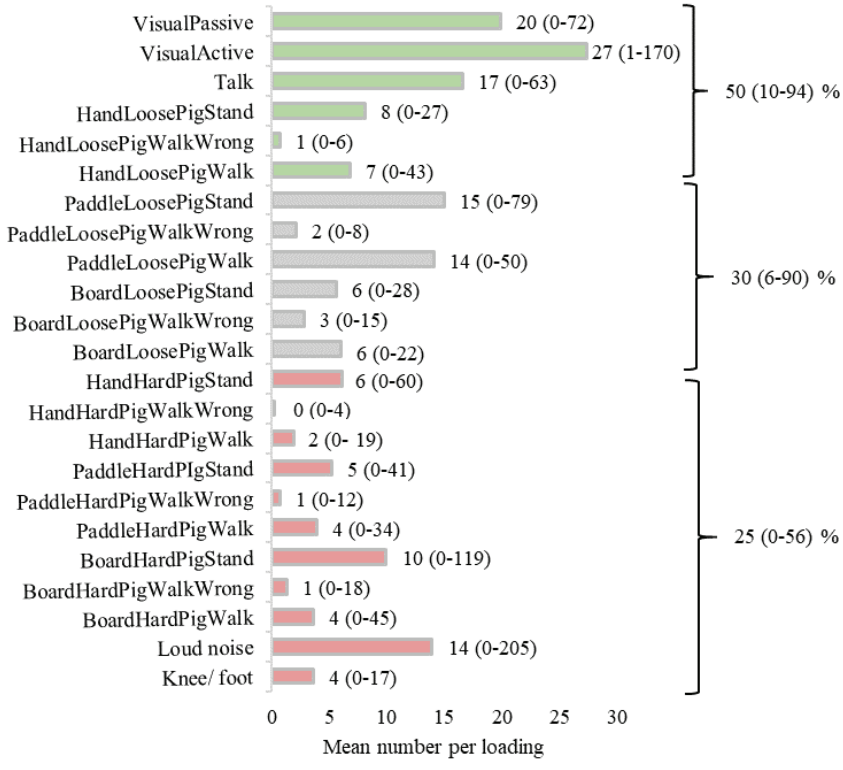

Figure 11. Incidence of 'positive' (green), 'mildly negative' (grey) and 'moderately-strongly negative' (red) transport driver handling behaviours observed during pig loading. Mean (min-max) number of behaviours and mean (min-max) proportion of 5-s intervals with the recorded behaviour category, per loading. n=18 drivers (and loadings), Sweden 2018-2019.

When recorded in the same or preceding 5-s interval, 'any negative' or 'moderately-strongly negative' TD behaviour significantly increased the probability of 'stress-related' pig behaviour (odds ratio (OR)=4.1-5.4 and 1.4-2.0, respectively; $p<0.0001$-0.013) (Figures 12 and 13). 'Any negative' TD behaviour, but not 'moderately-strongly' alone, significantly increased the probability of 'slow flow-related' pig behaviour in the same interval (OR=1.6; $p=0.0002$) (Figures 14 and 15). Occurrence of 'positive' TD behaviour significantly increased the probability of 'relaxed' pig behaviour when recorded in the same interval or preceding interval, but not in the interval before that (OR=1.3-1.9; $p<0.0001$-0.014) (Figure 16). 'Slow flow-

related' pig behaviour only slightly increased the probability of 'any negative' TD behaviour in the same interval (OR=1.3; p=0.046), but not in the preceding interval (OR=1.2; p=0.12), and not in any interval for 'moderately-strongly negative' TD behaviour.

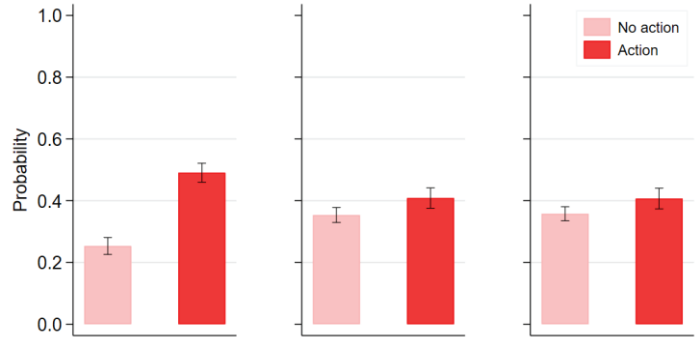

Figure 12. Estimated probability of 'stress-related' pig behaviours without (no action) and with (action) 'any negative' driver behaviour in the same 5-s interval (left), one 5-s interval back (middle) and two 5-s intervals back (right). Slaughter transport loadings (n=18), Sweden 2018-2019.

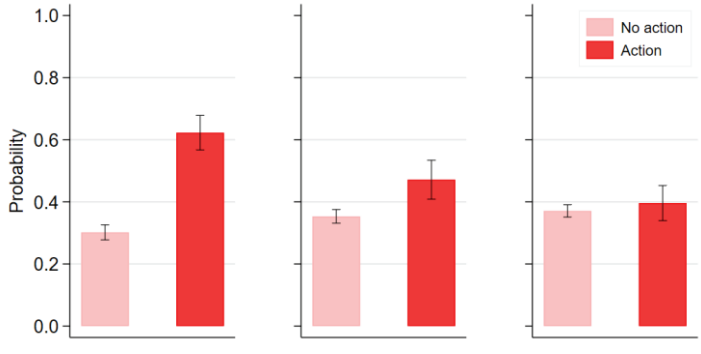

Figure 13. Estimated probability of 'stress-related' pig behaviours without (no action) and with (action) 'moderately-strongly negative' driver behaviour in the same 5-s interval (left), one 5-s interval back (middle) and two 5-s intervals back (right). Slaughter transport loadings (n=18), Sweden 2018-2019.

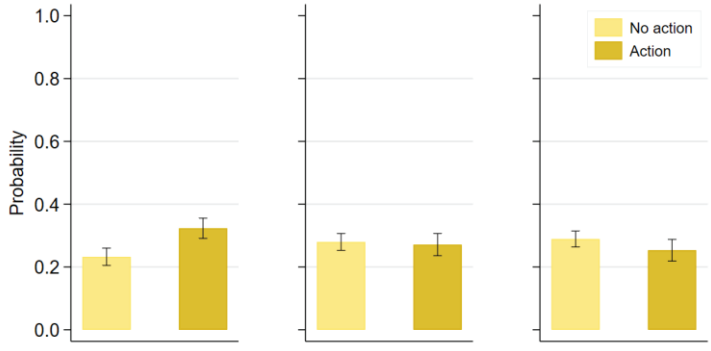

Figure 14. Estimated probability of 'slow flow-related' pig behaviours without (no action) and with (action) 'any negative' driver behaviour in the same 5-s interval (left), one 5-s interval back (middle) and two 5-s intervals back (right). Slaughter transport loadings (n=18), Sweden 2018-2019.

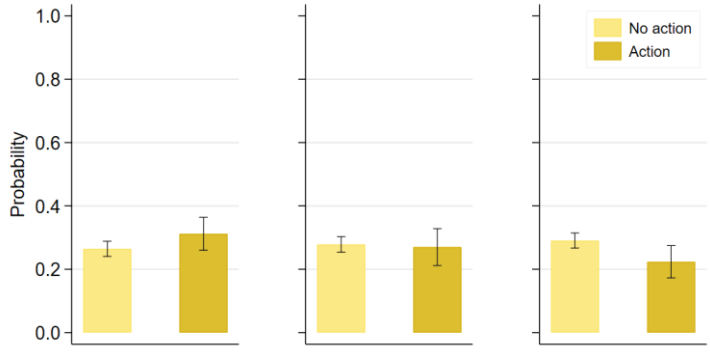

Figure 15. Estimated probability of 'slow flow-related' pig behaviours without (no action) and with (action) 'moderately-strongly negative' driver behaviour in the same 5-s interval (left), one 5-s interval back (middle) and two 5-s intervals back (right). Slaughter transport loadings (n=18), Sweden 2018-2019.

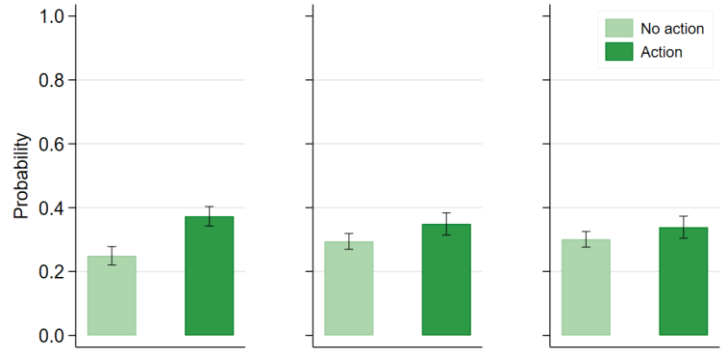

Figure 16. Estimated probability of 'relaxed' pig behaviours without (no action) and with (action) 'positive' driver behaviour in the same 5-s interval (left), one 5-s interval back (middle) and two 5-s intervals back (right). Slaughter transport loadings (n=18), Sweden 2018-2019.

Occurrence of 'stress-related' pig behaviour significantly increased the probability of 'any negative' TD behaviour and 'moderately-strongly negative' TD behaviour, in both the same 5-s interval (OR=4.0-5.4; p<0.0001) and the preceding interval (OR=2.9-3.4; p<0.0001) (Figures 17 and 18).

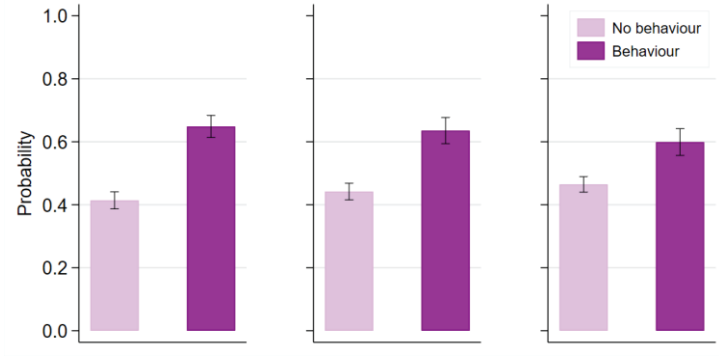

Figure 17. Estimated probability of 'any negative' driver behaviour without (no behaviour) and with 'stress-related' pig behaviour in the same 5-s interval (left), one 5-s interval back (middle) and two 5-s intervals back (right). Slaughter transport loadings (n=18), Sweden 2018-2019.

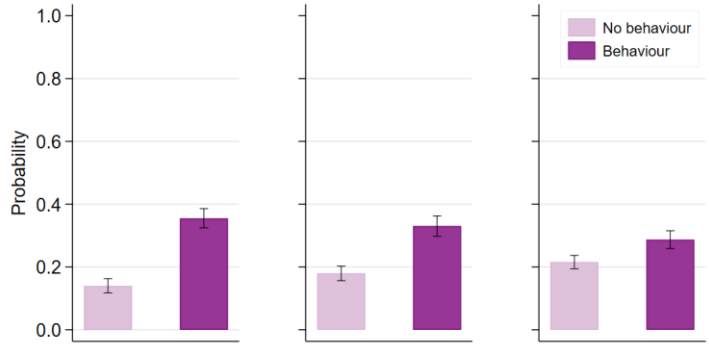

Figure 18. Estimated probability of 'moderately-strongly negative' driver behaviour without (no behaviour) and with stress-related pig behaviour in the same 5-s interval (left), one 5-s interval back (middle) and two 5-s intervals back (right). Slaughter transport loadings (n=18), Sweden 2018-2019.

5.2 Training intervention (not in paper)

5.2.1 Guidelines for professional handling

The following guidelines (adapted from material in the training programme ProHand Pig®) for professional handling of pigs at slaughter transportation were agreed upon at the end of day 2 of the group session (here translated from the original Swedish version):

- Prioritise your own safety and working environment
  - You have a lot of responsibility, transportation of pigs is hazardous for both humans and pigs
  - The risk of high workload potentially leading to physical discomfort is high during loading pigs and cleaning vehicles
  - Be sure to use pig driving tools correctly to avoid musculoskeletal discomfort
- Be aware of your own behaviour during handling
  - Minimise negative handling behaviours, for example shouting and hitting, because negative behaviours increase pigs' fear and the risk of panic behaviours, which makes it more difficult to handle the pigs
- Observe the pigs' behavioural response to you and estimate how fearful they are

  - Pigs' fear of new humans varies both within and between different farms. Pigs that are fearful of humans react by high vocalisations, try to flee behind you and look away when you approach them
- Make fearful pigs less stressed by working calmly and systematically
  - By using slow movements and talking with a soft voice, you reduce stress in pigs and increase their possibilities to handle challenging situations
  - Minimise negative behaviours and loud sounds as much as possible
- Adapt group size to the conditions at hand
  - If possible, load 5-6 pigs at a time and increase group size gradually if the circumstances allow
  - Trying to handle too large groups of pigs increases the risks of stopping among pigs that are out of reach, which is time-consuming
  - You should with ease be able to reach the pig behind the pig at the front, while standing in a upright position
- When possible, bring a pig that is walking in the wrong direction with the next group of pigs instead
  - Trying to handle single pigs that have turned and are walking back risks increase fear both in the individual pig and in a whole group of pigs, which increases the risk of more pigs turning around to go back or stopping
- Use pigs' natural behaviour of following one another
  - Avoid as far as possible handling or loading single pigs
- Use positive handling behaviours when possible, for example:
  - Gently lay a hand on a pig that has stopped, use slow movements and talk with a soft voice
  - This type of behaviour decreases fear of humans and is particularly important if the pigs appear fearful
- Remind colleagues and newly employed drivers about these advice
  - Remember that everyone who handles pigs contributes to whether and to what extent pigs are fearful of humans
  - Talk about possibilities for improvement with farm staff and staff at the slaughter facilities when conceivable
- Remember that you have a key position in the production chain
  - Your knowledge is important both for your own safety, pig welfare and meat quality.

5.2.2 Transport drivers' experiences and training evaluation

Examples of the TDs statements, translated from Swedish, are presented below (clarification in square brackets).

During discussions on day two of the group session, the TDs shared their experiences on *e.g.* how to handle pigs in order to keep up speed during loading. They also gave examples of links between their welfare and pigs' welfare when asked to elaborate on how potential conflicts with farmers affected their work:

> If you have a good loading area, it is possible to use the group dynamic to bring on a pig that is afraid.

> Sometimes they [pigs] accept the new environment, but they don't always have time to think, you need to give them some time but not too much.

> You notice it [the pigs' previous experience] in the first pig. When they are screaming from inside [the farm building] it is a bad sign.

> My mood affects [the situation] a lot, you have to try to be positive otherwise it will go to hell.

> Some farmers affect the loading, with their approach, never satisfied, that annoys me, I mean the farmer's attitude towards me, you try to be neutral but unfortunately it spills over on the pigs.

All 11 TDs participated in the individual sessions held two months after the group session. Six of them reported changes in how they handled the pigs, with four claiming to work more calmly, and two reported changes in how pigs responded to them:

> [I] have started to work more calmly, don't get stuck on individual pigs [refusing to walk], I relax more…

> I don't use the paddle as much and talk more with the pigs….

> People at the abattoir have told me that I work more calmly now.
>
> I give pigs more time when they stop.
>
> I have noticed that the pigs start to walk again with a light touch when they stop on the ramp… it works to lay a hand on [the pig].
>
> There is a difference in how the pigs react to me.

Two TDs highlighted the importance of being calm in order to avoid stress and poor time efficiency:

> There is no point to stress, it only make things worse.
>
> I sometimes say take it easy, there's no time to rush.

When asked if they had been able to make improvements in their working environment, two TDs reported having taken actions to improve their communication with farmers and veterinarians, for example by being more clear to the farmers about the ultimate pig group size. A few commented on how they had tried to decrease the physical workload, including changes in pig handling strategies:

> I try to use the board in the right position.
>
> I work more calmly and take fewer pigs per batch.
>
> It's difficult [to make changes] when washing the truck, I have changed my shoes, and I also think more about the driving board, and not to use the paddle on the pigs when they can't move.

Written evaluations of both the group and individual training indicated that the TDs were positive overall. Content mentioned as being particularly

useful in the group session was: talking to a veterinarian, information about physical workload, and information about pigs' behaviour and welfare and the importance of being calm during handling. Content mentioned as being particularly useful in the individual session was: how to improve pig handling, looking at videos of self, and the individual feedback on workload.

In the reinforcement phone-calls 2-4 weeks after training, four of the TDs mentioned that they had started to reflect more about how they work and three stated that they had found the training useful, but that it was sometimes difficult to practically implement changes, for example:

> I have use for the training, however it is hard on some farms to give pigs more time. If the farmer is in a hurry the pigs are already stressed, then it will be chaos if I take a step back.

> Some things [from training] worked instantly, e.g. to take smaller groups at unloading, other things are more difficult, such as not hitting those that are already walking or are blocked from walking.

All 10 TDs reported that they had been able to make changes in their handling behaviour, of which four had comments regarding the number of pigs during handling, three mentioned that they give pigs more time, two claimed to work in a calmer manner, and three mentioned that they used the paddle less:

> I reflect more now… instead of rushing I take two minutes extra, if you start pushing them [the pigs] they go in reverse… better to give 15 seconds extra and don't stress, start with just laying a hand on them instead, before training you didn't reflect at all, now I reflect.

> I notice in pigs how different it goes, some need more time than others.

> Handling of pigs has changed, I haven't used the paddle lately, I noticed by coincidence that it works just as well without it, works very well with just the board, the paddle isn't a hitting bat, it is easy to use it too much when holding it.

> I don’t reflect on positive behaviours but work calmly, put a hand on the [pig’s] back... I don’t have to work a lot, don’t get exhausted, and loaded pigs are happier.

> I understand why I work the way I do in a different manner now, understand the background to why it is good to e.g. lay a hand on [the pig], I have always tried to walk in the triangle [point of balance] but I give pigs more time now and I am not as intense with pigs that turn [in the wrong direction]…

> I aim to get pig number 2 to walk, instead of the unsure pig at the front.

> It works better now I think, you notice instantly how the pigs have been handled previously, the paddle just stands there, I only need it sometimes.

> Can tell a difference in the pigs when you give them time, some pigs need it… you can tell when they [farmers] are not good at handling pigs.

Five TDs reflected on their physical workload, of which two had noticed a decreased load:

> I haven’t really thought about working ergonomically lately, however I noticed a difference in my shoulders after working more calmly.

> Calmer loadings and back better now, can still feel it a bit when I relax.

> Difficult to know how to work correctly, hard to feel if the back is upright [position].

> Trying to think about standing more upright, like counting pigs when they are farther away and don’t bend the neck as much… I also think about not using the paddle as much and keeping it close to the ground.

Nine out of 10 TDs responded to the reinforcement phone-calls 1.5 years after training,. Five had stopped working with pig transportation, four of them mentioned that they had found the training useful in their current

occupations also involving animals. Two TDs still working mentioned that they had appreciated the training, and three said that they had reflected on their handling behaviour. One TD claimed to be more flexible in handling methods, and three claimed to be calmer during handling:

> You are moving them [pigs] in a calmer manner now and it works well to just walk calm behind and make some noise with the paddle… why stress, it doesn't go any faster.
>
> You stop more and let them look…
>
> I am a bit more conscious about both pigs and your own work, you take a step back and take it easy, in their pace…
>
> …you think in another way now, if the first way did not work you try another and then another, this has changed since before [training], I also try to make farmers improve their loading areas.

5.3 Study 2 (Papers III and IV)

5.3.1 Effect of training on attitudes (Paper III)

The overall mean±SD of the composite variables 'force', 'design', 'fear', 'quick', 'floor' and 'contact' was 3.29±0.271, 3.39±0.288, 3.78±0.416, 3.25±0.765, 4.50±0.516 and 3.28±0.752, respectively. The composite variable 'quick', constructed from the three statements 'It is best to move the pigs quickly', 'When the pigs start moving it is best to quickly keep them walking' and 'It can be irritating to work with unruly pigs' was reduced by 0.42 units ($p=0.095$) after training. Hence, there was a marginally significant effect indicating a weakening in the TDs' belief that it is necessary to rush when handling pigs. No other significant result was found.

5.3.2 Effect of training on handling behaviour (Paper III)

In total, 28 loadings (10 before training and 18 after), with 49-265 (median 110) pigs per loading, were performed on 23 farms by 10 TDs from four

haulage companies. There were 16 to 426 (mean 124) recorded 5-s intervals per loading and 166 to 634 (mean 347) intervals per TD in total. The average number of pigs within a 2 m radius in front of the TD, in the 5-s intervals used in video-recordings, varied from 1.4 to 5.2 (median 2.2).

'Visually interacting actively' was the most commonly performed TD behaviour overall, and 'walking' was the most commonly performed pig behaviour overall (Table 3). The proportion of 5-s intervals with the composite variable 'moderately-strongly negative' TD behaviour was reduced by more than half after training, mainly reflected by a reduction in the most commonly observed behaviours 'making loud noise or shouting' and 'using board hard while pig stands still'. The proportion of intervals with the composite variable 'mildly negative' TD behaviour was increased by one-third, with a substantial increase in 'using board lightly while pig stands still'. The proportion of the composite variable 'positive TD behaviour' increased, mainly due to an almost doubling in 'soft talking' and 'loose hand while pig stands still'. The proportion of intervals with the composite variable 'stress-related pig behaviours' decreased by a little less than one-third after training, reflected mainly by a decrease in 'head up ears back', 'freezing' and 'high-pitched vocalisations' (differences not tested) (Table 3).

Table 3. Percentage of 5-s intervals with different composite variables (mean values), and the 1-4 most common transport driver (TD) behaviours and pig behaviours within each composite variable before and after training. Data from a total of 28 loadings (10 before and 18 after training), 49-265 (median 110) pigs per loading, performed by 10 pig transport drivers, Sweden 2018-2020

	Composite variable[1]	**Before (%)**	**After (%)**	**Most common TD and pig behaviour**	**Before (%)**	**After (%)**
TD	Moderately-strongly negative	55.3	17.9	Using board hard while pig stands still	10.5	3.9
				Using hand hard while pig stands still	6.3	2.3
				Pushing with knee	2.9	3.4
				Making loud noise or shouting	14.6	1.9
	Mildly negative	33.7	50.5	Using board lightly while pig moves towards truck	5.0	8.3
				Using board lightly while pig stands still	4.4	12.3
				Using paddle lightly while pig moves towards truck	6.7	8.1
				Using paddle lightly while pig stands still	10.5	11.2
	Positive	65.5	94.3	Talking	11.3	19.4
				Visually interacting actively	21.3	23.3
				Visually interacting passively	14.2	14.3
				Loose hand while pig stands still	6.2	13.9
Pig	Stress-related	42.4	28.9	Attentive	15.1	2.6
				Crowding	15.4	13.7
				Freezing	16.4	7.4
				High-pitched vocalisations	10.7	6.1
	Slow flow-related	29.2	22.7	Backing away from truck	14.8	10.1
				Stopping without crowding	8.7	9.3
				Turning away from truck	10.6	5.8
	Flow-related	68.1	65.7	Turning towards truck	14.6	11.2
				Walking	64.6	63.2
	Relaxed	30.3	38.4	Calm/ relaxed/ investigate	30.3	38.4

A significant decrease in the odds of 'moderately-strongly negative' TD behaviour (57%, p=0.0013) and a significant increase in the odds of 'positive' TD behaviour (94%, p<0.0001) was found after training. No significant effect was found of 'mildly negative' TD behaviour (Figure 19).

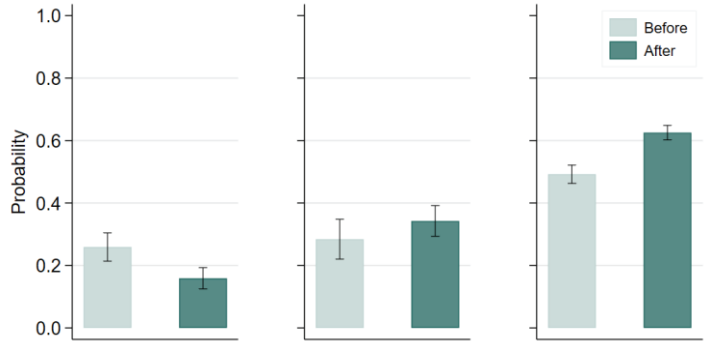

Figure 19. Estimated probability of 'moderately-strongly negative' (left), 'mildly negative' (middle), and 'positive' (right) behaviour of transport drivers before and after training. Predictive margins from logistic and mixed-effects random-intercept logistic models, with remaining covariates in model kept at their values in the sample (n=3,472). Pig slaughter transport loading (n=28), Sweden 2018-2020.

5.3.3 Effect of training on physical workload and time efficiency (Paper IV)

For all loadings and all TDs, both before and after training, loading of pigs started between 04:00 and 17:00 h, and the majority (83%) between 05:00 and 10:00 h. The number of pigs recorded was 49-265 per loading. In total, 4721 pigs were included in 37 loadings. Mean total loading time was 23 s (9-63s) per loaded pig, and mean active loading time was 16 s (5-55s) per pig. Descriptive statistics on physical workload are presented in Table 4.

The linear mixed regression models showed no significant effect of the training for TDs upper arm elevation or velocity in the peak load (90^{th} percentile), or on active loading time of pigs.

Table 4. Group mean (and standard deviation within brackets) of Swedish pig transport drivers' right upper arm elevation (°) and velocity (°/s) in the 90th percentile (peak load), and active loading time per pig before, ≤90 days after and >90 days after training (n=17, 13 and 6 TDs and loadings, respectively), during slaughter transport loading of pigs, Sweden 2018-2020

Variable	Before	≤90 days after	>90 days after
Arm elevation, °	56.8 (9.95)	55.2 (7.77)	57.8 (5.62)
Arm velocity, °/s	189 (57.6)	185 (37.1)	168 (42.0)
Active loading time, s	14.5 (7.53)	15.4 (12.9)	22.9 (9.13)

5.3.4 Loading facility design and pre-transport farm management (not in paper)

In total both before and after training of TDs, 37 loadings were observed at 33 different loading area locations and farms (two loading areas were observed on one of the farms). Production was specialised in fattening pigs on 21 of these farms, while 12 also had piglet production. Eighteen of the farms normally used rattle paddles during pig management. The number of levels in transport vehicles (trucks and trailers) was 2-4, although no more than 3 decks were used. All but one loading was carried out in daylight and/or in artificial light from the farm building or transportation vehicle. Mean ambient temperature, based on measurements directly before and after loading, varied from -4 to +12 °C. There was direct sunshine in the loading area at one loading, and shade or cloudy conditions at all remaining loadings. The weather was rainy at three loadings and there were strong winds at 17 loadings. Examples of loading area designs are shown in Figures 20 and 21. Farm characteristics and management routines prior to loading, loading area designs, vehicle ramp dimensions and loading time are shown in Table 5.

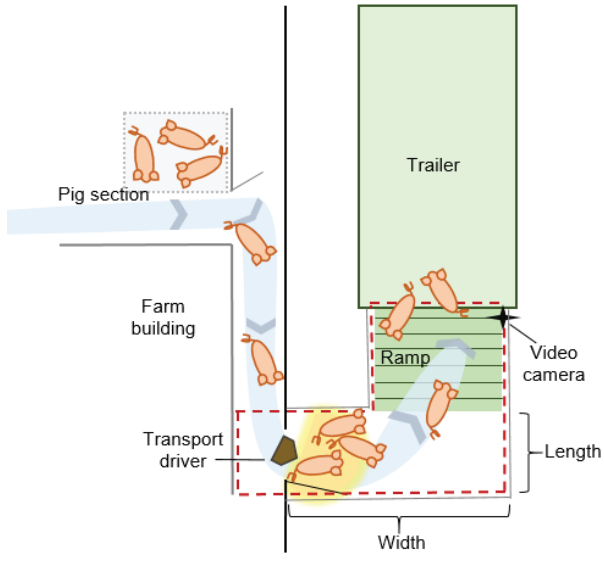

Figure 20. Example of a loading area design on Swedish farms with finishing pigs. Solid black lines show outer walls of farm building, dashed red lines show loading area where behavioural observations were made, determined by the area covered in video recordings. Vehicle parked alongside the building. Highlighted area shows pigs observed in behavioural recordings (in this case three pigs) within 2 m radius in front of the transport driver.

Figure 21. On-farm loading areas without roof or walls and at ground level (left), with roof and walls, elevated above ground level (middle) and with ramp positioned directly against the farm building door, at ground level (right).

Table 5. Loading-area design, farm staff management routines prior to loading, vehicle ramp dimensions and loading time at 37 loadings of finishing pigs on 33 farms in Sweden 2018-2020

Measure	Category	Number (%) or median	Std. Dev.	Range
Number of farm stockpeople[a]		3	1.3	1-6
Loading area width[b], cm	-	200	99.5	60-400
Loading area length[c], cm	-	185	141.7	0-685
Area of loading area, m^2	-	3	5.6	0-23
Narrow door[d]	Yes, included	9 (27)	-	-
	Yes, not included	14 (42)	-	-
	No	10 (30)		
Elevated loading area[e]	Yes	17 (52)	-	-
	No	16 (48)	-	-
Floor in loading area	Concrete	25 (76)	-	-
	Wood	2 (6)	-	-
	Ground	6 (18)	-	-
Roof over loading area	Yes	17 (52)	-	-
	No	16 (48)	-	-
Walls in loading area[f]	Yes	26 (79)	-	-
	No	7 (21)	-	-
Corners in loading area[g]	Sharp	16 (48)	-	-
	Soft	4 (12)	-	-
	No	13 (39)	-	-
Steps in loading area[h]	Yes	15 (45)	-	-
	No	18 (55)	-	-
Rearing time in section, days[i]	-	103	15.6	70-127
Fasting time, h[j]	-	8	3.6	0-12
Pigs sorted before loading[k]	Yes	20 (54)	-	-
	No	17 (46)	-	-
Width of vehicle ramp, cm	-	170	29.9	60-235
Length of vehicle ramp, cm	-	270	39.0	140-347
Coating on ramp[l]	Yes	23 (62)	-	-
	No	14 (38)	-	-
Litter on ramp	Cutter shavings	17 (46)	-	-
	Straw	6 (16)	-	-
	No	14 (38)	-	-
Slope of vehicle ramp, °	-	13	4.4	4-22
Litter in loading area	Cutter shavings	7 (19)	-	-
	Straw	10 (27)	-	-
	No	20 (54)	-	-
Number of pigs loaded	-	110	59.6	49-265
Total loading time, min	-	41	18.5	16-114
Total time per pig, s[m]	-	20	12.1	9-63
Active time per pig, s[n]	-	14	10.0	5-55

Na= Not applicable.
[a]Number of staff who take turns to attend to pigs on a daily basis.
[b]Width: the side of the loading area where the vehicle ramp docked.
[c]Length: excluding ramp, set to 0 when no space between the ramp and farm building door.
[d]Farm building doorway narrower than the vehicle ramp and included in the transport drivers' working area (yes, included), narrower than ramp but not included in the working area (yes, not included), or not narrower (No).
[e]Loading area elevated above ground level (Yes), or the same level as loading area (No).
[f]Solid walls or fence (> 60 cm high) in loading area (yes), or no walls on one or several sides (No).
[g]Sharp corner (>80 degrees), soft corner (40-80 degrees), or no corner (<40 degrees), included in the loading area.
[h]Differences in altitude in the loading area excluding vehicle ramp, e.g. a doorstep.
[i]Time in the fattening section (approx.. three months old when entering the section).
[j]Time without feed before start of loading.
[k]Selective sorting from housing section by farm staff for split-marketing (Yes) vs. emptying of section (No).
[l]Rubber or other coating on ramp (Yes), metal surface on ramp (No).
[m]Total loading time per pig, including the time transport drivers wait for pigs to exit the farm building.
[n]Active loading time per pig, excluding the time transport drivers waited for pigs to enter from the farm building.

6. General Discussion

The research described in this thesis covered several aspects of the welfare and wellbeing of pigs and transport drivers during slaughter transport. This discussion ties together the different parts and focuses on the more general aspects. A detailed discussion of specific results can be found in Papers I-IV.

6.1 Study 1

6.1.1 High demands and varying working conditions

The results obtained in this thesis showed that the working conditions of pig transport drivers (TDs) are in some ways unsatisfactory, and that this is determined by several fundamental factors that are outside the control of the TDs. Thus, in addition to training of TDs, actions by external actors are likely needed to reduce the risk of poor human wellbeing and impaired pig welfare during slaughter transport loading. The most obvious factors that appeared to complicate the work of Swedish TDs examined in this thesis were:

- Several pieces of complex and sometimes conflicting regulations
- Sector intensification, leading to three- or even four-deck high-capacity trailers and responsibility for the welfare of hundreds of pigs per transport, with limited possibilities to attend to all
- A subcontractor situation leading to competition between haulage companies and pressure to be very time-efficient
- Poor design of loading areas on some farms, with consequences for workload and pig welfare
- Conflicts with farmers regarding pig health status, and different assessments by official veterinarians at slaughterhouses.

Although loading of pigs constitutes a minor part of the whole transport sequence, it is probably the most interaction-intensive and demanding situation for TDs. Inappropriate loading area design, *e.g.* due to insufficient light, space or wind protection, was reported by the TDs to have a strong impact on their workload in general, and knee discomfort in particular, due to the knees being pressed against the driving board when pigs were pushed forward. A majority of the total 33 loading area locations studied in this

thesis had narrow doorways and sharp corners, and about half lacked a roof, were located on ground level or had an elevated or lowered step prior to the ramp. On around half of the farms, the space to position the trailer perpendicular to the farm building was limited, which led to sharp corners in the loading area. In combination, these features possibly led to limited visibility ahead for the pigs, a risk of wind and sharp sun exposure and steep ramps, all of which can decrease the willingness of pigs to walk forward (Grandin, 2017). There was large variation in the space inside the loading area (0-23 m^2) on the different farms. On some farms, the only available workspace for the TDs was the vehicle ramp, forcing them to work very close to the pigs, which likely increased the risk of pig stress. On other farms, large loading areas limited the possibilities for the TD to separate a small number of pigs and to use the pigs' flight zone efficiently, which likely decreased the potential to make pigs walk in the desired direction. According to European regulations, the loading area design should prevent injuries and suffering and minimise stress in animals, *e.g.* by having non-slip flooring, adequate lighting and a maximum ramp slope of 20 degrees ((EC) No. 1/2005). A well-designed loading area also likely needs to include a space of about 5-10 m^2 (or 1-2 pigs/m^2, ramp excluded (Animal Transport Guides, 2016)). A rectangular shape, with the short side towards the ramp to increase the possibilities for the TD to use the driving board to block pigs from going back, would likely also be good. A roof and two or three walls would reduce the risk of sharp sunlight and wind, and the area should be elevated above ground level to minimise ramp slope. Narrow doorways, sharp corners and steps should be avoided. Moreover, farmers likely need to have a plan for how to take care of pigs that are rejected by the TD, in case disease control regulations prohibit them from taking the pigs back into the farm building.

One explanation for the existing large variation in loading area design and poor design is that this feature is not included in the pre-testing of building plans to ensure the adequate design required by the authorities. Increasing the incentive for farmers to improve existing buildings would likely be necessary. Peden *et al.* (2018) concluded that the ongoing practice of mixing of pigs at slaughter transport appears to be due to a combination of low prioritisation, difficulties in practically implementing changes and lack of information about cost-effectiveness. Those authors suggested increased involvement of the industry when designing practical solutions and quantifying cost-effectiveness as possible solutions. Hence, slaughterhouses

are likely to play an important role in encouraging on-farm improvements of loading areas.

The TDs reported being committed to their work, with good confidence in their own working abilities and few psychosocial symptoms. In the training workshop, some TDs mentioned that good work satisfaction is a prerequisite to endure the demanding work. This contradicts previous findings of poor mental health in truckers (Garbarino *et al*., 2018; Shattell *et al*., 2012). Working predominantly alone and often during night hours are well-known risk factors for decreased psychosocial health (Costa, 1996). A possible explanation is that, compared with truckers with generally very long hauls, TDs in Sweden have relatively short-haul trips and are hence more physically active. However, this also comes with disadvantages, as TDs with several loading-unloading sequences during a work shift are more exposed to a risk of injury, due to performing more work outside the vehicle, as previously discussed by Chandler *et al.* (2017).

A majority of the TDs reported discomfort in their knees, shoulders and lower back. In practice, elevated arms during more active tasks (loading, unloading and vehicle cleaning) could be linked to their reported shoulder discomfort (Bodin *et al*., 2012; van Rijn *et al*., 2010). It is possible that the extreme crouching postures at the end of loading and beginning of unloading in the bottom level of the trailer (da Costa & Vieira 2010; Ribeiro *et al*., 2012), as well as static postures during driving (Senthanar & Bigelow, 2018), contributed to increased risk of lower back discomfort in the TDs. Increasing the minimum height in the lowest deck might decrease the risk of musculoskeletal discomfort and lower the risk of injuries arising due to the TD being squashed between pigs and the deck above.

During loading, the responsibility for pig welfare is shared between the TD and the farmer. This thesis showed that often more than 100 pigs are loaded per site, and the TD is obliged to count them at speed while also ensuring that all are fit for transportation. During the training workshop, the TDs expressed concerns about farmers sometimes trying to hide unfit pigs in the midst of a group and maintaining a high work speed, leading to disagreements between TD and farmer. Pigs coming out of the farm building at high speed and inadequate light or space in the loading area likely increase the risk of the TD not detecting whether a pig has wounds or hernias or detecting this once the pigs are loaded, in which case the TD must unload the unfit pig again. Apart from the pig welfare issues associated with separating

a single pig from the group, this also increases the amount of work for the TD. Moreover, the TDs expressed concerns about vague descriptions of what makes a pig unfit and differentiating assessments and lack of feedback from official veterinarians. This is not an issue limited solely to transportation of pigs, as similar concerns about assessment of cow fitness at slaughter transportation have been reported for Danish livestock drivers (Herskin *et al*., 2017). It is possible that farmers who may not have enough space to keep sick or injured pigs or are prohibited from returning diseased pigs to their building section due to disease control regulations likely need to euthanise pigs rejected by the TD. Increased farmer incentives to present only healthy pigs for transport to slaughter, additional training of TDs in assessment of pig fitness and more specific feedback from veterinarians might be needed in order to decrease these stakeholder conflicts and ensure pig welfare.

In both the group and individual training sessions, the TDs expressed concerns about time pressure. In a previous study of slaughterhouse staff, time pressure, due to a need to keep up with the slaughter line, was associated with increased aversive handling in efforts to move pigs quickly (Coleman *et al*., 2003). This likely also applies to the slaughter transport situation. During discussions, the TDs reflected on how conflicts with farm staff, *e.g.* regarding a high work speed, risked leading to negative effects on how pigs were treated. Moreover, the TDs reported that time limitations sometimes led to violations of regulations such as registering the vehicle wash period as a mandatory driver's rest period. Similar safety risks have been reported in a study of Danish drivers transporting sows, who reported concerns about animal welfare during stationary periods and violations of the regulation on mandatory driver rest stops (Thodberg *et al*., 2020). Moreover, the TD are obliged to tend to the pigs during road transport and are not allowed to leave the animals unattended in the trailer ((EC) 1/2005), although access to all pigs is limited in the modern vehicles with several decks, and regulations on drivers' road safety state that they are not allowed to perform any kind of work during their statutory breaks ((EC) 561/2006).

The subcontractor situation means that it is the haulier, and not the slaughterhouse, that is responsible in the case of violation of regulations during slaughter transport. As reported by TDs in the training workshop, the slaughterhouses are pushing for increased transportation efficiency, and hence they possibly have little incentive to provide hauliers with contracts that potentially decrease efficiency in order to lower the risk of conflicts

between safety and practice. Compared with slaughterhouses, hauliers have limited opportunities to assign their staff to less physically demanding tasks if their working capacity is impaired, which may increase the risk of TDs not reporting illness or injuries in an act of loyalty to their employer. This may also lead to a change of occupation in the case of injury. In the phone-calls 1.5 years after the training intervention in this thesis, five of the TDs reported no longer working with animal transportation, but the reason was not asked for. The above-mentioned issues, as well as rivalry between hauliers, might be prevented if TDs were instead directly employed by the slaughterhouse, which is in fact the case for a small number of slaughterhouses in Sweden today. In the current situation, with mainly sub-contracted hauliers, the contracts between slaughterhouses and hauliers should be formulated so as to minimise the risk of non-compliance with regulations and stress in TDs and in pigs. Decreased time pressure would likely also decrease the risk of negative interactions between TDs and pigs during loading and poor pig welfare, as further discussed in Section 6.1.2.

Altogether, to safeguard the welfare of TDs and pigs, several different types of actions on multiple decision-making levels are needed. The important role of stakeholders outside the transportation sector in reducing safety risks in truck drivers has been pointed out by Reiman *et al.* (2021). A common platform to facilitate communication between TDs, farmers, official veterinarians and slaughterhouses could lead to an improved mutual understanding of the TDs' work challenges, and would likely contribute to solutions. TDs' unique practical experiences and knowledge, *e.g.* about how to improve loading areas, should be of interest to all parties concerned. Moreover, improving TDs' working conditions would probably help to retain competent and resilient workers in the occupation, and ultimately reduce the risk of pig stress and poor meat quality. The results in this thesis are in line with Losada-Espinosa *et al.* (2020), who highlighted the importance of an occupational culture that prevents occupational health problems, ensures decent working conditions and promotes empathy towards animals.

6.1.2 Transport driver and pig interactions

The associations found in this thesis between 'negative' TD behaviour and increased 'stress-related' pig behaviour, and between 'positive' TD behaviour and 'relaxed' pig behaviour, are in line with previous findings

(Hemsworth *et al*., 1986b; Hemsworth, 2019; Tallet *et al*., 2014; Hayes *et al*., 2021). Interestingly, 'stress-related' pig behaviour in the same and preceding intervals appeared to increase the probability of 'negative' TD behaviour, which suggests that the stress-related pig behaviours to some extent had a persistent effect on the negative TD behaviour, and that the effect was likely causal. The most commonly recorded 'stress-related' pig behaviours *i.e.* crowding and freezing, likely also decreased the speed and flow of pigs during loading. The 'slow flow-related' pig behaviours turning away from truck, stopping and backing, could have been signs of pigs attempting to go back to a safe place due to fear and stress. The increased probability of 'slow flow-related' behaviour in the case of (any) negative TD behaviour in the same 5-s interval supports the assumption that those behaviours could also be a sign of pig stress, and suggests that it is to some extent contra-productive for TDs to apply negative physical interactions to increase pig flow and time efficiency during loading.

'Using the board hard while pig stands still' was the second most commonly 'moderately-strongly negative' TD behaviour, after 'loud noise'. This may indicate that when the pigs were crowding or freezing, the TD was located in the blind spot close behind the pigs, with limited opportunities to use the point of balance to make pigs walk forward. This might lead to a vicious cycle with increased stress levels in the pigs closest to the TD due to rough physical interactions, which in turn is likely to increase stress in the whole pig group and further strengthen the crowding behaviour. Crowding means a decreased likelihood that the pigs at the front of the group will start walking, and hence risks leading to the TD applying increased physical effort towards the pigs within reach. This risk is probably higher on farms where the space in the loading area is limited, since the TD is then forced into pigs' flight zone instead of working at the edge of the flight zone. Another factor likely contributing to this situation is large group size, since the pigs blocking at the front are outside the reach of the TD, as further discussed below. In addition, this sort of negative feedback loop can be expected to enhance negative beliefs about pigs in TDs (Hemsworth & Coleman, 2011), *e.g.* regarding pigs being stubborn and requiring a lot of force to handle. An example of a situation similar to that described above is shown in Figure 22.

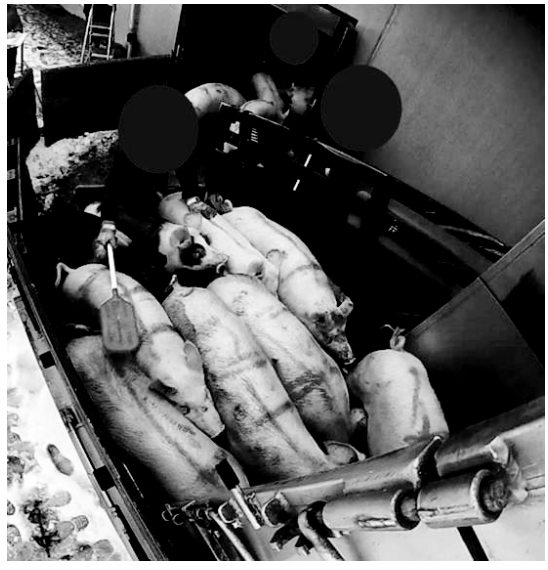

Figure 22. Pigs standing still, crowding, attentive and vocalising, with the TD standing close behind, outside reach of the pigs at the front, and using both paddle board and hand on pigs at the rear.

A sometimes large number of pigs probably decreased or inhibited the TDs' possibilities to properly use the pigs' flight zone and point of balance appropriately. During group training, it was discussed that while standing inside of the pigs' flight zone it is important to be calm, in order to minimise pig stress and behaviours such as pigs turning back and potentially colliding with the TD. It has previously been suggested that 5-6 pigs is a suitable group size during handling, and that an increased number of pigs does not increase time efficiency (Lewis & McGlone, 2007). Starting with a manageable number of pigs, and then increasing the group size gradually if circumstances allow, was a strategy agreed upon and included in the professional guidelines formulated in the training (see Section 5.2.1). However, this is likely to be difficult if the communication between TD and farmer is not working well, since farm staff usually decide on the number of pigs entering the loading area. It was emphasised in the training that in order to prevent high workload in the TDs and avoid fear in the pigs, it is beneficial to stand in an upright position and limit the pig group size to enable interactions with the pig standing next to the frontrunner in the group. This would probably decrease the risk of forceful interactions with pigs located in the back of the group.

'Stress-related' pig behaviours were recorded in almost one-third of all the 5-s intervals studied, and 'moderately-strongly negative' TD behaviours were recorded in one-fifth of the intervals. The considerable variation in these observed behaviours between loading occasions suggests possibilities for improvement of TD behaviour and pig welfare. Variations in pigs' fear of humans, loading area designs and individual TD handling strategies may be reasons for the variation. Presence of farm staff in the loading area was adjusted for in the statistical analyses and, although the quality of their handling behaviour was not classified, aversive handling of pigs was sometimes observed. All 18 farms included in study 1 were contacted and asked to participate in a study investigating on-farm human-pig interactions but only half agreed, making those results difficult to include in further analyses. Results from a limited analysis (not included in this thesis) indicated that the stockpeople on the nine participating farms spent a comparatively small amount of time with the pigs, and that the majority of the human-pig interactions were of a negative nature (Wilhelmsson *et al*., 2020). Hence, it is possible that the pigs were fearful of humans to some degree and that this negatively affected TD and pig interactions during loading. In the training workshop, TDs reported on differences between farms in how pigs respond to them, and one said that the sound of pigs screaming from inside the farm building prior to loading was a bad sign. A greater insight into farm management routines for pig handing would have enabled increased understanding of the interactions between TDs and pigs. Future studies should investigate the quality of human-animal interactions on Swedish pig farms and assess whether handling could be improved, and pigs' fear of humans reduced, by a introducing a training intervention similar to that applied in this thesis.

Pigs have a strong motivation to explore new surroundings (Jensen & Toates, 1993), so decreasing the amount of unnecessary objects in loading areas is generally recommended to decrease the risk of pigs stopping to explore. Explorative behaviour was not recorded in this thesis, due to lack of a full view of the pigs' heads in the videos, although this behaviour was frequently observed during field work. It is likely that many of the recorded 'relaxed' pig behaviours, when pigs held their head below shoulder height, included explorative behaviours. All pigs had been reared under conventional settings with very limited possibilities to explore, which has been suggested to lead to a strong rebound in explorative behaviour when

the pigs are presented with a novel situation (Wood-Gush & Vestergaard, 1993; Haskell *et al*., 1996). It is possible that pigs which were observed exploring were still stressed to some extent, but explored nevertheless due to the strong rebound effect. Puppe (2003) suggested that successful coping with cognitive challenging situations could enhance pig welfare, and Puppe *et al.* (2007) found that pigs which had been presented with cognitive enrichment expressed fewer fear behaviours than control pigs. Hence, pigs' overall cognitive stimulation during rearing may affect their coping abilities during loading. The lack of a complex rearing environment compared with that of pigs reared outdoors and the many novel factors associated with slaughter transport, including a new environment and mixing of pigs, suggests that transportation and related handling might be too challenging to prevent stress in finishing pigs entirely. To increase pigs' coping abilities and minimise stress throughout the pre-slaughter chain of events, rather comprehensive changes in today's conventional pig production systems would likely be needed. Such changes could include increasing the complexity of the rearing environment considerably, keeping stable and not too large groups of pigs (Dreissen *et al*., 2020; Gesing *et al*., 2011), training the pigs (Lewis *et al*., 2008) and increasing the quantity of positive human interactions (Hemsworth *et al*., 1994a; Hemsworth *et al*., 1986b).

6.2 Training intervention

The TDs made spontaneous requests for training content concerning increased knowledge in handling pigs and how to work to avoid attritional wear on their own body. This was in accordance with the initial plan for the training content, which was based on previous research on pig farmers (Coleman *et al*., 2000; Hemsworth *et al*., 1989) and the observations made in study 1. The majority of the participating TDs, with a few exceptions, had several years of experience of pig slaughter transportation. This is important to bear in mind when evaluating possible effects of the training, since inducing behavioural change in experienced stockpeople involves changing established habits and attitudes (Hemsworth & Coleman., 2011) and it is likely easier to learn correctly from the beginning. Future similar training interventions might have the greatest impact if they focused on the TDs involved in practical training of new employees and directly addressed inexperienced TDs. However, the changes in TDs' behaviours after the

training suggest possibilities to alter animal handling methods even among experienced TDs.

During the training workshops, there was an initial discussion on aspects of the TDs' working environment that lie within their own control and possible changes they could make themselves, including their part in stakeholder conflicts. This might have decreased potential learning resistance in the TDs and increased their receptivity to messages on why it is important to improve handling methods. For example, the TDs feared being unknowingly reported and believed that official veterinarians to be inconsistent in their assessment of pig fitness (both outside the control of the TD), which was discussed with an experienced veterinarian during group training. Addressing this was possibly beneficial in increasing TDs' receptiveness to the subsequent discussions about pig behaviour and welfare.

Involving and enabling active participation by non-academic actors is critical to achieving long-lasting improvements in animal welfare, as it increases the chances of them taking ownership and implementing outcomes in practice (Fernandes *et al*., 2019). Letting the TDs themselves make the distinction on what was, and what was not, within their control and involving them in formulating the guidelines for professional handling also led to new knowledge about their working situation and slaughter transport of pigs. Based on the overall positive training evaluations in this thesis, a holistic approach incorporating human wellbeing and animal welfare and involving practitioners in development of training content appears to be a beneficial strategy in future training of TDs, and possibly also of stockpeople within animal production in general.

6.3 Study 2

The slight increase in 'mildly negative' TD behaviour after training, although not significant, could have been caused by a change to this from the 'moderately-strongly negative' behaviour, the incidence of which decreased significantly. Physical interactions with driving tools are likely necessary to some extent during loading of pigs, depending on the loading area design and pigs' responses to the TD. The reduced proportion of 5-s intervals with recordings of the pig behaviours 'attentive', 'freezing' and 'high-pitched vocalisations' was likely partly an effect of the decrease in the 'moderately-strongly negative' TD behaviours, *e.g.* forceful use of the board and loud

noise, and the increase in 'positive' TD behaviours. This is supported by the comments made by TDs during individual training and in the reinforcement phone-calls regarding *e.g.* being calmer during handling, giving pigs more time, reduced tool use and in some cases changes in how pigs responded to handling. These results are in line with previous findings of reduced fear responses in pigs as a secondary outcome to improved handling behaviour in farmers (Hemsworth *et al*., 1994b). This highlights the importance of ensuring good knowledge of pig behaviour, welfare and appropriate handling techniques in TDs to decrease the risk of poor pig welfare.

One TD reported that it was easy to overuse the rattle paddle without reflecting on why, and stated that the use of this tool had decreased after training. The rattle paddle was however not the most commonly observed tool before training, most likely since some of the TDs did not use a paddle at all. The overall decrease in 'moderately-strongly negative' behaviours, and slight increase in using the board lightly after training is positive for both for pigs and TDs. McGlone *et al*. (2004) found the board to be a more effective tool than the paddle since pigs seem to perceive it as a solid wall, leading to fewer pigs turning around and a reducing the time needed to move pigs. Further, the driving board has been suggested as a suitable tool in tight spaces because it protects the handler from being stepped on or bumped into by pigs (McGlone *et al*., 2004). The shift towards less forceful interactions with the pigs, and TDs reporting being calmer after training than before, can be considered to be more aligned with the Swedish animal welfare legislation on transport and slaughter regarding the need to handle animals calmly and only using paddles or boards to direct animals.

Increased TD behaviours of a positive nature and signs of a reduced stress in pigs after training may also indicate an overall reduction in TDs' work load, due *e.g.* to reduced occurrence of pushing the knees against the driving board to make a group of crowding pigs walk. Potentially calmer working strategies and a reduction in time-consuming stress-related pig behaviours were expected to be associated with reduced upper arm velocity and improved time efficiency after training. However, no such changes were found. The limited possibilities to perform follow-up measurements on the same farms after training, and the large between-farm variations, could have obscured potential effects of training. The large differences in active and total loading time for all loadings most likely also reflected the large between-farm variation. Further, the challenging physical conditions during

loading and the limited sample size, and thus limited possibilities to include all potentially confounding variables in the analyses, may not have allowed all existing effects to be detected.

The belief that it is good to move pigs quickly was slightly decreased in TDs after training, but no other significant improvements in attitudes towards pigs and pig handling were found. However, the changes found in handling of pigs, towards more positive and less negative behaviours, suggest improvements in TD attitudes, and the small number of TDs included in the PCA-analysis calls for caution when interpreting the results. Moreover, it is worth noting that the TDs who participated in training were not chosen on the basis of having particularly poor attitudes. The observations of decreased rough behaviour and increased gentle behaviour after training indicate that, despite time constraints and challenging working conditions during loading, it is possible for TDs to improve their handling methods. There seem to be good opportunities to improve TDs' attitudes towards pig handling and subsequent handling behaviour, as well as stress in pigs during transport loading.

The results obtained in study 1 and 2 are in line with findings by Tarazona *et al*. (2019) and García-Pinillos *et al*. (2016) regarding the existing reciprocal links between human wellbeing and animal welfare. As previously suggested by Anneberg & Sandoe (2019), there seem to be an increased risk of poor animal welfare if stockpeoples' working environment impose a risk of physical or psychological stress.

6.4 Methodology

The methodologies used in this thesis were designed to enable mapping of the TDs working conditions and interactions with pigs under normal work practices, and hence more controlled experimental set-ups could not be applied. This led to a lack of control over the amount and quality of data. For example, difficulties in getting a larger number of participating TDs were partly caused by the time-consuming work of collecting data in various geographical locations, and the field work was sometimes delayed due to farmers not wanting to participate.

Ergonomic interventions, *e.g.* introducing engineering and organisational alterations and involving key stakeholders, are common and effective strategies to evaluate and reduce workload in different occupational groups.

Such interventions have previously been shown to reduce musculoskeletal symptoms in truck assembly workers (Zare *et al*., 2020). Future studies aiming to reduce the physical workload on TDs might gain from involving key stakeholders, namely farmers and slaughterhouse managers, in supporting necessary alterations in the TDs' working environment, including the on-farm loading area design and organisational aspects such as amount of time permitted for loading of the pigs.

Although only 10-20 TDs participated in the different parts of the work reported in this thesis, these constituted approximately 10-15% of the total occupational group in Sweden. Participating TDs had at least six months' experience of working with transportation of pigs and worked for four different haulage companies, in the south, centre and north of Sweden. The participating TDs were however not necessarily a fair representation of the occupational group as a whole. The majority of Swedish haulage companies and TDs work in the southern parts of the country, where the majority of farms and slaughterhouses are located, and where hauls are shorter and number of loadings per work shift higher than in the northern parts of Sweden. If the majority of Swedish TDs have more than one 'loading to vehicle cleaning' sequence per work shift, the whole-day measurements of physical workload are likely slight underestimates.

How well the results in this thesis represent the occupational group at an international level can also be debated. Sweden produces relatively little pig meat compared with countries such as Germany and Denmark, which are amongst the largest pig meat producers in the world. It is possible that the pre-slaughter chain logistics, and hence TDs working conditions, are different in other countries in the EU, although the relevant EU regulations are the same. More information about slaughter transport practices in other countries, for example regarding vehicle design and number of 'loading to vehicle cleaning' sequences in one work shift, is needed to determine the wider applicability of the results on physical workload in Swedish TDs. Nevertheless, the reciprocal relationships found between TD behaviour and pig behaviour, and the potential of training interventions to improve handling methods and pig welfare, are likely valid also in countries with substantial pig production.

Completely randomised sampling of TDs and of farms would likely have improved the overall reliability of the results. However, slaughterhouses, hauliers, TDs and farmers had to give their informed consent to participate

before field work could be carried out. The majority of participation refusals came from farmers, despite that the study objectives had been explained by the haulage company manager, the TD or an experienced research technician. This directly affected which TDs and farms that could be included in the project. Moreover, two TDs from the same haulage company chose not to participate in the training, for reasons other than practical circumstances, possibly indicating a poor motivation to change. A previous study by Tallet *et al*. (2018) showed that the potential positive effects of a training programme such as ProHand pig® are highly dependent on motivation and may be limited to those participants already sensitive to the human-pig relationship.

Three observers and a video camera were clearly visible to the TDs during data collection. Although the TDs had been introduced to the observers prior to loading, were well-informed about the aims of the project and were told to use their normal working strategies, being observed likely influenced their behaviour to some extent. However, according to Lindström (2000), subjects tend to pay attention to observers and video cameras only for a short period of time, which would have decreased the risk of poor data reliability. Becoming accustomed to the situation, combined with the intense nature of the work during loading, suggests that the effect of being observed on TDs' behaviour was limited.

It was only possible to observe two TDs on the same farm before and after training, and several farms were included in study 2 that had not been included in study 1. The between-farm variations in loading area designs and possibly also a varying degree of fear of humans in pigs on different farms might have influenced the behaviour of both TDs and pigs. However, the between-farm variation in loading area designs was present both before and after training, and farms were not included on any other criteria after training than before.

Insight into pigs' health status is important when evaluating pig welfare. Very few clear signs of *e.g.* lameness or poor general condition in pigs were visible in the videos (and therefore not included in the analyses), but the video material did not allow for detection of *e.g.* tail lesions. Moreover, inclusion of physiological parameters, such as heart rate in pigs and TDs, might have enhanced understanding of physiological responses to their physical efforts and interactions during loading. Goumon *et al*. (2013) found that an initial step before the ramp during unloading of pigs increased the

heart rate of both the TD and the pigs. However, performing a complete pig health assessment and including physiological measurements would have required a controlled study set-up, or one or two extra technical assistants during field work, amongst other things. It is also likely that the practically applicable information gained from observing TDs and pigs under normal work practices would have been lost in a controlled study set-up.

7. Main conclusions

Overall conclusions based on the findings presented in this thesis are:

- Pig transport drivers' physical workload varies between tasks and drivers, there is a risk of high load on the shoulders during loading, unloading and cleaning of vehicles, and on the back and knees during loading and unloading.
- Pig transport drivers in Sweden report high work satisfaction, but perceive that their psychosocial working conditions is negatively affected by complex regulations, time pressure and lack of communication with farmers and official veterinarians.
- Pig transport drivers' behaviour of a negative nature is associated with behaviours indicative of stress in pigs.
- Pig transport drivers' behaviour of a positive nature is associated with relaxed/explorative behaviours in pigs.
- No significant effects of training of pig transport drivers were found on their physical workload or active loading time per pig.
- Training of pig transport drivers improves their handling techniques in terms of decreased negative and increased positive behaviours.
- Training of pig transport drivers tend to decrease their belief that it is important to move pigs rapidly.

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Popular science summary

Approximately 1.5 billion pigs are slaughtered for human consumption globally each year. In Sweden, 2.6 million pigs are reared yearly on around 900 farms and transported to slaughterhouses by approximately 100 professional pig transport drivers. In the past 30 years, the number of pig farms has decreased drastically, while the number of pigs per farm has increased. At the same time, the slaughter industry has been consolidated, with an increased capacity in fewer locations. This consolidation has resulted in more pigs being loaded per transport and longer distances between farm and slaughterhouse. Specially designed trailers with 3-4 hydraulic decks, and a total capacity of 200-300 pigs are now commonly used. Loading onto the trailer is one of the most stressful events in the life of finishing pigs, and adequate handling is key to ensure good pig welfare.

Increased stress levels in pigs before slaughter indicates poor pig welfare and can also decrease meat quality. Swedish animal welfare regulations include a ban on hitting or kicking animals and driving tools are allowed only for directing animals. Transportation of pigs is potentially physically demanding and hazardous work for the truck drivers, who are key workers in the production chain. The working conditions and handling behaviour of transport drivers during pig loading have not been well-studied to date, and were therefore investigated in this thesis.

Many factors affect how pigs cope with the new environments and human interactions they experience during loading, for example farm management practices and the quality of animal handling by the transport driver. It is known that there are direct relationships between stockpersons' attitudes and behaviour and animals' behaviour and welfare. Some previous training interventions aiming to improve the attitudes and behaviour of stockpeople on pig farms have shown success in terms of improving the welfare and

productivity of animals. The effect of such training on pig transport drivers, who only briefly interact with a large number of pigs, was investigated in this thesis.

The overall aim of this thesis was to characterise Swedish pig transport drivers' working conditions, including their physical and psychosocial health, and the effect of their handling behaviour on pigs' behaviour during slaughter transport loading. A second aim was to evaluate the effect of a training intervention on transport drivers' attitudes, handling methods, physical workload and time efficiency during loading of pigs for slaughter transport.

The results showed that the physical workload varies greatly between tasks and between individual drivers. The drivers reported that a poor design of the on-farm loading area, such as lack of space and lack of protection from wind and sunlight, increase the difficulties in loading pigs and lead to knee discomfort. The drivers reported high job satisfaction, but time pressure, conflicts of interest, and difficulties in following a complex set of official regulations complicate their work. Moreover, working with elevated arms during loading, unloading and cleaning the trailer possibly contributes to shoulder discomfort in the drivers.

Prior to training, drivers' behaviours of a negative nature, such as forceful use of the board, and drivers' behaviours of a positive nature, such as lightly placing a hand on a pig, were approximately equally common. However there were large differences between drivers and loading occasions, which was probably partly due to variations in on-farm loading area design. The most commonly observed pig behaviours were walking, stress-related behaviours such as high-pitched vocalisations, and relaxed/exploratory behaviours. Driver behaviours of a negative nature were associated with more stress-related pig behaviours, while driver behaviours of a positive nature were associated with more relaxed pig behaviours.

The training intervention included information on how to work in an ergonomically correct way and on the importance of appropriate handling and attitudes to the pigs. There was a tendency of improved attitudes to pig handling in drivers after the training intervention, and their behaviours of a negative nature decreased while positive behaviours increased. These results indicate that providing training for transport drivers improve their handling behaviours and has the potential to improve pig welfare during loading. No

effects of training were seen on the drivers' physical workload or time efficiency during loading.

In conclusion, the results in this thesis indicate that Swedish pig transport drivers have a relatively high physical workload, that they work under time-pressure, that their handling behaviour during loading of pigs can vary, and that behaviours of a more negative nature are associated with stress in pigs, while more positive behaviours are associated with relaxed pig behaviour. Providing training results in less negative and more positive driver behaviours.

Populärvetenskaplig sammanfattning

Globalt slaktas ungefär 1,5 miljarder grisar för humankonsumtion varje år. I Sverige föds det årligen upp 2,6 miljoner grisar på cirka 900 gårdar som transporteras till slakterier av cirka 100 yrkesförare. De senaste 30 åren har antalet gårdar som föder upp slaktgrisar minskat drastiskt, medan antalet grisar på varje gård har ökat. Samtidigt har slakterierna konsoliderats, med ökad kapacitet på färre orter. Denna konsolidering har resulterat i fler grisar på varje slakttransport, och längre avstånd mellan gård och slakteri. Idag används vanligtvis specialdesignade lastbilar med 3-4 hydrauliskt höj- och sänkbara våningsplan och en total kapacitet på 200-300 grisar. Pålastningen är en av de mest stressfyllda händelserna i grisarnas liv, och god hantering är en viktig faktor för att säkerställa deras välfärd.

Ökade stressnivåer hos grisar före slakt indikerar dålig djurvälfärd och kan leda till försämrad köttkvalitet. Enligt svensk djurskyddslagstiftning är det förbjudet att slå eller sparka på djur, och drivredskap är endast tillåtna för att vägleda djuren. Transport av grisar är ett potentiellt fysiskt ansträngande och riskfyllt arbete för förarna, som är nyckelpersoner i produktionskedjan. Förarnas arbetsförhållanden och hanteringsmetoder vid pålastning av grisar har inte tidigare studerats vetenskapligt, och undersöktes därför i den här avhandlingen.

Många faktorer påverkar hur väl grisarna klarar av att hantera nya miljöer och mänskliga interaktioner under pålastning, till exempel förhållandena på gården och kvaliteten på förarens hantering. Det finns direkta samband mellan attityder och beteenden hos människor som arbetar med djur och djurens beteende och välfärd. Tidigare har utbildningsinsatser som syftar till att förbättra lantbrukares attityder och beteenden visats vara framgångsrika och har resulterat i både förbättrad djurvälfärd och produktivitet. Effekten av

en liknande utbildning av gristransportörer, som endast kort interagerar med ett stort antal grisar, undersöktes i den här avhandlingen.

Det övergripande syftet med avhandlingen var att undersöka svenska gristransportörers arbetsförhållanden, inklusive deras fysiska belastning och psykosociala hälsa, och effekten av deras hanteringsmetoder på grisarnas beteende vid pålastning. Ett andra syfte var att utvärdera effekten av en utbildningsinsats på förarnas attityder, hanteringsmetoder, fysiska arbetsbelastning och tidseffektivitet vid pålastning av grisar i samband med slakttransport.

Resultaten tyder på att den fysiska arbetsbelastningen varierar mycket både mellan olika arbetsuppgifter och mellan förare. Förarna rapporterade att en dålig utformning av gårdens utlastningsområde, som till exempel brist på utrymme och skydd mot vind och solljus, försvårade lastningen och ledde till knäbesvär. Förarna uppgav att de hade en god arbetstillfredsställelse, men tidspress, intressekonflikter och svårigheter att efterleva komplexa regelverk riskerade att försvåra deras arbete. Dessutom bidrar sannolikt arbete med upplyfta armar under lastning, lossning och rengöring av lastbilen till axelbesvär hos förarna.

Före utbildningen förekom förarbeteenden av negativ karaktär, såsom hårdhänt användning av drivskivan, och av positiv karaktär, såsom att lägga en lätt hand på en gris, i ungefär lika stor utsträckning. Däremot fanns det stora variationer i förekomst av olika beteenden mellan förare och lastningstillfällen. De vanligast förekommande grisbeteendet var att gå, följt av stressrelaterade beteenden såsom höga skrik, och därefter avslappnat/undersökande beteende. Förarbeteenden av negativ karaktär var associerade med stressrelaterade grisbeteenden, och förarbeteenden av positiv karaktär var associerade med avslappnat beteende hos grisarna.

Utbildningen inkluderade information om hur man arbetar ergonomiskt korrekt och vikten av goda hanteringsmetoder och attityder gentemot grisar. En tendens till förbättrade attityder angående hantering av grisar kunde ses hos förarna efter utbildningsinterventionen, och deras beteenden av negativ karaktär minskade medan positiva beteenden ökade. Dessa resultat indikerar att utbildning av förarna förbättrar deras hanteringsmetoder och potentiellt bidrar till förbättrad grisvälfärd under pålastning. Inga effekter på förarnas fysiska arbetsbelastning eller tidseffektivitet vid pålastning kunde ses efter utbildningen.

Sammanfattningsvis tyder resultaten på att svenska djurtransportörer som kör grisar till slakt har en relativt hög fysisk belastning och arbetar under tidspress, deras hanteringsmetoder vid pålastning varierar, och det finns samband mellan negativa hanteringsmetoder och stress hos grisarna, och mellan positiva hanteringsmetoder och avslappnat/undersökande grisbeteende. Utbildning av gristransportörer resulterar i minskade negativa och ökade positiva beteenden.

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Physical workload and psychosocial working conditions in Swedish pig transport drivers

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ABSTRACT

Working conditions of 20 Swedish pig transport drivers (PTD) were assessed by a questionnaire, a workshop, and recorded postures and movements during on-farm loading, driving, unloading at abattoir and vehicle cleaning. High arm positions and high frequencies of shoulder problems indicated an excessive physical load on shoulders. Extreme crouching postures inside vehicles and high frequencies of lower back problems indicated high load on the back of PTDs. Inadequate design of on-farm loading areas was associated with knee discomfort. Observed variation in workload between PTDs could be explained by differences in physical working environment and pig handling practices. PTDs reported high job satisfaction and commitment although conflicts with farmers and official veterinarians, as well as regulatory conflicts were emphasized. We conclude that issues of inadequate farm and abattoir facilities, stakeholder conflicts and insufficient training in animal handling need to be addressed to ensure sustainable PTD working conditions.

1. Introduction

Since the beginning of the 20th century, pig production continues to undergo massive intensification and specialisation in most industrialised countries, leading to larger and fewer farms and abattoirs with increased distances between them (Sørensen et al., 2006). In Sweden today, approximately 2.5 million finishing pigs are transported to slaughter annually by some 100 pig transport drivers (PTD) (pers. comm., A. Falk., Swedish Association of Road Transport Companies, June 18, 2020), from about 900 farms to 20 abattoirs of which a few slaughter the majority of all pigs (Statistics Sweden, 2020; Swedish Board of Agriculture, 2020).

PTDs play a key role in the pork production chain and in many countries including Sweden they are legally responsible for the welfare of the animals during loading, driving and unloading (EU Regulation No. 1/2005). Abattoirs contract commercial animal hauliers, either sole proprietors or with up to dozens of employed PTDs, to collect and transport pigs from farmers. Such a subcontractor situation, combined with rivalry between hauliers, is associated with insufficient safety management (Valluru et al., 2017) and violations of best work practices. Transport routes are planned by either the haulier manager or the abattoir, depending on contract details, and are determined by the trade relationship between abattoir and farmer, not necessarily related to transport distance.

Transportation employees are frequently reported in work-related accidents, including fatalities (Wiatrowski and Janocha, 2014; Chandler et al., 2017), with the majority of injuries occurring outside the truck while handling goods (Chandler et al., 2017). A high centre of gravity and unsecured loads in moving vehicles are generally known to decrease vehicle stability. Modern transport vehicles used by Swedish PTDs have 2–4 loading levels with hydraulic hoist systems and the combined capacity of a truck-trailer is 200–300 pigs. In farming, including pig production, handling of animals is the major cause of physical injury in handlers (Langley and Morrow, 2010). Handling of large animals, for example finishing pigs which weigh approximately 120 kg at slaughter transport, increase the risk of accidents. Moreover, varying and sometimes frequent use of handling tools has been observed in PTDs during unloading of pigs (Bornhede, 2014) indicating a potentially high physical workload. Although little is known about other tasks, loading of pigs at the farms may be even more demanding due to

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occasional suboptimal conditions. A broad assessment of PTDs physical workload is therefore needed to reveal potential risks of work-related musculoskeletal disorders.

Monotonous repetitive work, awkward postures, heavy lifting and lack of recovery are aspects important within the construct of physical workload (da Costa and Vieira, 2010). Long-term exposure to high physical load can cause musculoskeletal disorders such as rotator cuff syndrome in shoulders and back pain illness (Dalbøge et al., 2014; Rwamamara et al., 2010). Because physical exposure is difficult to assess through observations or self-reports, technical recordings are necessary to evaluate ergonomic risks (Balogh et al., 2019). Methods for assessing both task and job exposure, applicable for intervention studies, have previously been evaluated (Hansson et al., 2010). Triaxial accelerometers have been found suitable for objective assessment of angular velocities and positions (flexion/extension) of the head, neck, back and upper arms during work (Hansson et al., 2001), and are used to establish exposure-response relationships for work-related disorders. For example in the meat-cutting industry, a high physical workload indicated by rapid movement in the upper arms and wrists and high prevalence of hand and elbow disorders (carpal tunnel syndrome), have been found (Arvidsson et al., 2012). Relationships between head, arm and wrist velocities and reported disorders such as tension neck syndrome and carpal tunnel syndrome have been described (Balogh et al., 2019) and threshold limit values of postures and velocities for head, upper arm and wrists have recently been suggested (Arvidsson et al., 2021 in press).

PTDs usually work alone, sometimes during night-hours, circumstances that reduce recovery possibilities and are regarded as psychosocial risk factors (Costa, 1996; European Agency for Safety and Health at Work, 2011). Generally, psychosocial risk factors also involve high work demands, low perceived control and role conflicts. PTDs work is governed by legislations covering a range of topics from occupational safety and animal welfare to traffic rules. For example, legislations cover responsibilities such as safeguarding pig welfare, limiting transportation to 8 h (including loading and unloading) and limiting driving to 4.5 h before taking a break. Violations often involve fees to the haulier company. Along with the agreed delivery time to abattoirs, this potentially results in safety policy and practice (deliver on time) conflicts (Murphy et al., 2018).

Ensuring the wellbeing of professionals in the animal production sector is important in itself and, moreover, in the holistic 'one welfare' perspective due to links between human wellbeing and animal welfare (Pinillos, 2016). The main focus of previous research related to animal transportation have been on effects of animal stress on meat quality (Goumon and Faucitano, 2017; Gesing, 2010; Fitzgerald et al., 2009; Werner et al., 2007), and loading and unloading have been described as highly stressful situations for pigs with risk of decreased welfare (McGlone et al., 2014; Bench et al., 2008). If PTDs working environment is poor, it will likely adversely affect the welfare of the pigs (Anneberg and Sandoe, 2019). To date, PTDs physical and psychosocial working environment have received little scientific attention, possibly due to demanding conditions for data collection.

This study was part of a large multidisciplinary project, aiming to find solutions for improved human wellbeing and animal welfare during slaughter transport of finishing pigs. The objective was to study Swedish PTDs' working environment, and more specifically to a) estimate their physical workload, b) describe their psychosocial working environment and c) identify factors that may influence the physical and psychosocial working environment.

2. Material and methods

2.1. Ethical approval

This study was approved by the Regional Ethical Review Board of Gothenburg (ref. 070–18) for human subjects, and by the Animal Ethics Committee of Gothenburg (Dnr 5.8.18–12650/2018) for animal research. Participation was voluntary and haulier managers, PTDs, farmers and abattoirs gave their informed consent before data collection.

2.2. Study design and subjects

A mixed-method exploratory approach, involving quantitative and qualitative methods, was adopted. To support the choice of methods, a meeting was arranged in February 2018 where two retired PTDs, two abattoir managers and two farmers commented on the questionnaire content and shared their knowledge about PTDs work.

Haulier companies were randomly selected by asking Swedish large-scale abattoirs to participate and to provide contact details of contracted hauliers. Haulier managers suggested PTDs among their staff, who were then asked to participate. Permission from farmers to collect data during loading was obtained before each visit. Four abattoirs and four hauliers participated. One abattoir, one haulier and several farmers declined participation. A total of 18 participants (2 females and 16 males, aged 20–54 years) from four hauliers operating in the south, southwest and middle-north of Sweden were included in technical recordings of physical workload and answered a questionnaire. Additionally four PTDs not included in physical recordings answered the questionnaire after distribution from haulier managers. Participants had at least 6 months experience of pig transportation. Altogether, the 22 participants constituted approximately 15–20% of the PTDs operating in Sweden today.

PTDs participating in physical workload recordings estimated the average time per week for loading and unloading pigs between 2 and 20 h (median 10 h), and the average time for driving pigs between 5 and more than 30 h (median 27 h). Transport vehicles usually had three levels. (Table 1).

Table 1
Descriptive background information from a questionnaire for Swedish pig transport drivers (n = 22), 2018–2019.

Variable	TDs included in workload measurements		TDs included in survey only	
	n	Value	*n*	Value
Age (years)	18	31[a] (20–54)[b]	4	30[a] (27–32)[b]
Males/females	18	16/2[c]	4	4/0[c]
Total number of pig transport drivers employed by haulier	16	10[a] (3–18)[b]	4	11[a] (3–14)[b]
Experience of working with pigs before present employment, yes/no	16	9/7[c]	4	0/4[c]
Time working with pig transport (years)	16	4[d] (0.5->10)[b]	4	5[d] (2->10)[b]
Number of abattoirs receiving transports (1/2/3/>3)	16	7/5/2/2[c]	4	3/1/0/0[c]
Number of decks on vehicle (1/2/3/4)	16	0/3/11/2[c]	3	0/0/3/0[c]
Number of pigs usually unloaded at abattoir (<100/100–200/>200)	15	1/8/6[c]	4	0/0/4[c]
Average time per week loading or unloading pigs (hours)	14	10[d] (2–20)[b]	4	15[d] (10–15)[b]
Average time per week driving pig transport vehicle (hours)	14	27[d] (5->30)[b]	4	25[d] (20->30)[b]

[a] Mean.
[b] Range.
[c] Number of respondents.
[d] Median.

2.3. Work tasks

Standard pig transportation routines involved driving to farm-site, one to three loadings of pigs at one or several farm-sites, driving to abattoirs, unloading pigs and cleaning vehicles. Before, between, during and after these tasks, PTDs also had to for example position vehicles, arrange gates inside vehicle, change clothes and wait. Five work tasks were distinguished:

Loading: started when the first pig entered the loading area and finished when the ramp was hoisted after the last pig was loaded. Handling tools, a sorting board and/or a rattle paddle, were used to herd pigs. Variations in loading area design influenced the physical work space and ramp slope, and farm management influenced the number of pigs to be handled at a time. Loading included walking, waiting, using tools, pushing and crouching (in the bottom level of the vehicle at the end of loading).

Driving: started when the vehicle started moving, either before or after the completion of the first loading and stopped when the vehicle stopped, either at the farm-site or at the abattoir. Working postures were not observed while driving.

Unloading: started when the first pig was unloaded and finished when the last pig exited the vehicle. Handling tools, a rattle paddle and/or a sorting board, were used to herd pigs. Unloading conditions were more consistent than at loading, with little or no ramp slope and consistent flow of pigs. Unloading included walking, using tools, pushing and crouching (in the bottom level of the vehicle at the beginning of unloading).

Cleaning: started with removal of manure in vehicles and finished when PTDs changed into clean work-wear. Cleaning included shoveling or washing out manure, applying detergents and washing with high water-flow hose while walking, crouching and standing stationary.

Preparing/other: occurred before, between and after the tasks described above. Preparing included waiting time, change of clothes, and preparing vehicles and surroundings for loading, unloading or cleaning.

2.4. Data collection

Physical workload recordings and questionnaire responses were collected from October 2018 to January 2019. A workshop was conducted in June 2019, approximately 6 months after the last technical recording. Data collection was performed cognizant of avoiding prolonging or disturbing PTDs work.

2.4.1. Physical workload

PTDs (n = 18) included in the technical recordings were, except while driving to the abattoir, observed during one 'loading at farm to cleaning vehicle after unloading at abattoir'- sequence (described as 'whole day').

Postures and velocities of head, upper back and upper arms were recorded with two types of triaxial accelerometers. For the first 7 PTDs, accelerometers (Logger Teknologi HB, Åkarp, Sweden) connected to a separate data logger (Logger Teknologi HB, Åkarp, Sweden) with a sampling frequency of 20 Hz, were used (described by Hansson et al., 2001; Hansson et al., 2003). For the remaining 11 PTDs, accelerometers with an integrated data logger (USB Accelerometer Model X16-mini, Gulf Coast Data Concepts, LLC, Waveland, MS, USA) with a sampling frequency of 25 Hz, were used (Dahlqvist et al., 2016). Reference postures for head, back and arms were set as described by Dahlqvist et al. (2016).

Biaxial flexible electro-goniometers (Model SG75; Biometrics Ltd., Cwmfelinfach, Gwent, UK) connected to a Mobi-8 logger (TMS International, Oldenzaal, The Netherlands) with a sampling frequency of 128 Hz were used to record postures and velocities of both wrists (Simonsen et al., 2018). Reference postures were set as described by Simonsen et al. (2018).

Workload was thus expressed as eight different measures, varying continuously over time: head angle forward-backward (flexion), back angle forward-backward, upper arm elevation angle (in any direction) on both sides and wrist angle forward-backward on both sides.

2.4.2. Questionnaire

After these observations, PTDs received a questionnaire containing 82 questions; 23 questions covered the topics of work experience and operating procedures and 59 covered the topics of working environment and psychosocial and physical health disorders. Questions about operating procedures included vehicle design and time spent on different tasks. Working environment questions involved work demands, work control, role expectations and musculoskeletal complaints, corresponding to the QPS Nordic Questionnaire (Q 1–33; 48–59) (Kuorinka et al., 1987). Questions on perceived skills, work commitment, work satisfaction and mental symptoms were based on the Copenhagen Psychosocial Questionnaire (COPSOQ; Q 34–47) (Kristensen et al., 2005). Likert scales with five levels were used in all working environment questions except for mental symptoms which had six levels. Scales varied from "very rarely or never", "do not agree at all", "very bad", "no part of the time" and "no, never" to the opposite. In total 20 PTDs

Table 2
Group means (standard deviation) of the physical workload of head, back and upper arms in 17 Swedish pig transport drivers during work (a loading at farm to cleaning vehicle at abattoir-sequence), 2018–2019.

	Distribution (percentile)	Whole day	Loading	Driving	Un-loading	Cleaning	Preparing/other
Duration minutes [min/max]	Na	369 [177/566]	56 [18/120]	147 [41/244]	22 [10/38]	82 [33/166]	62 [37/111]
Head flexion							
Posture (°)*	50th	7 (6.3)	23 (8.2)	−2 (4.9)	22 (6.4)	26 (7.6)	17 (8.6)
	90th	43 (9.4)	44 (9.1)	9 (6.2)	47 (9.5)	50 (9.8)	51 (8.8)
Velocity (°/s)	50th	15 (2.7)	21 (8.9)	11 (2.3)	25 (4.1)	22 (7.4)	19 (4.9)
Back, forward							
Posture (°)*	50th	7 (5.2)	14 (7.7)	−2 (8.2)	14 (5.8)	15 (5.5)	10 (6.5)
	90th	30 (8.8)	35 (11.7)	11 (6.3)	52 (15.5)	37 (9.8)	35 (8.9)
Velocity (°/s)	50th	12 (2.4)	17 (9.6)	8 (1.9)	22 (4.5)	20 (6.8)	15 (3.8)
Upper arm, right							
Elevation (°)	50th	41 (4.4)	31 (4.8)	47 (7.7)	32 (5.4)	35 (4.1)	35 (4.6)
	90th	66 (6.7)	57 (9.9)	65 (9.5)	60 (10.4)	73 (13.4)	71 (9.1)
Velocity (°/s)	50th	30 (8.6)	49 (26.8)	16 (3.7)	63 (11.4)	67 (23.8)	44 (11.4)
Upper arm, left							
Elevation (°)	50th	44 (7.8)	30 (6.5)	60 (9.9)	32 (5.8)	32 (5.9)	35 (7.2)
	90th	74 (10.7)	56 (7.6)	76 (12.3)	61 (7.7)	66 (9.8)	68 (8.4)
Velocity (°/s)	50th	28 (8.8)	50 (24.5)	16 (2.8)	56 (13.8)	56 (22.5)	42 (11.2)

NA= Not applicable
Positive values indicate flexion (forward), negative values indicate extension (backwards).

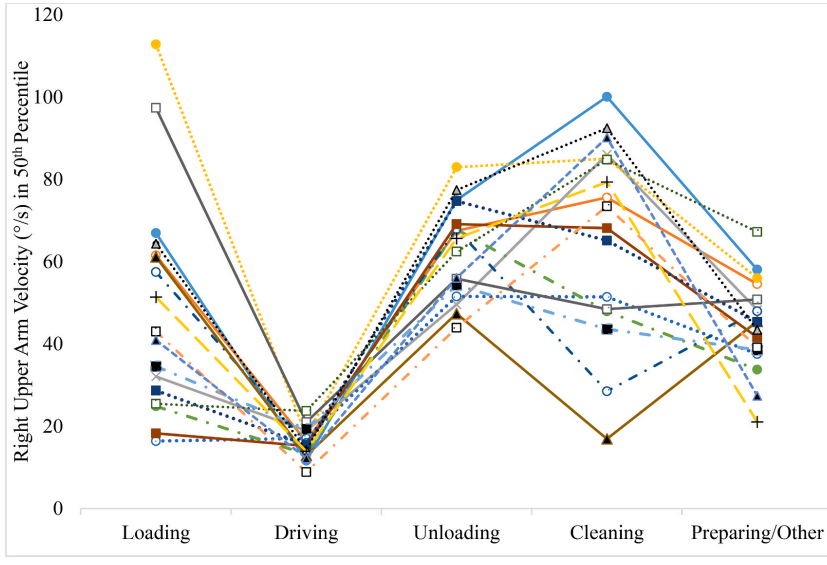

Fig. 1. Generalized angular velocity for right upper arm (°/s, 50th percentile) in 17 transport drivers during different work tasks, 2018–2019.

Table 3
Group means (standard deviation) of the physical workload of wrists in 15 Swedish pig transport drivers during work (a loading at farm to cleaning vehicle at abattoir-sequence), 2018–2019.

	Distribution (percentile)	Whole day (n = 15)	Loading (n = 15)	Driving (n = 13)	Un-loading (n = 13)	Cleaning (n = 12)	Preparing/other (n = 15)
Wrist flexion, right							
Posture (°)[a]	50th	−17 (10.3)	−14 (9.9)	−18 (16.1)	−16 (7.6)	−22 (10.5)	−11 (9.3)
Movements							
Velocity (°/s)	50th	11 (5.5)	12 (7.5)	5 (2.2)	18 (4.2)	20 (5.2)	17 (4.1)
Rest <1°/s (% of time)	Na	4 (2.9)	8 (6.6)	5 (5.1)	2 (2.1)	1 (0.9)	3 (3.0)
Wrist flexion, left							
Posture (°)[a]	50th	−17 (10.9)	−17 (10.4)	−20 (18.0)	−16 (12.7)	−17 (8.2)	−12 (10.0)
Movements							
Velocity (°/s)	50th	8 (2.7)	9 (5.4)	6 (2.2)	13 (4.6)	12 (5.6)	13 (3.5)
Rest <1°/s (% of time)	Na	4 (2.1)	8 (5.1)	2 (1.6)	2 (2.1)	3 (4.8)	5 (2.3)

Na= Not applicable.
[a] Positive values indicate palmar flexion, negative values indicate dorsal flexion.

responded with 16 of these participating in the technical recordings.

2.4.3. Facilitated workshop

The 18 PTDs observed and their haulier managers were invited to a workshop to discuss working environment and physical workload of PTDs. Out of 22 invited, 12 participated (11 PTDs whereof 1 manager). One researcher (SW) facilitated the workshop. Questionnaire and workload results were presented first. The participants were then divided into three mixed groups based on affiliation and work experience, and asked to discuss flaws, challenges and difficulties in their work, reflect on causes and suggest corrective action. A plenary discussion followed. Notes were taken continuously during the discussions and participants were given the opportunity to add information anonymously in writing.

2.5. Statistical analysis

2.5.1. Technical recordings

The data from the recordings were processed according to Hansson et al. (2003) and Dahlqvist et al. (2016). The data from one PTD were excluded due to technical problems. The ten workload measures were summarized by work task and for the whole day by calculating the 10th, 50th and 90th percentiles of the angular distribution for head and back inclination and upper arm elevation, the 50th percentile of the angular velocity distribution of the head, back and wrists, the generalized angular velocity distribution for upper arms, and the percentage of time with wrist flexion angular velocity <1°/s for each PTD.

2.5.2. Questionnaire

Descriptive statistics were obtained for background information and musculoskeletal complaints. For data on working environment and musculoskeletal complaints, indices were constructed for each scale

Table 4
Statistics of six different dimensions describing perceived psychosocial working environment according to a questionnaire to 20 Swedish pig transport drivers, 2018–2019.

Dimension	Description of scale (number of questions)	Mean ± sd
Work demands[a]	Quantitative demands (4)	0.43 ± 0.18
	Decision demands (3)	0.70 ± 0.14
	Learning demands (2)	0.38 ± 0.16
	Safety & economic risks (2)	0.60 ± 0.33
Role expectations[a]	Role conflicts (3)	0.25 ± 0.21
	Pressure from farmer/veterinarian (2)	0.48 ± 0.29
Work control[b]	Positive challenges (3)	0.82 ± 0.11
	Control of decision (2)	0.58 ± 0.18
	Control of pacing (2)	0.61 ± 0.23
Mastery of work[b]	Perception of mastery (3)	0.85 ± 0.11
	Perception of physical and psychosocial ability[c] (2)	0.83 ± 0.10
Work commitment and satisfaction[b]	(4)	0.60 ± 0.19
Psychosocial workload[a]	Psychosocial symptoms[d] (8)	0.17 ± 0.09

[a] High score indicates high demands, risks, role conflicts and psychosocial workload.
[b] High score indicates high perceived control, mastery and engagement.
[c] One missing value (19 responses).
[d] Psychosocial symptoms in the last 4 weeks.

within dimensions. The original five-, and six-level ordinal scores were rescaled to a range of 0–1. Indices were calculated on individual levels as means of the corresponding scores for the questions included in the scale. The group-level means from each scale are presented with standard deviations (SD). Seven questions were excluded from the analysis because they did not contribute with useful information.

2.5.3. Workshop

Workshop notes were compiled and key concepts identified by sorting into 1. Main area, 2. Main issue, 3. Psychosocial cause and effects, 4. Physical cause and effects and 5. Suggested corrective actions.

3. Results

3.1. Physical workload

For practical reasons, some of the PTDs repeated pig loading at one or several farms. In total, 27 loadings and 18 unloadings were observed, whereof ten PTDs loaded one time, seven loaded two times and one loaded three times. The number of pigs per loading varied from 49 to 258 (mean 120) and in total 3229 pigs were transported. Whole day recordings varied in length from 177 to 566 min (mean ± SD, 369 ± 119 min), starting between 4:00 and 13:00 h. The mean (min-max) time for loading, driving, unloading, cleaning and preparing was 56 (18–120), 147 (41–244), 22 (10–38), 82 (33–166) and 62 (37–111) minutes respectively. For moving pigs, PTDs used sorting boards and/or rattle paddles of a Swedish design (LG Produkter AB, Sölvesborg, Sweden). At loading, 13 PTDs used both a paddle and a board and five used the board alone. At unloading, 12 used only a paddle, three used only a driving board and three used both. One PTD used ear protection and all wore steel-capped boots during loading and unloading, but no other use of protective equipment was observed.

Results for inclinometry recordings are presented in Table 2. Due to technical difficulties, data from one PTD were lost. The group means (means of PTDs median values) for whole day measurements of head and back forward flexion (50th percentile) were both 7°, and velocities were 15°/s and 12°/s respectively. Group means of whole day measurements in right upper arm elevation was 41° and the velocity 30°/s (50th percentile), in the 90th percentile right upper arm elevation was 66°. At *loading*, *unloading* and *cleaning* the highest arm velocities (49, 63 and 67°/s), head velocity (21, 25 and 22°/s) and flexion (23, 22 and 26°), and back velocity (17, 22 and 20°/s) and flexion (14, 14 and 15°) (50th percentile) were recorded. *Preparing/other* involved less active movement and values for velocities and postures were lowest during *driving*, except for arm elevation. Arm elevation exceeded 30° in all tasks (50th percentile). Back flexion was 52° in the 90th percentile during *unloading*. High between PTD variations were recorded in median arm velocities during *loading* (16–112°/s) and *cleaning* (17–100°/s) (Fig. 1).

Results for goniometry recordings of wrists are presented in Table 3. Due to technical difficulties, data were lost for the whole day in three PTDs and partly lost for another three PTDs. The group means for whole day recordings of right wrist posture and velocity (50th percentile) were 17° (dorsal flexion) and 11°/s. Velocities were highest during *cleaning* (20°/s) and lowest during *driving* (5°/s).

3.2. Questionnaire

Participants reported high personal engagement, high work quality satisfaction and good ability to cope with psychosocial and physical demands (Table 4). However, high work demands (decision demands and safety and economic risks), and to some extent pressure from stakeholders and lack of control of decision were also reported. A few psychosocial symptoms were reported (Table 4). High prevalence of discomfort or pain in lower back was reported by most PTDs, in neck/shoulders by approximately one third of the PTDs, and in knees by half of them, in the last 12 months as well as the last 7 days (Table 5).

3.3. Facilitated workshop

Several issues were perceived by the PTDs to negatively impact their working environment. Psychosocial and physical workload issues related mainly to conditions on farm, at abattoirs, and to regulations and abattoir requirements or conditions for delivery. The PTDs stated that they generally did not report work-related injuries, so as to not to complicate the work of their superior. Nevertheless, the PTDs expressed belief in their own ability to handle physical and psychosocial demands. They were committed to the job and perceived it as highly meaningful. One PTD summarized his view by "You are satisfied because you enjoy the job. Otherwise, you would no longer be here. Then you would be on sick leave".

Seven main issues were identified (Table 6). Lower back, neck/shoulder and knee complaints were at times reported due to unsatisfactory design of loading/unloading and cleaning areas at farms and

Table 5
Perceived work-related physical complaints (pain or discomfort) during the preceding 12 months or 7 days according to a questionnaire to 20 Swedish pig transport drivers, 2018–2019; number (%) of respondents.

Complaint	Last 12 months					Last 7 days, at any rate
	Very seldom or never	Rather seldom	Occasionally	Rather often	Very often or always	
Lower back	3 (15)	6 (30)	9 (45)	2 (10)	0 (0)	12 (60)
Neck or shoulders	3 (15)	11 (55)	3 (15)	1 (5)	2 (10)	6 (30)
Elbows or hands	11 (55)	3 (15)	6 (30)	0 (0)	0 (0)	3 (15)
Knees	5 (25)	5 (25)	4 (20)	4 (20)	2 (10)	10 (50)

Table 6
Issues related to working environment and workload on farm, at abattoir, in vehicle and structurally, identified in a facilitated workshop with 12 Swedish pig transport drivers, 2019.

Area	Main issue	Discussed psychosocial cause – effect	Discussed physical cause – effect
Farm	Design of loading area	Insufficient space or lack of separate indoor loading space; lack of weather protection and lighting – difficulty to inspect pigs and sort away pigs not fit for transport; flexible operational procedures required; high workload	Insufficient space or lack of a separate indoor loading space; lack of weather protection and lighting – physically demanding to load pigs; high pressure on knees
	Communication with farmers	Unrealistic expectations from farmers; insufficient preparations; lack of communication from farm staff, especially regarding injured or diseased pigs – pressure to transport pigs not fit for transport; fear of conflict with farmer; insufficient time to count and assess pigs; need to sort pigs during loading, resulting in impaired work flow and efficiency	Pigs are fed shortly before loading – pigs less willing to move; increased overall workload
Abattoir	Communication with official veterinarians	Inconsistent veterinary judgements; lack of clarity from abattoir veterinarians regarding unfit pigs – unclear criteria for fitness of pigs; feeling of being monitored and sometimes filmed; fear of getting reported	–
	Equipment for cleaning vehicles	Varying availability of appropriate cleaning facilities – need to remove manure manually instead of flushing with water hose, resulting in high overall workload; queue to cleaning area, resulting in long waiting time before cleaning can start and limited time for cleaning	
Vehicle	Vehicle design	–	decrease working height on bottom floors of three- to four-tier vehicles – necessary to crouch inside vehicle, especially during unloading, resulting in increased load on back
Structural	Time constraints	Complex regulations; penalties at late arrival to abattoir and at violation of rules on driving and rest times – necessary to sometimes clean vehicle during breaks; rush during loading of pigs	–
	Lack of competence	High demands on expertise and job commitment; high workload; not possible to get less demanding work in the same employment – hard to find skilled drivers with an eye for animals; estimated high number of non-reported work-related injuries and sick-leave	

abattoirs. PTDs believed inappropriate design of the loading area at farms had a strong impact on workload in general and knee discomfort in particular, due to the knees being pressed against the driving board when pigs were pushed forward. A poor loading area design was described as insufficient light, insufficient space and lack of protection from wind and direct sunlight, making it difficult to load pigs and to detect health issues that would deem pigs unfit for transport.

One PTD described how farmers occasionally tried to hide diseased pigs in the middle of an animal group, and before the current disease control regulations that prohibit farmers returning pigs to their housing facilities, it was easier to reject loading pigs unfit for transport. PTDs also emphasized the need to adapt to farmer routines at loading, and a lack of communication from farm workers, for instance regarding the number of pigs brought out of the building at one time. There was also a concern about inconsistent assessment of fitness of pigs between official veterinarians at abattoirs, and lack of feed-back from veterinarians to PTDs on those pigs consider to be unfit, increasing PTDs' fear of being secretly monitored and reported to animal-welfare authorities. One PTD described how some competing hauliers regularly transported pigs unfit for transport in order to gain good reputation among farmers. Difficulties to comply with all legislation governing time limitations, especially provisions on driving times and driving breaks for drivers *versus* transport times for animals, were emphasized. In case of unforeseen events that prolonged loading or driving time, compliance with one regulation was said to violate another one.

To solve or alleviate the perceived problems, the PTDs suggested a number of actions, such as well-designed on-farm loading areas, adequate lighting in loading areas, suitable flow of pigs (not too fast, nor too slow), improved farmer commitment to deliver only pigs fit for transport, improved communication with veterinarians about what should be regarded as an unfit pig, more uniform assessment of pigs between veterinarians, and adequate facilities for cleaning vehicles at abattoirs.

4. Discussion

This study reveals large differences in physical workload between both PTDs and the different tasks required. Although PTDs reported high job satisfaction and commitment, as well as contentment with their own performance, there were indications of high work demands, conflicts with different stakeholders, and difficulties in meeting different regulations governing time limitations.

The varied and in some respects high physical workload recorded, especially during loading, unloading and cleaning vehicles, is consistent with what PTDs reported in the workshop. Varied work is associated with a lower risk of musculoskeletal disorders in the neck and upper limbs compared to more repetitive work (Nordander et al., 2009), however large variations in workload have been found in several varied and/or mobile types of work (Hansson et al., 2010). In this study, none of the PTDs was observed to take work breaks, indicating a possible lack of essential rest, although breaks may have occurred during driving to abattoirs. Efforts to reduce PTDs' workload and improve their wellbeing will most likely increase their ability to ensure good welfare of the animals that they handle (Anneberg and Sandoe, 2019).

There are not many technical aids for loading/unloading pigs, which means that work flow is highly dependent on the pigs' willingness to enter/exit the truck, which is in turn influenced by the design of the loading area, weather, lighting, farm-staff working routines, unloading-bay design, pigs' handling experience and pig genetics (Goumon and Faucitano, 2017). In this study, PTDs reported that inadequate designs of the loading area contributed significantly to increased physical workload when handling pigs, especially leading to knee pain. A detailed plan for the loading area is not required in the Swedish official process of approval of new or rebuilt animal buildings (Hultgren 2009), which may lead to unnecessary inferior designs. Research has shown that pig welfare is affected by handling and that management procedures vary among farmers as a result of underlying beliefs about pigs (Hemsworth et al., 1989). Difficulties to load slaughter pigs, due to previous rough handling or inferior loading area design, is clearly an animal welfare issue. Future research should elucidate how different loading area designs affect loading efficiency, PTD workload and pig welfare.

Three-level transport vehicles, in which the floors can be lifted up and down by hydraulic hoist systems, are standard in Swedish commercial pig transport. To access the inner parts of the vehicle when the two top floors are occupied, i.e. towards the end of loading and in the beginning of unloading, the working space is limited to a height of approximately 100 cm. The observed 90th percentile back forward

flexion of 52° during unloading of pigs reflects extreme crouching postures, and is likely a contributing factor to reported lower back problems. Even though unloading is the least time-consuming task, it should be considered a risk factor. In addition to having to stoop, there is a risk of being pushed or run over by pigs in the confined space. Four-level vehicles also exist, which have an even lower minimum working space. Threshold limits have not previously been suggested for back postures or velocities, but studies on professional garbage collectors, who also reported lower-back discomfort, have shown high back loads during pushing, pulling or lifting garbage containers (Barkstedt et al., 2016). In some respects, these tasks are similar to PTDs work, such as spreading litter material, moving gates, pushing pigs, and scraping litter.

Group means of whole day velocities of upper arms and wrists did not exceed recently reported threshold limits of 60°/s and 20°/s, respectively (Arvidsson et al., 2021 in press), most likely due to low arm velocities during driving when PTDs arms are rested on the steering wheel. The variation between PTDs in arm velocity during loading and cleaning probably reflects differences in the physical environment (for example, design of loading area and cleaning facility), which agrees with the PTDs concern for sometimes inadequate loading and cleaning facility designs leading to increased work effort. The variation could also indicate individual variations in working methods (for example, pig handling behaviour and work pace), and a possible need for training in animal handling of some of the PTDs.

Head flexion, upper arm elevation and wrist velocity have been previously associated with neck problems in various occupational groups (Nordander et al., 2016). In the present study, high upper arm elevations (right arm, whole day exposure, 90th percentile) exceeded threshold limits previously suggested for the prevention of musculoskeletal disorders (Arvidsson et al., 2021 in press). However for a large part of the time, during driving of the vehicle, arms were supposedly supported by the steering wheel, and therefore arm elevation during this task is unlikely to contribute to musculoskeletal disorders in neck and shoulders. This complicates the assessment of the whole day's exposure to elevated arms, as recently discussed by Palm et al. (2018). During cleaning of vehicles, the most time-consuming of the more physically active tasks, head forward flexion and right wrist velocity were found to be highest. Together, these findings possibly explain PTDs reported discomfort in neck/shoulders, and signal the importance of access to adequate cleaning facilities. The sub-contractor situation further complicates this, and abattoir management, who is responsible for the facilities, may lack motivation to provide proper facilities for PTDs (Valluru et al., 2017).

Despite physically demanding working conditions, PTDs reported that they perceived the work as meaningful and engaging, indicating a high work satisfaction. Moreover, the reported high perceived work capacity, i.e. the belief of being able to handle physically and psychosocially demanding situations, is possibly a prerequisite for this type of work. Reported demands for attentiveness and endurance, as well as fear of severe consequences in the event of mistakes, are matters known to increase stress (Leijten et al., 2015) and could, in combination with the moderately low perceived control over workload, increase the risk of discomfort in neck, shoulders and back, as reported by the Swedish Council on Health Technology Assessment (SBU, 2012, 2014). PTDs stated that work-related injuries were generally not reported, which may reflect a norm that one should endure difficulties without complaining, and therefore, related official statistics may underestimate the incidence of work-related injuries.

The expressed concern about difficulties in finding and rejecting pigs with health disorders during loading and the lack of clarity from abattoir veterinarians regarding unfit pigs suggest a problem for PTDs communicating with stakeholders, and may have contributed to the perceived lack of control over workload. The importance for truck drivers to collaborate and communicate well with stakeholders was described by Wioland (2013) who emphasized the need for professional skills, such as ability to readjust and communicate while still following regulations. In this study, PTDs suggested that improved commitment of farmers to present only healthy pigs would likely improve the working environment. To reduce PTDs fear of unknowingly being reported for transporting unfit pigs, communication between veterinarians and PTDs needs to be improved.

Existing regulations meant to safeguard human wellbeing (EU Regulation No. 561/2006 on driving times, breaks and rest periods for drivers) and animal welfare (EU Regulation No. January 2005 on animal transport) are not always compatible. In animal welfare legislation, transportation starts when the first animal is loaded and ends when the last one is unloaded, while PTDs' regulated driving time starts when the vehicle first moves, i.e. usually before the loading starts and finishes when the PTDs stops the vehicle after completing the day's driving. Thus a lengthy loading process will reduce the time on road, which, along with keeping the planned time for delivery to abattoirs, is likely to increase time pressure, stress and the risk of making mistakes with possible negative consequences for both the PTD and the pigs. Moreover, PTDs reported to sometimes register time for cleaning of vehicles as driving breaks. This can be described as a conflict between safety policy and practice (Murphy et al., 2018), possibly caused by an increasingly competitive livestock transport industry.

The limited number of participants in the workshop and questionnaire (n = 12–20) necessitates cautious interpretation of the results, although the sample was estimated to constitute approximately 15% of PTDs working in Sweden at this time. It cannot be ruled out that the PTDs who agreed to participate had a comparatively positive attitude towards their work, which may have created selection bias. However few approached PTDs declined participation and the study subjects represented a reasonable spread in age and work experience. All but two PTDs were male, presumably reflecting the distribution between sexes in this occupational group.

The participating PTDs transported pigs in the middle-north, southwest and south of Sweden. PTDs working in areas with relatively many farms in close proximity to abattoirs (typically for southern Sweden) would be expected to have shorter hauls with increased number 'loading-to cleaning-sequences' per work shift. Subsequently, workload and safety risks for those PTDs increase due to increased proportion of work outside the truck (Chandler et al., 2017; Reiman et al., 2018), compared to PTDs working in areas with less farms and abattoirs (typically for northern areas) where hauls are longer.

Information about PTD musculoskeletal complaints was acquired through a questionnaire. Clinical examinations may have given a more objective view, but were not considered feasible in this context. After completion of observations in the same day but outside the study, a few of the PTDs repeated the loading-to-cleaning sequence with another slaughter delivery; hence the whole day recordings probably underestimated the total workload of a working day. Some goniometer data were lost, which may be explained by the fragility of sensors.

In conclusion, the present study indicates that Swedish pig transport drivers' working conditions vary considerably both between tasks during the working day and between drivers performing these tasks. There is a risk of high loads on shoulders during loading and unloading pigs and cleaning of vehicles, and on back and knees during loading and unloading. Poor loading area design, specifically a lack of sufficient lighting, space and protection from wind and direct sunlight, causes difficulties in moving pigs forward and therefore increases the risk of knee discomfort. The psychosocial work environment is impaired by complex regulations, time pressure and lack of communication with farmers and official veterinarians regarding health status of pigs. These matters need to be addressed to ensure sustainable working conditions for drivers. Regardless of perceived difficulties, work satisfaction in Swedish pig transport drivers is high.

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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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Slaughter transport is stressful for pigs and potentially also for transport drivers. This thesis investigated Swedish pig transport drivers' working conditions and driver and pig interactions during slaughter transport loading, and evaluated the effect of training on drivers' attitudes, handling methods, physical workload and time efficiency. The results indicate that transport drivers have good work satisfaction and varying physical workload. There is a reciprocal relationship between driver and pig behaviour, and drivers' handling of pigs can be improved through training.

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