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Associations between litter size and medical treatment of sows during farrowing and lactation

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ABSTRACT
Sow litter sizes have increased recently, and there is a lack of data on the effect of litter size on sow health and sow medical treatment. This study investigated associations between litter size and medical treatment of sows, using data for a 10-year period from one Swedish research farm. The data comprised 1947 litters from 655 Yorkshire sows. Association between litter size and medical treatment of sows during farrowing and lactation investigated using a multivariable multilevel logistic regression model. We found that odds of medical treatment of sows decreased for each additional piglet born up to five piglets (odds ratio 0.50, p = .002). For litter sizes ≥5, the odds for each additional piglet born (odds ratio 1.11, p < .001). Problems with milk let-down in early lactation were the main reason for treatment. Results imply that sows with very small or very large litters may be less profitable.

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Health; welfare; pig; piglet; postpartum dysgalactia syndrome

Introduction

Sow welfare, including health, plays a fundamental role in successful piglet production. Herds with good management and healthy sows produce more litters and more piglets per year (Jaaskelainen et al., 2014). Health problems, such as reproductive disorders and udder problems, are associated with unplanned removal of sows in early parities (Engblom et al., 2007). Removal of these sows is a financial burden for producers, as sows need to stay in production for at least three parities to be profitable (Stalder et al., 2003).

An increased risk of early and unplanned removal has been found to be associated with large litter size in early parities (Andersson et al., 2016). Large litter size may result in impaired welfare of the sows, e.g. increased energy demand and risk of uterine fatigue (Rutherford et al., 2013; Eriksson et al., 2014; Andersson et al., 2016) and of the piglets, such as large variation in birth weight and high perinatal and pre-weaning mortality (Lund et al., 2002; Milligan et al., 2002; Weber et al., 2007; Rutherford et al., 2013). Despite this, much remains unknown about the effects of litter size on sow health during gestation and lactation. Sow litter sizes have increased in Sweden (Andersson et al., 2016), as well as, in other European countries (Baumgartner, 2012), during recent decades. However, there is a lack of recent research on the effect of litter size on sow health and the need for medical treatment of sows. Therefore, the main objective of the present study was to investigate the association between litter size and medical treatment of sows during farrowing and lactation. A second objective was to describe and evaluate medical treatment of sows, including diagnosis and drug choice, during farrowing and lactation.

Materials and methods

In this observational study, the potential association between litter size and medical treatment of sows was investigated by retrospective analysis of pig production data and medical records. These were retrieved from a database on the research farm at the Swedish University of Agricultural Sciences, located near Uppsala in east-central Sweden.

General management of the herd

The herd covered by the data (2001–2010) consisted of approximately 110 piglet-producing sows, mainly

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purebred Yorkshire. Replacement gilts were raised in partly slatted pens with straw, with a maximum of six gilts per pen, until insemination. They were then housed in groups of 8–10 gilts/sows per pen and provided with deep-litter straw and individual feeding stalls. One week before expected parturition, sows were moved to a farrowing unit with partly slatted individual farrowing pens (8.4m^2) with fender bars. Each farrowing pen had a creep area (2.2 m^2), accessible for piglets only, with a heating lamp. The pens were bedded with sawdust and straw. In compliance with Swedish legislation, all sows were loose-housed during farrowing and lactation and straw was supplied daily. Lactating sows were fed individually according to their litter size. However, cross-fostering, split suckling and tail docking were not practised. Male piglets were surgically castrated at approximately 4 days of age and all piglets were in general weaned six weeks after farrowing. Each farrowing batch consisted of 12 sows and a batch of sows farrowed every second week. Before gestation, all sows and gilts were routinely dewormed and vaccinated against erysipelas, parvovirus and *Escherichia coli*.

Table 1. Descriptive data on litter size by any medical treatment, birth year of litter, parity and season[a].

		Number of piglets per litter				
	N	Mean	SD	Median	Min	Max
Total	1947	12.8	3.4	13	1	23
Medical treatment						
No	1560	12.6	3.3	13	2	22
Yes	387	13.4	3.5	14	1	23
Birth year of litter						
2001	250	11.8	3.3	12	3	20
2002	231	12.7	3.3	13	2	20
2003	144	12.4	3.4	13	1	21
2004	164	12.7	2.9	13	3	22
2005	173	12.9	3.5	13	2	21
2006	183	13.3	3.2	13	2	22
2007	178	13.0	3.3	13	4	23
2008	177	13.0	3.3	13	4	19
2009	212	13.1	3.4	13	2	22
2010	235	13.3	3.6	14	2	22
Parity						
1	591	11.7	2.9	12	1	19
2	408	12.6	3.4	13	2	21
3	322	13.5	3.3	14	2	22
≥4	626	13.6	3.4	14	2	23
Season						
Winter	462	12.8	3.4	13	2	22
Spring	487	12.7	3.3	13	2	23
Summer	515	12.7	3.4	13	2	22
Autumn	483	12.9	3.3	13	1	22

[a]Data for the period 1 January 2001–31 December 2010 retrieved from a research farm. The final dataset comprised observations on 1947 litters from 655 Yorkshire sows.

Study population

Information about animal identity, farrowings, medical treatments etc. were continuously recorded and transferred to the research farm database. The initial dataset comprised production data and records of medical treatment of sows during farrowing and lactation for every litter born from 1 January 2001 to 31 December 2010. Only purebred Yorkshire sows were included in the study. The quality of data was validated by use of descriptive statistics and biologically impossible typographical errors were manually changed to missing data. The final dataset included observations on 1947 litters from 655 sows, ranging from 144 to 250 litters per year (Table 1). The sows included in the final dataset were born between 1997 and 2009.

Data records

The production data records consisted of sow identity, sow birth year, parity, farrowing date, total number of piglets born, number of piglets born alive, number of piglets weaned and weaning date. Parity number was for the statistical analyses transformed to a categorical variable with four categories: parity 1, parity 2, parity 3 and parity ≥4. Season at farrowing was extracted from farrowing date and categorized as winter (December-February), spring (March-May), summer (June-August) and autumn (September-November).

Records on medical treatment of individual sows included date of medical treatment, type of drug, dosage and reason for medical treatment. For every medical treatment, up to two reasons for treatment were recorded, e.g. fever and loss of appetite. The day of farrowing was defined as day 0 and any medical treatment given to the sow on the day before farrowing (day -1, to include onset of farrowing) until the day of weaning (defined as the treatment period) was included in the analyses.

A total of 21 different pharmaceutical drugs and other treatments were administered to sows during the 10-year study period. These were grouped into four categories: oxytocin, antibiotics, anti-inflammatory drugs (NSAIDs and corticosteroids) and miscellaneous treatments (e.g. selenium and vitamins). In two observations, information about the type of pharmaceutical drug treatment was missing. Furthermore, 24 different reasons for medical treatment were recorded. These were grouped into four categories: leg and claw disorders, udder and reproductive tract disorders, lethargy (fever and loss of appetite) and other miscellaneous disorders. Medical treatments that were recorded as preventative were grouped into ‘udder and reproductive tract disorders’ if the pharmaceutical drug given was oxytocin. Otherwise, they were grouped as ‘miscellaneous disorders’. In three observations, information about the reason for the medical treatment was missing.

Statistical analysis

The statistical software Stata (release 12, StataCorp LP, College Station, TX) was used for both data editing and statistical analyses. To investigate the association between litter size (exposure) and medical treatment of sows during farrowing and lactation (outcome), multi-variable multilevel logistic regression was applied. Each observation represented one litter, and each sow could thus contribute to several observations in the data. For the outcome variable in the statistical analysis, observations where the sow received at least one medical treatment during farrowing or lactation were recorded as 'yes' (1) and observations where the sow did not receive any medical treatment were recorded as 'no' (0). In addition, to litter size (total number of piglets born), parity of the sow (1, 2, 3, ≥4) and season when the litter was born (winter, spring, summer and autumn) were included as covariates in the model. The year when the litter was born (2001–2010) and sow identity of the litter (655 sows) were included as random variables (multilevel effects).

Initially, models were tested to estimate the random effects of year and sow identity, both as single-level random effects and as multilevel random effects with sow identity nested within the year. At single level, both year and sow identity were found to be significant. In the multilevel model, sow identity nested within the year was also found to be significant.

Litter size, parity and season were first tested for their association with the outcome by univariable multilevel logistic regression analysis, applying the XTMELOGIT procedure in Stata. Litter size was analysed as a continuous variable in the model and showed a significant ($p <$ .001) association with the outcome. The potential covariates season and parity were not significant, but parity was still selected for further analysis and entered in the preliminary multivariable model as a fixed effect.

As part of building the regression model, different formats of the litter size variable were tested. In addition to the original continuous form, tested formats of litter size included categorization using 11 categories (≤7, 8, 9, 10, 11, 12, 13, 14, 15, 16, ≥17), best fit of first- or second-degree fractional polynomials (created using Stata's FRACPOLY command) and linear splines. The final multivariable multilevel logistic regression model was then constructed using manual backward stepwise elimination. The models with litter size categorized in different formats and the model with litter size as a continuous variable were compared based on Bayesian information criterion (BIC).

Results

Median litter size of the total born for the whole study period was 13 piglets (range 1–23). The observed median litter size increased over year and parity, but there was no apparent difference over season (Table 1). During the 10-year study period, 19.9% of the litters had a sow that was given at least one medical treatment during farrowing and lactation. This percentage appeared to increase with parity, and differed between litter size, years and season (Table 2), and 36.4% of these sows at that special farrowing, receiving more than one medical treatment. Oxytocin was the most common pharmaceutical drug used (Table 3). It was given alone, or in combination with antibiotics and/or NSAID or corticosteroids, to 81.4% of the treated sows. On average, the first medical treatment was given during the first days of lactation (median 1 day, range −1 to 36 days) (Figure 1).

The main reason for giving medical treatments to sows during farrowing and lactation was udder and

Table 2. Percentage of litters where the sow received medical treatment during farrowing or lactation by litter size, birth year of litter, parity and season[a].

	N	% litters where the sows were treated
Total	1947	19.9
Litter size		
≤7	140	17.9
8	61	13.1
9	88	12.5
10	136	16.9
11	169	13.6
12	242	18.6
13	255	14.9
14	258	24.4
15	215	21.9
16	153	24.2
≥17	230	29.1
Birth year of litter		
2001	250	19.2
2002	231	30.7
2003	144	20.1
2004	164	18.9
2005	173	16.2
2006	183	15.8
2007	178	19.1
2008	177	12.4
2009	212	15.6
2010	235	26.4
Parity		
1	591	17.3
2	408	19.1
3	322	19.9
≥4	626	22.8
Season		
Winter	462	22.1
Spring	487	19.1
Summer	515	19.2
Autumn	483	19.3

[a]Data for the period 1 January 2001–31 December 2010 retrieved from a research farm. The final dataset comprised observations on 1947 litters from 655 Yorkshire sows.

Table 3. Descriptive statistics on different medical treatments administered to sows according to parity[a].

Any treatment	Number of sows treated							
	Parity = 1		Parity = 2		Parity = 3		Parity ≥ 4	
	n = 591	%	*n* = 408	%	*n* = 322	%	*n* = 626	%
Single treatments								
Oxytocin	48	8.1	37	9.1	40	12.4	80	12.8
Antibiotics	17	2.9	5	1.2	5	1.6	10	1.6
NSAID or corticosteroids	2	0.3	1	0.2	0	0.0	1	0.2
Combined treatments								
Oxytocin + antibiotics and/or NSAID or corticosteroids	25	4.2	28	6.9	16	5.0	41	6.5
Antibiotics + NSAID or corticosteroids and/or other treatments	8	1.4	6	1.5	1	0.3	7	1.1
Other treatments and combinations	2	0.3	1	0.2	2	0.6	4	0.6
No treatment	489	82.8	330	80.9	258	80.1	483	77.2

[a]Data for the period 1 January 2001–31 December 2010 retrieved from a research farm. The final dataset comprised observations on 1947 litters from 655 Yorkshire sows.

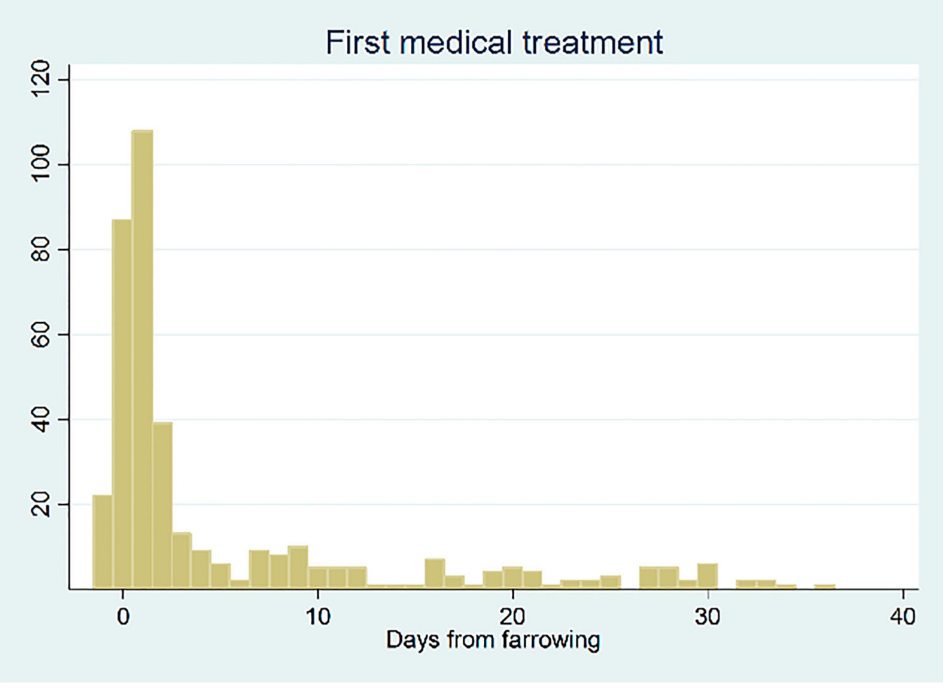

Figure 1 Number of first medical treatments of sows (in total 387 farrowings) in relation to days after farrowing. Based on data for the period 1 January 2001–31 December 2010 retrieved from a research farm. The final dataset comprised observations on 1947 litters from 655 Yorkshire sows.

reproductive tract disorders (Figure 2). Of the first medical treatments, 45.5% were given due to problems with milk let-down. The second and third most common reasons were weak contractions during farrowing (11.0%) and fever (10.0%). Fever was the most common reason for giving medical treatment more than once to a sow.

Based on the results from the model evaluation, it was concluded that the model with litter size included as second-degree fractional polynomials best captured the relationship between litter size and medical treatment of the sow during farrowing and lactation (Figure 3). However, to facilitate interpretation of model results, a model where litter size was kept continuous, but included in linear spline format, was chosen to be studied further. The cut-offs used for creating the linear splines were based on an assessment of the shape of observed and fitted values. Based on this relationship, litter size was divided into two groups, <5 and ≥5 piglets born in total, and this categorical variable was then chosen as the main predictor in the final multivariable model. Parity number was non-significant ($p = .51$) and did not appear to confound the main predictor variable (changing its estimates by <15%). Therefore, parity number was excluded from the final model.

Results from the final dual-level model showed a significant effect of litter size on any medical treatment. The odds of medical treatment decreased with each additional piglet born up to a total of 5 piglets (odds ratio 0.5, $p = .002$) and increased for each additional piglet born for litter sizes ≥5 (odds ratio 1.11, $p < .001$).

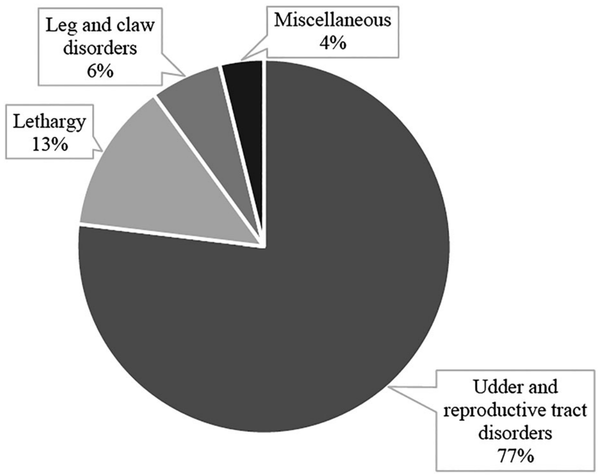

Figure 2 Main reason for giving the first medical treatment (in total 387 farrowings) to sows during farrowing and lactation. Based on data for the period 1 January 2001–31 December 2010 retrieved from a research farm. The final dataset comprised observations on 1947 litters from 655 Yorkshire sows.

The results from this model are shown in Table 4. The random effect of the year in which the litter was born explained 2.3% of the variance between observations, while sow identity nested within year explained 13.5% of the variance between observations.

Table 4. Association between litter size and medical treatment of sows during farrowing and lactation.

Number of piglets	Odds ratio[a]	*P* value	95% Conf. interval
<5	0.50	.002	0.32–0.78
≥5	1.11	<.001	1.06–1.15

[a]Estimates of odds ratio from multivariable multilevel logistic regression. Year and sow identity nested within year were included as random variables in the model. Based on data for the period 1 January 2001–31 December 2010 retrieved from a research farm. The final dataset comprised observations on 1947 litters from 655 Yorkshire sows.

Discussion

The present study investigated the association between litter size and medical treatment of sows during farrowing and lactation. Analysis of data for 1947 litters from 655 sows showed that the odds of medical treatment decreased for every additional piglet born up to five piglets. For larger litters (≥5 piglets), however, the odds of medical treatment increased for each additional piglet born. Medical treatment of sows was mainly required on the day of farrowing or in the first two days after farrowing, with problems with milk let-down being the main reason for medical treatment. Oxytocin alone, or in combination with antibiotics and/or anti-inflammatory drugs, was the most common drug administered, probably related to problems with milk let-down and contractions.

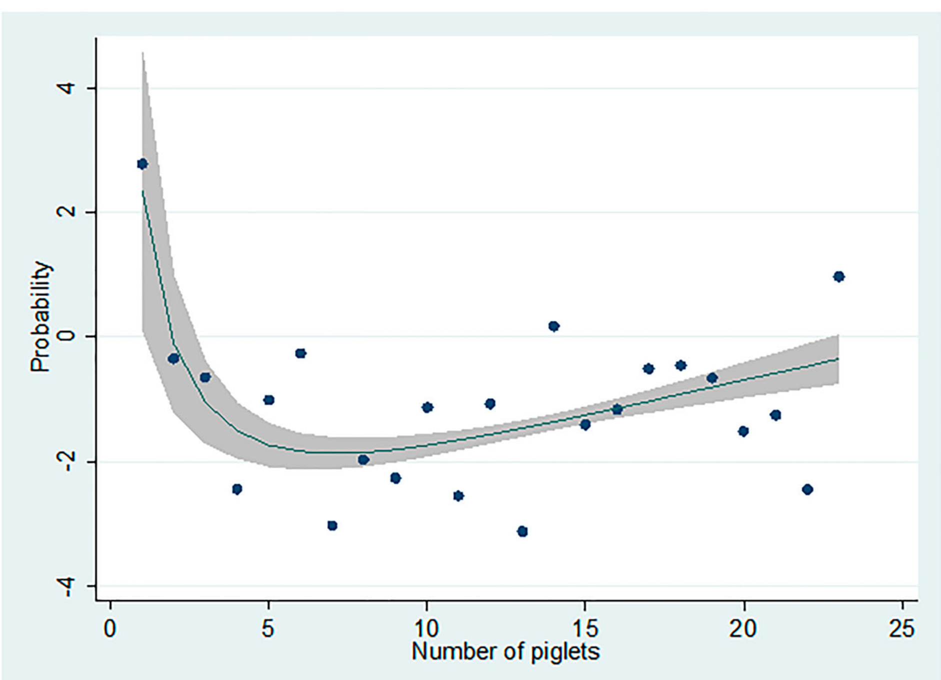

Figure 3 Predicted probability of the relationship between litter size and medical treatment of the sow during farrowing and lactation. Predicted probability (with 95% confidence interval, grey band) in a model with litter size included as second-degree fractional polynomials of a sow being medically treated, plotted as a function of total number of piglets born per litter. Based on data for the period 1 January 2001–31 December 2010 retrieved from a research farm. The final dataset comprised observations on 1947 litters from 655 Yorkshire sows. In total, sows were medically treated in 387 of the observed litters.

These results imply that giving birth to very small or large litters has a negative effect on sow health and welfare during the first days of lactation. As those first days in lactation are very important for the new-born piglets, the impaired health status of the sow due to very small or large litter size will probably have a negative effect on piglet health and welfare, as well as, a negative effect on farm profits.

During lactation, the sow invests much of her resources in her piglets. Therefore, nursing a large litter while maintaining her own body condition is a challenge for the sow and there is a risk of substantial weight loss of the sow during lactation (Drake et al., 2008). This may be associated in turn with an increased risk of clinical disease during lactation (Sterning et al., 1997). A Swedish study in the 1970s found a significant positive association between large litter size and agalactia (previously called mastitis–metritis–agalactia complex, now commonly referred to as postpartum dysgalactia syndrome; PDS) (Hermansson et al., 1978). Regression model results in the present study revealed significant associations between litter size and medical treatment of sows during farrowing and lactation. The odds of the sow receiving medical treatment increased for every additional piglet born in the litter above a total of ≥5 piglets. Modern sows give birth to at least two litters per year, and Hermansson et al. (1978) have previously found that sows with PDS are at greater risk of developing the disorder again in their next parity. Thus, these facts could be the reason why sow identity nested within year explained a considerable proportion of the variance in observations (13.5%) in the present study. Several studies have reported positive associations between increasing litter size and sow disease occurrence (Hermansson et al., 1978; Bäckström et al., 1984; Gerjets et al., 2011), but to our knowledge, no previous study has explained the causality of the effect of large litters on sow health. Prolonged farrowing duration (Oliviero et al., 2010), (Tummaruk & Sang-Gassanee, 2013) and birth interventions (Gerjets et al., 2011), have been suggested as factors explaining why larger litter sizes have a negative effect on disease occurrence.

We found that for very small litters (<5 piglets) the odds of the sow requiring medical treatment decreased for every additional piglet born up to five piglets. This is in agreement with that it has previously been found that disease in the sow during gestation can result in a small number of piglets being born per litter (Friendship & O'Sullivan, 2015). The average frequency of medical treatment of sows included in this study (19.9% of litters) and the main reason for giving medical treatment to sows during farrowing and lactation were similar to findings in a previous study by Sterning et al. (1997) based on data from the same research farm. The study indicated that most of the treated sows were affected by PDS or weak contractions, and the prevalence of PDS has previously been found to differ between herds, season (Bäckström et al., 1984) and parity (Tummaruk & Sang-Gassanee, 2013). In the present study, data records from only one research farm were used. Further studies are needed to determine whether the associations observed here between the medical treatment of sows and litter size are present in commercial piglet production and occur in other pig breeds.

Sows with PDS fail to meet the nutritional needs of their piglets and reproductive disorders and udder problems in sows are associated with unplanned removal (Engblom et al., 2007; Rutherford et al., 2013). Already Hermansson et al. (1978) found that sows affected with PDS were more likely to be culled and that they weaned fewer piglets than sows, which did not have PDS. This, together with the cost of medical treatments, causes economic losses for the producer. Therefore, sow welfare including health plays a fundamental role in successful piglet production. The results in this study imply that sows giving birth to very small or very large litters (>14 piglets; Andersson et al., 2016) may have impaired health and welfare in the first days of lactation and that these sows are not always profitable. This should be considered in national pig breeding goals. Producers should also pay particular attention to sows giving birth to very small or very large litters, in particular just after farrowing, considering the risk of these sows suffering health problems.

The present study was retrospective and the data used were not recorded for a specific research aim, so data recording was beyond our control. However, the data were retrieved from a research farm that provides clear instructions and has well-established routines for record-keeping. Specific data of interest for this study were selected based on relevance, completeness and consistency. In order to achieve a large study sample, 10 years of data were used. The robustness of the data may differ over time since different personnel (mainly research technicians) carried out the recordings during the 10-year study period. However, one single member of staff transcribed the data from manual records into digital records.

Litter size was chosen to be the exposure variable in the analyses, and definition was based on previous studies have shown that it is important to consider both the number of piglets born alive and the number of stillborn piglets when assessing the effects of litter size on sow welfare (Baxter et al., 2013; Rutherford et al., 2013). The herd mainly consisted of purebred Yorkshire but some of the litters were crossbred. Therefore, in order to avoid any effects of breed on the outcome, all crossbred and other purebred sows in the database were excluded from analyses. Sows in this study were housed on a research farm and the production goals may differ from those in commercial herds. However, the total number of piglets born per litter corresponded well with the number reported in commercial piglet-producing herds in Sweden and elsewhere during the study period (Tummaruk et al., 2000; Cutshaw et al., 2014).

Associations between litter size and medical treatment of sows during farrowing and lactation were found, where giving birth to very small or very large litters was negatively associated with sow health. Problems with milk let-down in early lactation were the main reason for medical treatment. Thus, pig producers should pay particular attention post-farrowing to sows that give birth to very small or very large litters, as these sows have an increased risk of suffering health problems and decreased performance.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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