Management effects on preweaning mortality: A report of the NAHMS National Swine Survey

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Summary: *We analyzed data collected in the National Swine Survey to find the management variables that may affect preweaning piglet mortality. We also considered other recently reported significant facility variables in our models to expand and unite the two independent investigations. We found that techniques (all-in–all-out and cleaning between groups) which should reduce the exposure of suckling piglets to the pathogens of older or previous inhabitants to be more strongly associated with reduced preweaning mortality than methods to increase immunity or reduce parasites.*

Studies spanning several decades and numerous countries have shown that, in the absence of specific management intervention, the preweaning mortality rate of domestic piglets is typically 20% or higher. The death of one or two piglets per litter is far too common to be viewed as abnormal.[1] Biological factors that contribute to high death losses in neonatal pigs include:

- low initial body weight,
- lack of substantial energy stores within piglets,
- poor body temperature regulation,
- lack of hair coat or other insulation,
- large surface area:body mass ratio, and
- strong competition among litter mates for colostrum and milk.[1,2]

For our purposes, preweaning mortality includes only those liveborn piglets that die before weaning. This is in contrast to some conventions that also include stillborn piglets in the preweaning mortality category.

Preweaning piglet death loss is a major inefficiency in pork production and results in lost profit opportunities for producers.[3,4] Consequently, preweaning mortality is an area where there is the potential for significant improvement in many operations. The number of pigs-weaned-per-sow-per-year is a commonly cited measure of breeding herd productivity, and preweaning mortality is one of its principal determinants (Figure 1).[5] Increasing pigs-weaned-per-sow-per-year helps to maximize profits as it decreases production costs per pig by expanding the number of pigs to share fixed costs.[3,6] Decreasing preweaning mortality may be a way to realize a significant improvement in pigs-weaned-per-litter, especially if the initial preweaning mortality rate is average or high.

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Many authors have expounded on management practices to be addressed when attempting to reduce preweaning death losses.[3,7,8] Strategies usually considered include sanitation in the farrowing house, adequate colostrum intake soon after birth, preventing chilling-starvation-overlaying complex, fostering, birth weight, and ensuring optimal sow condition, to name a few. Herds can attain a preweaning mortality rate of less than 10% with good management and adequate farrowing facility design.[9]

Yeske, et al., have identified risk factors associated with preweaning mortality that could be attributed to facilities and facility management.[10] Our objective was to expand that analysis by examining additional management variables that could influence preweaning mortality. The variables we added included:

- sow prefarrowing management,
- sow farrowing management,
- piglet management,
- farrowing house management, and
- use of computer-generated records.

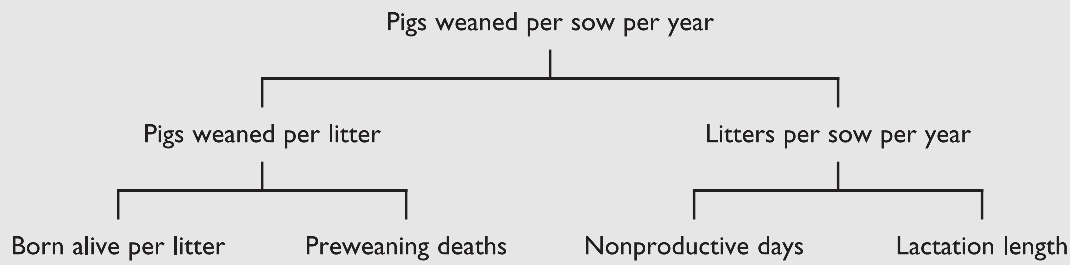
Methods

Survey

We used data from the National Animal Health Monitoring System's (NAHMS) National Swine Survey. The study design for the NAHMS Swine Survey has been previously described.[11,12] Briefly, each producer participating in the NAHMS Swine Survey provided information about their sow and preweaning piglet management, facilities, and equipment used, and recorded farrowing information on diary cards for a 3-month period.

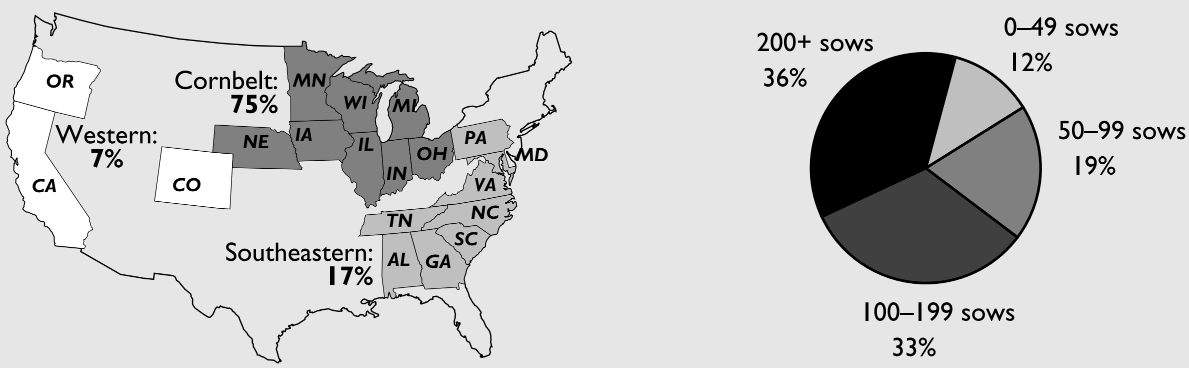
A total of 712 producers from 18 states, representing 84% of United States swine operations and 95% of the hogs, completed the entire monitoring phase. We limited our investigation to the management practices of the 585 farms with total confinement facilities. We chose facilities to be our unit of analysis because many of these farms had more than one total confinement facility and with some of the data collected at the facility level. Because some farms had multiple facilities, total confinement facilities numbered 750. However, some of these facilities had so few monitored cohort litters that their resulting preweaning mortality could be very high (100%) or low (no death loss). It is unlikely that such extremes accurately reflect a facility's long-term performance. To reduce the variation associated with facili-

Figure 1



Preweaning deaths are an important factor in determining how many piglets are weaned per sow per year. Source: Dr. Gary Dial.[30]

Figure 2



Demographics of the 703 facilities studied. Location was divided into three regions: "Cornbelt"—Illinois, Indiana, Iowa, Michigan, Minnesota, Nebraska, Ohio, and Wisconsin—75% of farms; "Southeastern"—Alabama, Georgia, Maryland, North Carolina, Pennsylvania, Tennessee, and Virginia—17%; and "Western"—California, Colorado, and Oregon—7%. The average farm size measured the number of sows in the breeding herd and was divided into herds with 0–49 sows (12% of farms), 50–99 sows (19%), 100–199 sows (33%), and 200 or more sows (36%).

ties with few monitored litters, we excluded from analysis those facilities with fewer than five monitored litters, thus reducing the number of facilities in the analyses to 703 (19,732 cohort litters) (Figure 2).

Statistical analysis

We modeled preweaning mortality as a function of management variables using square root of death incidence rate as our measure of mortality. Death incidence rate measures the number of suckling piglets that die per 1000 piglet days at risk up to 21 days of life. Death incidence rate ranged from 0 to 46 piglets per 1000 piglet days with a median value of 7.36. Its distribution was not normal with skewness of 5.88 and kurtosis of 10.65. To improve normality we took the square root of death incidence rate. This transformed distribution of mortality approached normality with a skewness of 0.86 and kurtosis of 2.83.

The management variables we selected for analysis were procedures that are generally regarded as being associated with preventing illness and death in neonatal piglets. The variables investigated were:

- vaccinating gestating females in the prefarrowing period;
- treating gestating females against internal and external parasites in the prefarrowing period;
- washing sows on their entry to the farrowing house (percent washed);
- injecting sows with oxytocin during farrowing (percent injected);
- type of animal flow in farrowing house (continuous or all-in–all-out [AIAO]);
- sharing the farrowing unit with other activities;
- extent and regularity of cleaning and disinfecting procedures;
- length of vacancy of unit between farrowing groups;
- cross-fostering of piglets among litters;
- administering supplemental iron to newborns;
- administering supplemental milk to piglets (percent fed); and
- using a computerized record-keeping system for breeding herd management.

To determine which variables were most associated with preweaning mortality we used a three-step or model process. For the first step (Model I), we regressed each management variable independently on the square root of death incidence rate using the least-squares regression procedure (PROC REG).[13] Management variables with *P*-values

< .1 from the first step, along with farm size and region of country were placed into a forward step-wise multivariate model (Model II). Farm size and region were forced into the solution; management variables entered if their *P*-values were < .1. The third step added to Model II the facility and facility management variables that Yeske, et al.,[10] found significant in their univariate analysis of preweaning mortality. Once again a forward stepwise procedure was performed to determine the variables that had the most impact on mortality (Model III).

As confounders, both farm size and region were forced into the regression equations. Farm size categories are based on the number of sows in the herd. The categories are:

- 0–49 head,
- 50–99 head,
- 100–199 head, and
- 200+ head.

The 18 states that participated in the National Swine Survey were divided into three geographic regions, which are referred to as the Cornbelt, Southeastern, and Western.

The facility variables considered from Yeske, et al.,[10] included flooring type, piglet heat source, farrowing crate construction, and source of sow drinking water.

To transform the coefficients from the regression model into meaningful numbers (i.e., back to deaths per 1000 piglet days), we used the following formula:

$$D = (I + E)^2 - I^2$$

where D = difference in death rate per 1000 piglet days, I = model intercept, and E = estimate of variable coefficient.

Results

The average preweaning mortality for the 703 facilities studied was 15.8%, with a death incidence rate of 8.5 per 1000 piglet days. Using computerized records, washing sows before farrowing, fostering piglets among litters, and managing facilities AIAO were the management variables statistically associated ($P < 0.10$) with lower preweaning mortality in the univariate analysis (Table 1). The two most significant management variables ($P < 0.01$) were use of AIAO and washing sows before farrowing. Facilities managed AIAO experienced 1.6 fewer piglet deaths per 1000 piglet days than facilities managed in a continuous-flow fashion. Every percentage point increase in the percentage of sows washed before farrowing reduced mortality by 0.01 piglet per 1000 piglet days. Other management variables tending to reduce mortality, but which were not statistically significant, included oxytocin injections, deworming and mange treatments, and vaccinations for transmissible gastroenteritis (TGE), rotavirus, and erysipelas.

When combined in a multivariate analysis (Model II), the only management variables that were statistically significant at the $P < .1$ level were use of AIAO and washing the sow before farrowing (Table 2). Computerized record keeping and piglet fostering did not enter the model. Both record keeping and fostering are highly associated with the other variables in the model. Over 60% of the largest farms (> 200 sows) used computerized records while less than 10% of the smallest farms (< 50 sows) did. Use of computerized farm records was also greater in those that practice AIAO, and by those who washed their sows. Similarly, as farm size increased so did fostering intensity; fostering intensity was greater among those farms that practiced AIAO farrowing.

Both AIAO and sow washing remained statistically significant when the facility and facility management variables from Yeske, et al., were added (Model III, Table 2). In addition, supplemental piglet heat, idle

Table 1

Impact of selected management variables on preweaning piglet mortality—Univariate analysis (Model I)

Variable [n]	Difference*	prob. > t
Farm size		
1–49 sows [83]	0.00	(n.a.)
50–99 sows [136]	-0.6387	0.36
100–199 sows [233]	0.1858	0.78
200+ sows [251]	-1.0102	0.10
Region		
Cornbelt [534]	0.00	(n.a.)
Western [49]	0.0439	0.95
Southeastern [120]	-1.0263	0.04
All-in–all-out		
[423][n]	-1.6073	0.00
Advanced records		
[273]	-0.9408	0.01
Share facility		
[130]	0.6176	0.21
Sow vaccinations		
TGE [125]	-0.2399	0.62
E. coli [216]	0.1978	0.63
Rotavirus [72]	-0.0092	1.00
C. perfringens [106]	0.2245	0.67
Erysipelas [121]	-0.0006	1.00
Sow treatments		
Oxytocin† [604]	-0.0057	0.32
Deworm [278]	-0.5331	0.16
Mange [237]	-0.2872	0.47
Wash† [342]	-0.0136	0.00
Piglet treatments		
Fostering† [597]	-0.0463	0.07
Any iron [682]	-0.1193	0.91
Supplemental milk† [261]	0.0098	0.32

* represents change in number of piglet deaths per 1000 piglet days at risk for the given variable.
† continuous variables (percentage treated or fostered); n represents number of facilities.

Table 2

Impact of selected variables on preweaning piglet mortality—Multivariate analysis (Models II and III)

Variable* [n]	Model II Difference† (prob. > F)	Model II Partial r^2	Model III Difference† (prob. > F)	Model III Partial r^2
Farm size	***(0.3724)***		***(0.0933)***	
1–49 sows [83]	0.00 (n.a.)		0.00 (na)	
50–99 sows [136]	-0.5399 (0.4694)		-0.4033 (0.6140)	
100–199 sows [233]	0.3042 (0.6669)		0.6113 (0.4299)	
200+ sows [251]	-0.4429 (0.5282)		-0.7273 (0.3527)	
Region	***(0.1934)***		***(0.2671)***	
Cornbelt [534]	0.00 (n.a.)		0.00 (n.a.)	
Western [49]	0.1029 (0.9031)		0.4670 (0.6179)	
Southeastern [120]	-0.9545 (0.0789)		-0.8318 (0.1622)	
All-in / All-out [423]	***-1.5089 (0.0002)***	***0.0219***	***-1.2917 (0.0058)***	***0.0219***
Cleaning method			***(0.0048)***	***0.0208***
Not every farrowing [39]			0.00 (n.a.)	
Washed with water [67]			-3.7435 (0.0003)	
Water wash and disinfect [47]			-2.2496 (0.0474)	
Pressure wash [127]			-1.3815 (0.1612)	
Pressure wash and disinfect [423]			-1.9628 (0.0301)	
Supplemental piglet heat			***(0.0038)***	***0.0237***
Heat lamp [349]			0.00 (n.a.)	
None [53]			-1.4338 (0.0779)	
Heated floor or pads [96]			2.2718 (0.0012)	
Over and under [125]			0.4464 (0.4594)	
Radiant heat [51]			0.0736 (0.9323)	
Lamp and radiant [29]			-1.0215 (0.3502)	
Idle time (>2 days) [270]			***-1.1726 (0.0131)***	***0.0077***
Flooring			***(0.0247)***	***0.0104***
Wire only [269]			0.00 (n.a.)	
Any wood [53]			1.2445 (0.1707)	
Concrete floor [190]			1.3392 (0.0239)	
Coated wire [136]			-0.7210 (0.2298)	
Other [55]			0.4550 (0.5975)	
Wash sow [342]	***-0.0096 (0.0460)***	***0.0055***	***-0.0099 (0.0549)***	***0.0048***
Model r^2		**0.0439**		**0.1095**

* variables listed in order they entered the model with farm size and region being forced in.

† represents change in number of piglet deaths per 1000 piglet days at risk for the given variable.

time between farrowings, farrowing pen floor type, and cleaning intensity were also statistically associated with preweaning piglet mortality. The first variable to enter in this stepwise model was AIAO. The difference in mortality from AIAO and continuous flow was almost 1.3 piglets deaths per 1000 piglet days.

Methods for facility washing entered as the second most important variable. Pressure washing and disinfecting, the most popular form of cleaning, reduced mortality by almost two piglets per 1000 piglet days compared to not cleaning between farrowings. Other forms of cleaning were equally as effective as pressure washing with disinfection.

Third in importance was the source of supplemental piglet heat. Facilities using heat lamps or radiant heaters experienced two piglet deaths per 1000 piglet days fewer than facilities using heated mats or floors.

Next to enter the model was idle time between farrowings (i.e., keeping the facility vacant for more than 2 days), which reduced piglet mortality by 1.2 piglets per 1000 piglet days. Floor type was the fifth group of variables to enter the model. Wire floors and coated wire floors were superior to those of wood or concrete with piglet savings of at least 1.2 piglets per 1000 piglet days. Sow washing was the last variable to enter and each percentage point in the percentage of sows washed was associated with a 0.01 piglet decline in mortality per 1000 piglet days.

For all three models, farms with 100–199 sows had the highest death incidence rate while farms with 200 or more sows had the lowest death incidence rate. These differences, however, were not statistically significant ($P < 0.10$). The southeast region had lower death incidence rates than the Cornbelt, and for Models I and II the differences were statistically significant.

Discussion

Farrowing facility management

In a farrowing facility, limiting or preventing the exposure of the new group of piglets to the pathogens of their predecessors seems to be one of the most important factors when attempting to control preweaning mortality. In all three of our models, preweaning mortality was significantly lower in facilities using AIAO flow when compared to continuous flow. When considered in the stepwise model with the management and facility variables found by Yeske, et al., to be associated with significantly lower preweaning, four of the six most important factors (AIAO, facility washing, long idle time, washing sows) reduce exposure of the piglets to pathogens.

Sow flow

With regard to the routine operations of the farrowing facility, producers in the National Swine Survey were asked to characterize their operation as either continuous farrowing or AIAO. With continuous farrowing, while an individual pen or crate may be empty, the farrowing room or house is always occupied. In the case of AIAO, the unit is filled within a 1- to 2-day period and is entirely vacated after weaning until the next group of gestating females to farrow enters. All-in–all-out pig flow makes it feasible to thoroughly clean and disinfect the facility to a degree not possible if some animals remained in the unit. All-in–all-out also eliminates disease transmission from older piglets to younger piglets as there is no contact among them.[14] A recommendation is that there should be no more than 2 weeks' age difference among the piglets in a given airspace in the farrowing and nursery stages.[15] All-in–all-out, in addition to reducing disease transmission within the herd, allows the herd to make more efficient use of labor with most sows farrowing in a short time span. Fostering is enhanced as the piglets are nearly the same age. It's possible that the performance improvement associated with AIAO may be in part a function of several other procedures that AIAO makes possible. The AIAO system does require more labor for cleaning for the short period of time between groups. It also dictates attention to the breeding schedule, and facility use and off-schedule farrowings/weanings can be problems. All-in–all-out pig flow was used in 60% of the studied facilities and of the variables we considered, it was the most important one related to preweaning mortality.

Sharing the farrowing unit with other activities

Producers were asked whether the farrowing building was used exclusively for farrowing or whether it housed any other farm activity, but we did not ask the nature of the co-located activity. We speculated that a multipurpose building might compromise biosecurity, bringing more traffic and visitors or increasing the chance of disease through exposure to older pigs. The presence of other activities may indicate that the facility was not originally designed as a farrowing facility, or it could indicate a lack of dedication to raising hogs; using a modern confinement farrowing unit, typically the most expensive facility on a per-animal-space basis, for a secondary farm enterprise could be difficult to justify from the standpoint of cost. Managers in the survey indicated that 82% of the farrowing facilities were used exclusively for farrowing. Although conventional wisdom would give preference to exclusive use for farrowing, we could not identify any effect on preweaning mortality from sharing the facility.

Cleaning and disinfection

We investigated the frequency and the regimes for cleaning and disinfecting to explore the associations of the various methods with preweaning mortality in our management model because Yeske, et al., found it to be significant in their analysis.[10] Because residual organic material inactivates many commonly used disinfecting agents, the use of a high pressure-type washing unit facilitates the physical removal of debris necessary for the disinfectant to be used effectively.[16] In itself, complete cleaning reportedly removes 95% of the contamination and permits disinfectants to more easily penetrate and kill remaining microorganisms.[17] It would seem that the thoroughness and regularity of the cleaning and disinfecting are important factors in managing the farrowing unit to control infectious diseases. Producers were asked to characterize their cleaning procedures with respect to using water at normal pressure, high pressure, with and without a disinfectant. They were also asked whether the farrowing facilities were cleaned between every group, to give an indication of the regularity of the cleaning. The frequency of cleaning is a separate variable to test the importance of cleaning after every farrowing. Our analysis shows that cleaning, regardless of the technique used, is important in controlling preweaning mortality.

Period of vacancy

Allowing the farrowing unit to stand idle for 3 or more days between farrowing was identified by Yeske, et. al., as associated with lowering preweaning mortality.[10] The length of time that the farrowing unit stands vacant between farrowing groups may affect the number of pathogens surviving in the environment to perpetuate disease problems. To maximize facility use, many managers schedule groups tightly, allowing very little time empty. In some cases one farrowing group may be weaned, the facility cleaned and disinfected, and refilled with the next group of sows within the same day. A common recommendation is to allow the unit to dry after cleaning and disinfecting before moving in the next group of sows. An unknown factor is the ambient temperature within the unit at the time it is vacant. An increase in the ambient temperature increases the activity of most disin-

Table 3

The average facility prevalence of the management practices in the 703 confinement farrowing facilities studied

Practice	Prevalence
Sow prefarrowing management	
E. coli vaccination	31%
Erysipelas vaccination	17%
C. perfringens vaccination	15%
TGE vaccination	18%
Rotavirus vaccination	10%
Deworming	40%
Mange/lice treatment	34%
Sow farrowing management	
Washed entering farrowing house	39% of sows
Given oxytocin at farrowing	27% of sows
Piglet management	
Fed supplemental milk	6% of piglets
Given supplemental iron	97%
Farrowing house management	
Facility used only for farrowing	82%
Facility operated all-in–all-out	60%
Record-keeping	
Computer-based records	39%

fectants[18] and shortens the survival of many pathogens in the environment.[19] It is possible that a 2-day vacancy in the summer may be more effective than a week in the cold of winter.

From the aspect of breaking the disease cycle, it also seems that the significance of the time vacant would decrease as the effectiveness of cleaning and disinfecting increased. It would be logical to find the longer vacancy (> 2 days) to be associated with reduced preweaning mortality.

Managing gestating females

Washing the sow with mild soap and water when she is moved to the farrowing house physically removes debris that may be carried on the sow from the gestation area. Soil and fecal material adhered to the sow may contain ova of internal parasites (such as ascarid ova) and bacteria or their spores (*Clostridium perfringens*) which would contaminate the farrowing environment and be the source of piglet infection. The benefits of cleaning the farrowing house, prefarrowing deworming, and antibiotic therapy would be partially negated if the sows brought in the contamination on their skin. Thirty-nine percent of the sows included in this study were washed at the time they were placed in the farrowing house. While this variable was the last of the six variables to enter Model III, we found sow washing to be associated with lowered preweaning mortality in all three models.

Prefarrowing vaccination

In the 703 confinement facilities, an average of 31% of the pregnant females were routinely vaccinated using a product to prevent *Escherichia coli* scours in piglets (Table3). The other frequently used vaccines in gestating sows included transmissible gastroenteritis (TGE), *C. perfringens*, and rotavirus.[20] Vaccinating against erysipelas was frequently practiced but may not affect preweaning mortality because nursing pigs are seldom affected.[21] The common use of erysipelas vaccine prefarrowing may be largely a function of its inclusion in numerous multivalent vaccines.

The benefits of using either TGE vaccine and rotavirus vaccine varies greatly from farm to farm. The value of TGE vaccinations has been questioned in herds where the dams have not been exposed to the field virus.[22] The protection provided by rotavirus vaccines has not been consistent.[23] While we found the use of these vaccines tend to reduce mortality, the difference was not significant for either.

We did not attempt to correlate vaccine use with the presence of the disease on the farm. It would seem that if the vaccine is used to combat an existing disease problem, the potential to reduce preweaning mortality would be greater than when a vaccine is administered as defense against a problem not currently existing in the herd. The survey did not question producers on their rationale for vaccine use, but did ask producers to report diseases in their herds. We can speculate that some producers may have under-reported disease problems, because Ott found that producer-reporting of diseases increased with the sophistication of their record keeping system;[24] more than 60% of the 703 facilities did not use computerized records.

Prefarrowing parasite treatments

Routine treatments to rid pregnant sows/gilts of internal and external parasites in the last 2 weeks before the expected farrowing date were also recorded in the National Swine Survey. It is a common practice to treat the sows in late gestation to minimize contamination of the farrowing crate, the habitat of the piglet. In this way, piglets remain essentially free of internal and external parasites as long as they are kept in clean facilities in the farrowing house and nursery. The routine prefarrowing treatment of sows against internal parasites was reported in 40% of the 703 facilities studied while measures against external parasites were used in 34% (Table 3). We found the difference in preweaning mortality between treated and untreated sows/gilts was not significant in any of the three models.

Oxytocin injections during farrowing

For 27% of the sows in this study, oxytocin was routinely administered in conjunction with farrowing. Prolonged periods of labor beyond the normal 2–4 hours have been shown to increase the number of stillborn and weak piglets delivered.[25,26] To minimize the duration of labor and to correct uterine inertia, oxytocin injections are often recommended in the course of delivery and immediately following to aid in the expulsion of piglets and fetal membranes. Oxytocin may also be used to initiate letdown in cases where milk flow is inadequate to sustain the piglets. Injections of oxytocin did not significantly alter the preweaning mortality in our analysis.

Piglet management

Fostering

The size and number of piglets produced in a given litter can vary considerably. Balancing the number of piglets with the ability of the sow to feed them is a way to reduce the number of piglets suffering from inadequate milk intake. Fostering is also used to reduce the size variation of piglets within the litter. The variation of piglet size within the litter has been reported to be a cause for high mortality among the smaller piglets as the smaller piglets are often not able to compete with larger littermates for teats.[27] Most fostering is done in the first 24 hours after birth. In our univariate analysis (Model I), preweaning mortality was significantly lower where fostering was used. Fostering failed to significantly affect preweaning mortality in either multivariate analysis.

Supplemental iron

Newborn piglets reared away from dirt frequently develop anemia because the growth demands for dietary iron are not met by sow's milk. While the use of injectable iron is regarded as more satisfactory than oral preparations,[28] the use of either was considered a positive response in the National Swine Survey. It is likely that many farms used a combination of routes because injectable iron was in short supply or unavailable in many regions of the nation during part of the survey period.[29] Administering supplemental iron is the most commonly practiced procedure we found in variables studied with 97% of the piglets receiving iron as a routine procedure. With only 3% of the piglets not receiving supplemental iron, we failed to show any significant difference in preweaning mortality among those receiving supplemental iron and those that didn't.

Feeding supplemental milk

Supplemental milk can be offered to nursing piglets as a way of meeting the nutritional requirements of the litter when the sow is not producing sufficient milk. This process should reduce the number of piglets affected by malnutrition or starvation. A disadvantage of supplemental feeding of milk is that pigs ingesting milk replacer do not have the benefit of immunoglobulin A (IgA) protection against pathogens in the gastrointestinal tract as do piglets consuming sow's milk. Six percent of the piglets received supplemental milk and we were unable to detect any difference in piglet mortality.

Record-keeping method (management ability)

While the keeping of records in and of itself would not be expected to reduce preweaning mortality, the sophistication of records system can be used as a proxy for managerial attention to detail. Also, analyzing and evaluating accurate records provides producers with information that enhances decision making that can result in lower preweaning mortality. We categorized those producers who use either a computer-based or bureau-based record system as having an advanced record-keeping system. Producers indicating their records were kept only in a diary or on a calendar did not qualify as having advanced records.

Farm size and region

Because of regional differences in climate, feed supplies, markets, and other intrinsic factors, producers often believe that they have an advantage or disadvantage related to the region of the country in which they operate. Likewise, producers often hold the size of the farm responsible for their ability or inability to achieve economy of scale and production efficiency. To determine whether location or farm size were related to preweaning mortality, these two variables were forced into the regression in Model II and Model III as they did not enter on their own merit. We were unable to demonstrate any significant difference in preweaning mortality related to either farm size or region of the country although we did find that a higher percentage of large farms used computerized records and made more frequent use of fostering than did the small farms.

Implications

- Minimizing exposure of suckling piglets to pathogens would be an integral part of controlling preweaning mortality, with the keystone being AIAO.
- We found no significant reduction in preweaning piglet mortality associated with certain practices commonly regarded to be part of good management practices, namely prefarrowing vaccination and deworming/delousing, supplemental milk, and iron.
- Fostering and use of advanced records were significant ($P < 0.1$) only in the independent regression, failing significance in both the multivariate analysis with farm size and region forced-in (Model II) and when considered with the facility variables (Model III). Some of the variables may be associated with measures of production efficiency other than preweaning mortality and deserve more study in themselves.
- While there is generally room for further reduction of preweaning mortality, the amount of benefit for the cost incurred is the limiting factor and varies from farm to farm.

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