Perinatal mortality in 48 North American swine herds

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Summary: *Retrospective data from 48 herds were selected from a database of swine farms located in the United States and Canada. Perinatal mortality, defined as stillbirths and deaths that occur within 24 hours of birth, was recorded by producers. On average, 6.8% of all piglets were stillborn. Of piglets born alive, 3.9% died within 24 hours of birth (day 0). Stillbirths and day-0 mortality varied with litter size. The highest perinatal mortality rates were recorded for very small (fewer than four piglets) and very large (>17 piglets) litters. Stillbirth percentages accounted for most of the variation among total born litter sizes. Overall, perinatal deaths increased as parity increased. However, day-0 mortality did not vary with parity, except for sows with a parity greater than seven. When considering the number of birth events on each day of the week, the highest mortality percentage was recorded on Monday. Most of the difference between Monday and the other days of the week could be attributed to day-0 mortality of liveborns. The influence of day of the week on the probability of being stillborn was virtually non-existent. Over half of all perinatal mortality (51.3%) could be attributed to only 13.2% of the litters.*

The major portion of total preweaning losses occur during the perinatal period.[1] When stillbirths are included, approximately 5%-10% of all pigs born are typically recorded dead by the end of the first day postpartum.[2] This often represents over 50% of the mortality that occurs before weaning.

Stillbirths are pigs that die shortly before or during parturition. The majority of stillborn pigs die intrapartum (i.e., sometime during the farrowing process). Early postpartum deaths are those that occur within 24 hours after birth (i.e., on day 0). Unless a necropsy is performed, it is often difficult to differentiate pre- or intrapartum deaths from early postpartum deaths. About 10% of pigs recorded as stillbirths by producers were alive at birth.[3] Such misclassifications were as high as 40% on one farm.[4] This is as expected, since about 39% of all preweaning mortality occurs prior to the first observation of the litter.[5]

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Day-0 mortality may be due to a number of different causes or combinations of causes, including:

- piglets born weak or undersized, and subsequently starving;
- piglets that die after becoming chilled; and
- those that die after being laid on or traumatized by the sow.[6]

Because producers are usually not able to intervene to improve the chances of piglet survival, it is commercially advantageous to develop a better understanding of the risk factors that influence piglet survival. Many practitioners assume that perinatal mortality is a greater problem in large litters, litters born to older sows, or litters farrowed on the weekend (Saturday and Sunday). In this study, we used PigCHAMP® data to test these assumptions.

Materials and Methods

We defined perinatal mortality as stillbirths and as death of liveborn piglets within 24 hours of farrowing (i.e., on day 0).

Retrospective data from 48 herds were selected from the PigCHAMP® database of 431 swine farms located in the United States and Canada. Data were collected between January 1986 and December 1987. The farms studied were not randomly selected herds but were recruited to fulfill certain criteria described elsewhere.[7] In summary, 48 of 431 herds were selected based on five criteria:

- at least 12 months of production data recorded using PigCHAMP®;
- a minimum, on average, of 10 farrowings per month;
- less than 10% difference between the number of pigs recorded dead by the producer and the result of the equation "number of piglets liveborn + net fostered - number of piglets weaned." The data used for this equation were also recorded by producers;
- producers were required to respond to a mailed questionnaire (Table 1) which we used to characterize the producer's recording strategy of mortality events; and
- the number of pigs recorded weaned by producers had to equal the number weaned calculated by using other data provided by the producer: number of pigs liveborn + net

Table 1

Questionnaire information for 48 North American swine herds

Question	Response	Number of herds (%)
Location of operation	Canada	6 (12.5)
	Nebraska or Kansas	7 (14.6)
	Minnesota, Iowa, Illinois, Indiana, or Ohio	31 (64.6)
	Virginia or Georgia	4 (8.3)
Primary person in charge of farrowing section	Owner	17 (35.4)
	Spouse or children	6 (12.5)
	Employee(s) (nonfamily members)	25 (52.1)
Person in charge during weekend	Same as during week	16 (33.3)
	Different person from week	4 (8.3)
	Rotating schedule among personnel	23 (47.9)
	Different person only during vacation	5 (10.4)
Consider all piglets found dead behind sow on farrowing day as stillborn	Yes	15 (31.3)
	No	33 (68.7)
Piglets found dead in the morning recorded as dying on...	Preceeding day	2 (4.2)
	Same day	41 (85.4)
	Depends on appearance	5 (10.4)

fostered – mortality events. An agreement between the number recorded weaned and calculated weaned was required for at least 85% of the litters.

The average size of the selected herds was 284 sows (median = 208 sows; range: 68–1576).

Perinatal mortality was calculated as follows:

$$\frac{\text{Stillborn + Day-0 Mortality}}{\text{Stillborn + Liveborn}} = \text{Perinatal mortality}$$

The average mortality percentages for the two components of perinatal mortality were determined using these formulas:

$$\frac{\text{Stillborn}}{\text{Stillborn + Liveborn}} = \text{Stillborn \%}$$

$$\frac{\text{Day-0 deaths}}{\text{Liveborn}} = \text{Day-0 mortality}$$

The information was reported in the form of basic descriptive statistics (mean, standard deviation, median, range). To control for piglets at risk, we compared proportions instead of raw mortality data and used the Bonferroni method of multiple comparisons to compare among means.[8]

Results

Questionnaire

The questionnaire solicited data on location, person in charge, and recording strategy (Table 1).

Perinatal mortality

On average, 6.8% (SD = 1.9; median = 6.6) of all piglets were stillborn. The percentage of stillborn piglets per herd ranged from 3.9%–12%. Of all piglets born alive, 3.9% (SD = 2.9; median = 3.2) died on day 0. The percentage of mortality among liveborn on day 0 ranged from 0.3 to 15% depending on the herd. Day-0 mortality represented 25% of all preweaning deaths recorded among liveborn piglets.

Relationship between perinatal mortality and litter size

Stillbirths and day-0 mortality varied with litter size (Figure 1). The relationship seemed curvilinear, with the highest mortality percentages recorded in the largest litters (>16 pigs). Stillbirth percentages accounted for most of the variation among total born litter sizes.

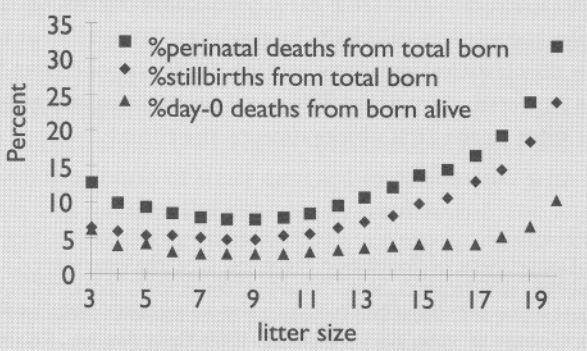
Relationship between perinatal mortality and parity

Overall, perinatal deaths were positively associated with parity. Day-0 mortality remained stable except for sows in their seventh or greater parity. Stillbirth rates increased ($P<.05$) from a low of 5.4% (parity 2) to a high of 10% for the oldest sows (parity >7) (Figure 2).

Day of the week

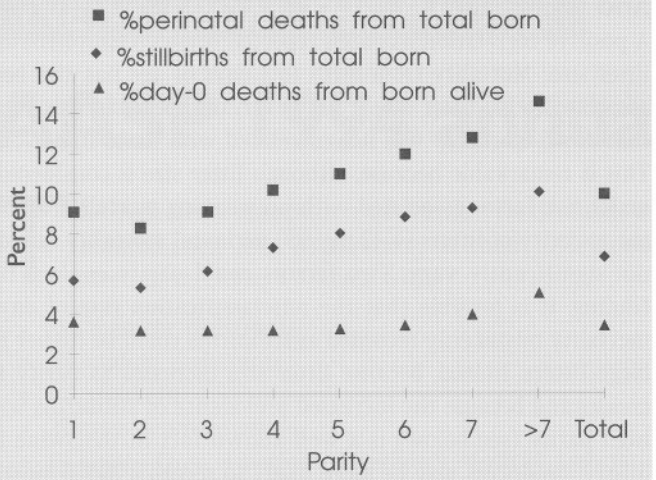
The highest mortality percentage was recorded on Monday. However, when controlling for the number of pigs at risk, the influence of day of the week on the probability of being stillborn was virtually non-existent (Figure 3). The only statistical difference for stillbirths was observed between Friday (lowest risk ratio = 0.93) and Monday and Tuesday (highest risk ratios of 1 and 0.99, respectively) ($P < .05$). A greater variation in risk ratio was found for day-0 mortality (lowest risk ratio on Wednesday = 0.86; highest risk ratio on Monday = 1). Although, as for stillbirths, there was no difference between Monday and Tuesday, Monday's risk ratio for day-0 mortality was significantly higher than for the other 6 days of the week ($P < .05$).

Figure 1



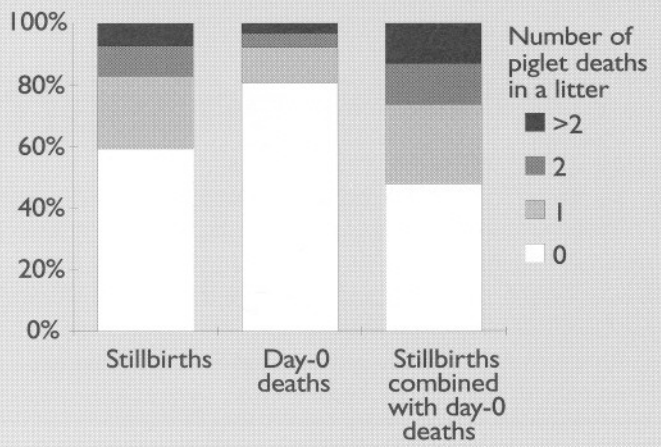
Perinatal mortality is associated with litter size.

Figure 2



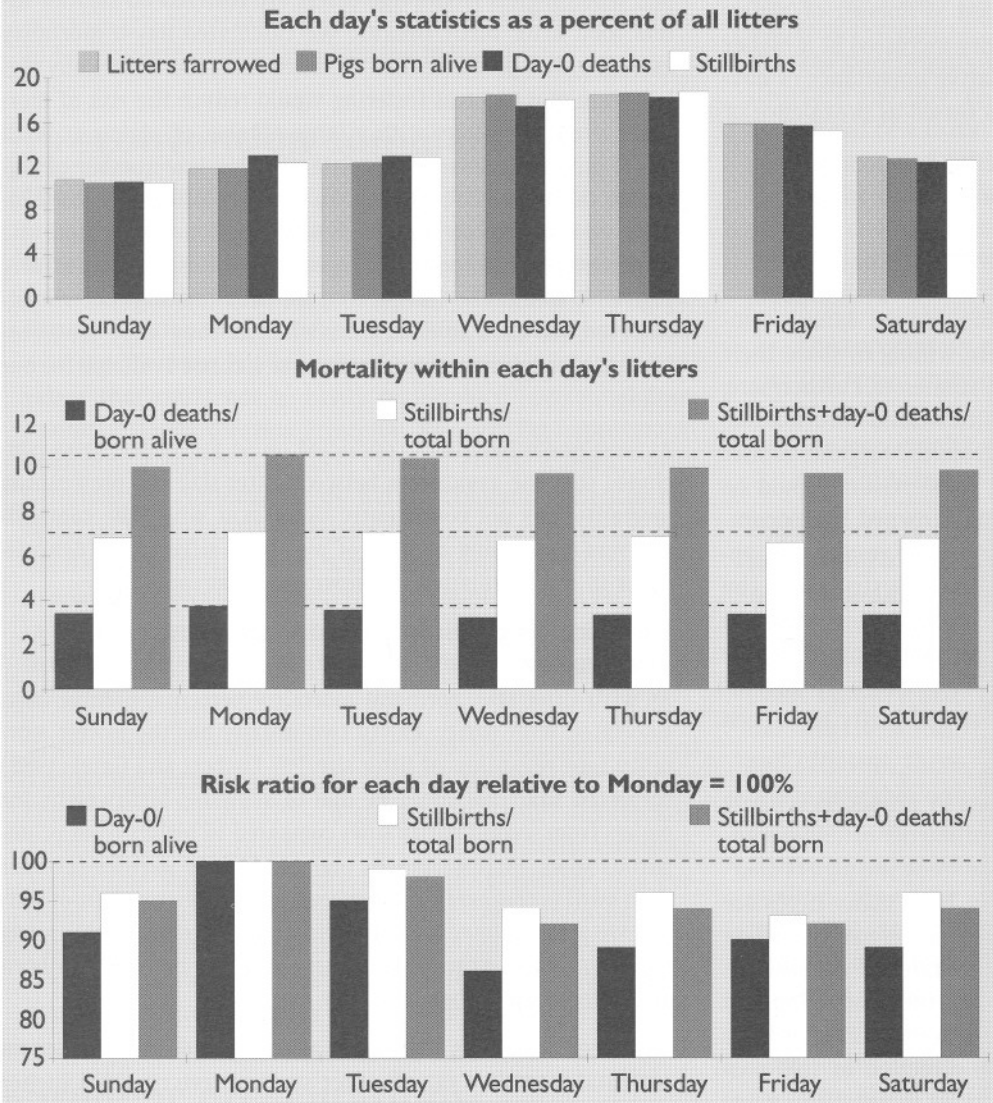
Relationship between perinatal mortality and parity.

Figure 4



Distribution of the litter prevalence of perinatal mortality by number of piglet deaths in a litter.

Figure 3



Relationships between perinatal mortality and day of the week. Source data may be found in the Appendix at the end of the manuscript.

Thus, most of the difference in perinatal mortality between Monday and the other days of the week could be attributed to mortality among liveborn piglets.

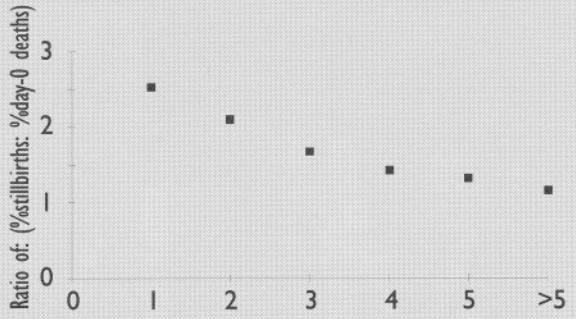
Distribution of the within-litter prevalence of perinatal deaths

Over half of the litters (59.2%) had no stillbirths (Figure 4). About one third of all stillbirths (32%) were from litters that had only one stillborn piglet. The remaining stillborn piglets (68%) were from 17.3% of the litters included in the study, all of which had two or more recorded stillbirths.

Eighty percent of the litters had no day-0 mortality events among liveborn piglets (Figure 4). Litters that had only one day-0 death contributed to about one-third of recorded deaths (34%). The other two-thirds of day-0 mortality came from only 7.8% of the litters.

When stillbirths and day-0 mortality were considered together (perinatal mortality), 47.8% of the litters had neither mortality event recorded. Over half of all perinatal mortality (51.3%) could be attributed to only 13.2% of the litters. Each of these litters had a minimum of three perinatal deaths.

Figure 5



Relationship between stillbirth:day-0 death ratio and number of perinatal deaths per litter.

The % stillbirth : % day-0 mortality ratio ranged from a high of 2.5 for litters with one mortality event during the perinatal period to a low of 1.2 for litters with more than five recorded deaths. The change in this ratio indicated that although both stillbirths and day-0 mortality increased as number of piglets recorded dead increased, day-0 mortality increased at a higher rate (Figure 5). In other words, the relative importance of day-0 mortality compared to stillbirths increased as prevalence of total perinatal mortality increased.

Discussion

Limitations of the study

Herds were not selected at random. The original dataset comprised only PigCHAMP® users who were willing to share their production data with the University of Minnesota. Furthermore, because of the selection process for litter-based information, only about 11% (48/431) of the herds from the original dataset could be used for the analysis. Thus, these results should be interpreted and generalized only to herds owned by cooperative, record-conscious producers. However, the results may apply to the entire North American swine industry, since the perinatal mortality values of these herds were comparable to those observed in typical North American swine units.[9,10,11,12] The curvilinear relationships between perinatal mortality and litter size, and between perinatal mortality and parity have been previously reported.[13,14]

The misclassification of mortality events by producers is likely to obscure the relationship between stillbirths or day-0 mortality and factors such as the "day of the week the piglets died". This is particularly the case when data from many herds are analyzed together, as in this study. The results from this study suggest that several different recording strategies are possible. However, by questioning those recording the production and health information for a given farm, practitioners should be able to determine the extent and the direction of this misclassification. Such knowledge can sharply increase the value of producer-recorded data.

Relationship between perinatal mortality and litter size

A positive correlation has been reported between stillbirths and litter size.[1] Mortality from birth to 3 days of age has also been associated with litter size.[13,15] However, it appears in this study that day-0 mortality was not correlated with litter size (r=.48). This is remarkable because, although litter size is considered a major risk factor associated with preweaning mortality, among the majority of litters (4–12 piglets) perinatal mortality rate did not significantly vary. Two factors could partly explain this finding. It is possible that the misclassification rate of day-0 mortality mistakenly recorded as stillbirths could be higher for large litters. Indeed, because litter size increases as parity increases and because the increased prevalence of stillbirths with high parity (see below) is a well-known fact in the swine industry, producers may be more likely to record a day-0 mortality event as a stillbirth for litters from old sows.

Cross fostering could also have reduced the magnitude of the association between litter size and mortality. This would happen when piglets from large litters are fostered on smaller litters soon after birth. Because we calculated day-0 mortality assuming that producers had recorded litter size before any piglets were moved, cross fostering would reduce the risk of mortality events in litters with a large number of piglets at birth while increasing this risk for litters with a low number of piglets at the time of farrowing. To actually determine the benefits of cross fostering, we would need to *know* that the producers recorded perinatal mortality *before* they moved any piglets. It would also be best to trace back the origin of all piglets recorded dead to determine whether they were cross fostered. Unfortunately, this information was not available for our study.

At least one other study conducted on 54 European farms concluded that the association between litter size and preweaning mortality was not consistently significant when the comparison was made using number of pigs born alive as the denominator in the calculation of preweaning mortality.[15]

Relationship between perinatal mortality and parity

As with litter size, perinatal mortality percentages have been associated with parity. Parity two usually has the lowest mortality rate, regardless of litter size.[15,16,17] Lucbert and Gatel (1988) suggested that this could be due to a higher birthweight for piglets from second-parity sows compared to piglets from primiparous sows. Birthweight in piglets of older parities (greater than two) is comparable, on average, to the birthweight of parity-two piglets. However, the variability of birthweights among piglets increases as parity increases, and this increase has been associated with higher mortality rates.[18]

While one study has reported that parity had no influence on perinatal mortality rates,[19] other studies have reported higher mortality rates in older sows, especially in sows with more than seven parities.[15,16]

Most of the changes in perinatal mortality associated with parity could be attributed to changes in the stillbirth percentage. As mentioned above, stillbirth rates have long been known to be associated with parity. Older sows are thought to have more stillbirths because parturition is often prolonged. Indeed, after correcting for the linear increase in mortality as parturition time increases, the stillbirth rate in one study was reported to be independent of the age of the sow.[20] Therefore, when controlling for confounding factors, such as duration of parturition, the association between parity and perinatal mortality is likely to be weak.

Day of the week

The increase in mortality among liveborn on Monday could be explained by pigs dying on Sunday (or during the weekend) but not actually being recorded until Monday. A high proportion of herds had hired help. Some herds had a different person in charge during the weekend than during the work week. On approximately half of the farms, regular personnel followed a rotating duty schedule during the weekend so there were probably fewer workers on the weekends (Table 1). However, even assuming that the difference between Monday and the other days of the week was not the result of recording bias, the biologic and economic significance of this difference remains questionable.

Stillbirth rates decrease when sows are supervised during farrowing.[18] The fact that perinatal mortality rates did not significantly differ by day of the week suggests that the proportion of farrowings attended did not change on these farms throughout the week. Therefore, we can conclude that without adjusting for any other factors, the day of the week the pigs were born was not likely to have a major impact on perinatal survival. This, of course, does not exclude the possibility of an extreme case where a producer would clearly be negligent during the weekend. The results of this study suggest that one should consider such factors as low temperature or temperature variation during the perinatal period, housing, and farrowing equipment before concluding that high perinatal mortality is due to the "weekend factor."

Distribution of within-litter prevalence of mortality

A minority of litters was responsible for most of the perinatal mortality. The percentage of litters (17.3%) with at least two stillborn piglets (i.e., two-thirds of the stillbirths) was identical to the percentage of litters responsible for 66% of stillborn piglets in a previous study.[21] Most stillbirths occur in a small percentage of sows: Svendsen, et al., observed that 75% of all stillbirths occurred in only 25% of the litters.[20] They also observed that over 50% of the stillborn piglets were from litters that had two or more stillborn piglets.

A small percentage (7.8%) of litters was responsible for approximately two-thirds of the total mortality among liveborn piglets on day 0. This is especially remarkable considering that deaths on day 0 were responsible for nearly 25% of the entire mortality among liveborn piglets during the preweaning period. Detecting sows most at risk of increased perinatal mortality could noticeably reduce the overall mortality rate. However, there is no well-established means at present for detecting these sows. Based on our results and on the literature, we recommend that one pay special attention to:

- older sows;
- large litters;
- litters with low birthweight piglets;
- litters with a wide variation in birthweight; and
- litters that have had several piglets fostered on.

It is also important to pay special attention to sows that are experiencing prolonged farrowings. The likelihood of a similar performance from one parity to the next for sows that have experienced high perinatal mortality (>2 deaths) has never been studied carefully. Given the importance of these sows relative to preweaning mortality, it is certainly an area of investigation worth pursuing.

Implications

- When perinatal mortality is high, it is likely that many of the piglets were actually born alive and it is probably worth pursuing efforts to save these pigs.
- Although the "weekend factor" is statistically significant, it is not as likely to be a problem as parity or litter size in determining perinatal mortality.

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Appendix

Data used to construct Figure 3

Day of the week	Litters farrowed	Pigs born alive	Day-0 deaths	Stillbirths	Day-0 deaths/ alive	Stillbirths/ total born	Stillbirths+ deaths/ total born
Sunday	10.8	10.5	10.6	10.5	0.91 ab	0.96 abc	0.95 ab
Monday	11.8	11.8	13.0	12.3	1.0 c	1.0 b	1.0 c
Tuesday	12.2	12.3	12.9	12.8	0.95 bc	0.99 bc	0.98 bc
Wednesday	18.2	18.4	17.4	18.0	0.86 a	0.94 ac	0.92 a
Thursday	18.4	18.6	18.2	18.7	0.89 ab	0.96 abc	0.94 ab
Friday	15.8	15.8	15.6	15.2	0.90 ab	0.93 a	0.92 a
Saturday	12.8	12.6	12.3	12.5	0.89 ab	0.96 abc	0.94 ab
Total	100	100	100	100	*Risk of dying on day x : risk of dying on Monday*		

Numbers within the same column with the same letter are not statistically different, $P > 0.05$

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