ORIGINAL RESEARCH

Preweaning morbidity and mortality in the United States swine herd

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Summary— *In the first comprehensive, national effort to explore the scope and severity of swine disease and mortality, the USDA National Animal Health Monitoring System (NAHMS) conducted a National Swine Survey to gather data on preweaning morbidity and mortality in the United States swine herd. States were chosen on the basis of prior involvement in NAHMS programs and on the percentage of the nation's hogs they contained, so that the states selected to participate represented 95% of hogs in the nation. Data collectors and producers were trained to enhance the likelihood that the data was valid. The most common cause of preweaning morbidity was scours, 42% of which occurred during the first 3 days postpartum. The most common causes of mortality were trauma (causing 43.2% of mortality), starvation (causing 20% of mortality), "unknown" causes (13.1%) and scours (10.8%). These common morbidity/mortality causes all suggest that management factors are responsible for the majority of preweaning morbidity/mortality in the United States swine herd.*

Preweaning morbidity and mortality diminish swine production efficiency and are a source of opportunity cost for producers. The ubiquitous nature of preweaning mortality (which hovers around 15% in the large swine industry databases [PigCHAMP®, Swine Graphics® and PigTales®]) seems to desensitize some producers to its economic consequences. Diseases that cause neonatal losses are endemic in most swine herds. The impact of many of these diseases, however, may well be minimized by improving management. The United States swine industry must:

- determine the reasons for preweaning morbidity and mortality; and
- make the appropriate management changes to improve production efficiency.

The National Animal Health Monitoring System (NAHMS:USDA:APHIS:VS)— in cooperation with state livestock officials, the Cooperative Extension Service, universities and the swine industry— conducted a National Swine Survey to gather data on a wide variety of aspects of swine production in the United States. The data were used to suggest how management factors may affect preweaning death and disease. This is the first comprehensive, national effort to explore the scope and severity of disease in the United States swine herd.

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This is the first in a six-part series of articles that describe and/or analyze the results of the NAHMS National Swine Survey.

Methods

Sample selection

Data collected from the NAHMS National Swine Survey were used to estimate the number of piglet mortalities in the United States in 1990. The NAHMS program was actively involved in 13 states (Alabama, California, Colorado, Georgia, Iowa, Illinois, Maryland, Michigan, Ohio, Oregon, Tennessee, Virginia and Wisconsin) prior to the swine study (Fig 1). For design purposes, these states were preselected to maintain the investment already in place. Additionally, a prior commitment was made to include Indiana because of its large swine population. These 14 states were then considered part of the swine study and included regardless of their swine populations. All of the remaining states that had an average of 2% or more of the nation's herds and hogs were made eligible to be in the program. Ten additional states met this criteria. Due to budget priorities, only four states (Minnesota, Nebraska, North Carolina and Pennsylvania) were randomly selected from the group of ten. It was NAHMS's goal to achieve 70% hog farm representation. The 14 certainty states and the four probability-selected states represented 84% of United States swine operations and 95% of the hogs in the nation.

NAHMS selected herds within states using the multiple-frame sampling technique of the National Agricultural Statistics Service (NASS). The sample size was chosen to provide a margin of error of ±1%, assuming an expected prevalence of 50%, for most management factors. The NASS list stratification for swine is based on approximate herd size (i.e., total inventory). The herd-size groupings vary by state in accor-

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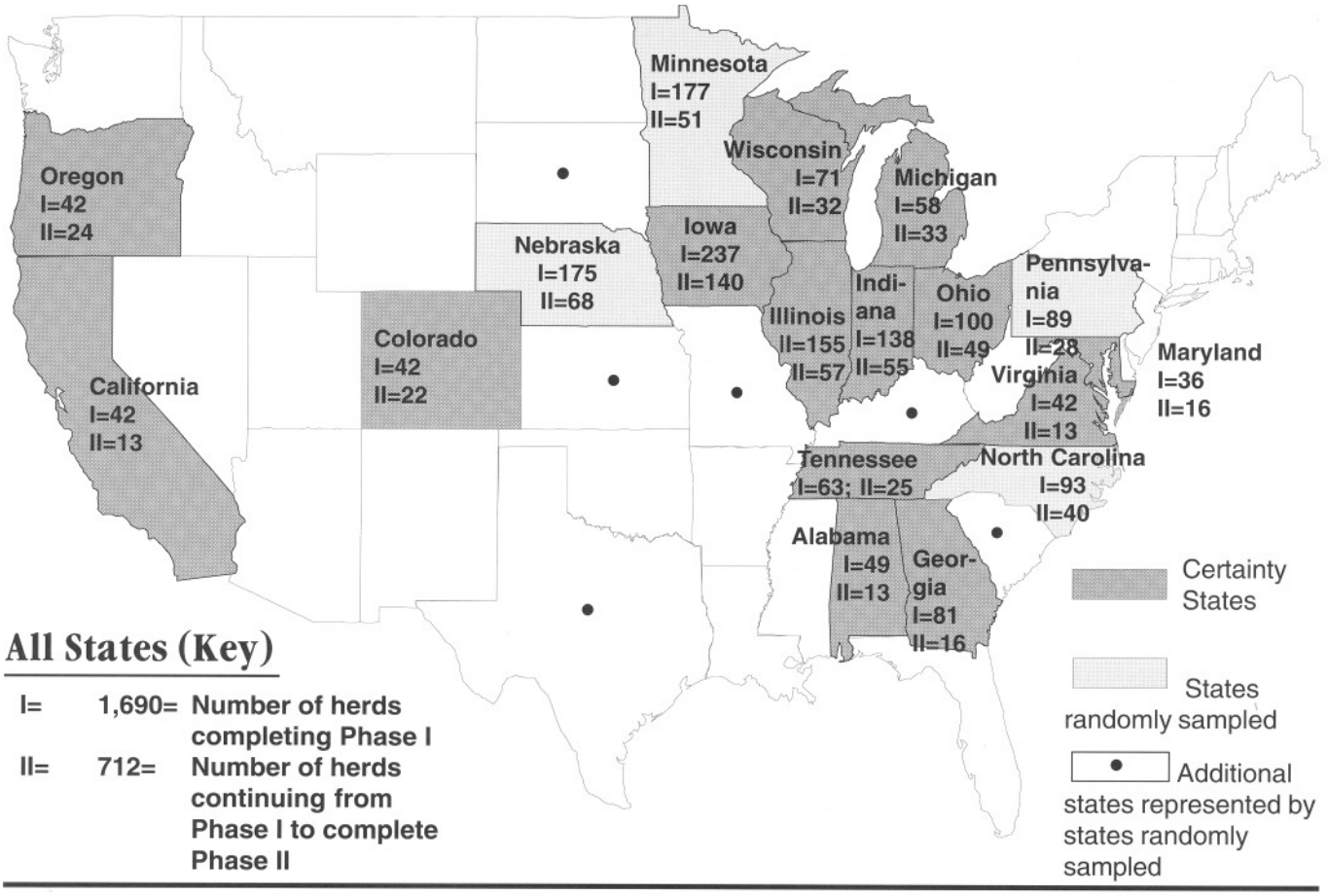

Survey Timeline

1988–1989

Information needs assessment
- — Study design
- — Development of data collection instruments

January, 1989

NASS contacted 70,000 producers for *Quarterly Hogs and Pigs Report* data.

October–November, 1989

Staff training:
- — NAHMS staff trains NAHMS coordinators
- — NASS trains enumerators
- — NAHMS coordinators train Veterinary Medical Officers (VMOs)

Training course includes benefits and objectives of the study, swine production, basic epidemiology, interview techniques (questionnaires and data collection methods).

November, 1989

Quarterly data collection begins.

Phase I:

- NASS randomly selects 3184 producers from *Quarterly Hogs and Pigs Report* list. One quarter of this number are contacted each quarter.
- NASS enumerators make initial contact visit to producers, 1690 producers agree to fill out the General Swine Farm Management (GSFM) survey (Phase I). One quarter of this number are contacted each quarter.

Phase II:

- VMOs train producers to collect reliable data.
- Phase II producers are divided into 16 groups, each receiving three monthly VMO visits. Groups are staggered at 2-week intervals.
- 712 (of 1690) producers complete data collection on diary cards for 90–120 days.

Fig 1.— NAHMS National Swine Survey: state sample selection and data collection timeline.

NAHMS-9
(JAN 90)

Farrowing Diary Card (Sow Section)

Form Approved
O.M.B. Number 0579-0079
Approval Expires 12/31/91

State [ ][ ] Facility Name _____ Parity/Litter Number [ ][ ]

Farm Number [ ][ ][ ][ ] Facility Number [ ][ ] Sow Number [ ][ ][ ][ ]

Instructions:

1. Monitor one sow and litter per card.
2. Observe the sow until she is re-bred, culled, dies, the study period ends, or for a specific reason she can no longer be monitored.
3. Date and check each health problem observed and activity performed.
4. Only record new cases.
5. If the sow and litter are moved to a new location prior to weaning, give the date moved.
6. If the sow is culled or dies, record date and check the reason or cause.

A Dates (MM/DD/YY)

Bred (exposed) _____
Entered Farrowing _____
Farrowed _____
Moved to Preweaning _____
Weaned _____

(Check 1 reason for exiting the survey and enter date)

Re-Bred	A	[ ]
Culled	B	[ ]
Died	C	[ ]
End of Study	D	[ ]
Drop Out	E	[ ]

Date _____

Comments:

B New Treatment or Prevention Activities

Date (MM/DD)										
Vaccinate	B01	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Deworm	B02	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Mange/Lice Treatment	B03	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Antibiotics:										
in feed	B04	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
in water	B05	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
injection	B06	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Coccidiostats	B07	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Other treatment	B99	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

C New Health Problems

Date (MM/DD)							
Reproductive:							(Check 1)
Farrowing Problem	C01	[ ]	[ ]	[ ]	[ ]	[ ]	D01 [ ]
Other	C02	[ ]	[ ]	[ ]	[ ]	[ ]	D02 [ ]
Respiratory System	C03	[ ]	[ ]	[ ]	[ ]	[ ]	D03 [ ]
Lame or Joint	C04	[ ]	[ ]	[ ]	[ ]	[ ]	D04 [ ]
Scours	C05	[ ]	[ ]	[ ]	[ ]	[ ]	D05 [ ]
Milk Problem	C06	[ ]	[ ]	[ ]	[ ]	[ ]	D06 [ ]
Other Known	C99	[ ]	[ ]	[ ]	[ ]	[ ]	D99 [ ]
Unknown	C98	[ ]	[ ]	[ ]	[ ]	[ ]	D98 [ ]

D Death

(Check 1)

E Cull

(MM/DD) _____

		(Check 1)
Age	E01	[ ]
Failure to Breed	E02	[ ]
Disease	E03	[ ]
Lame	E04	[ ]
Size	E05	[ ]
Performance	E06	[ ]
Other	E99	[ ]

Farrowing Diary Card (Litter Section)

Instructions:

1. Observe piglets until weaned.
2. Only record new cases.
3. Date and record number of piglets observed for each health problem and activity performed.
4. Record number of dead piglets by cause of death.

F Number of Piglets Born

Alive _____
Stillborn _____
Mummies _____
Total _____

G First Day Inventory

Complete Section G only if this diary card is being initiated on the 1st day of the study.

Date (MM/DD/YY) _____
Number of Piglets _____

H Number of Piglets Fostered

Date (MM/DD) ____ ____ ____
Number In ____ ____ ____
Number Out ____ ____ ____

Number of Piglets Weaned

Date (MM/DD) ____ ____ ____
Number ____ ____ ____
Average Weight ____ ____ ____

I Number of New Treatment or Prevention Activities

Date (MM/DD)						
Vaccinate	I01					
Deworm	I02					
Mange/Lice Treatment	I03					
Clip Teeth	I04					
Dock Tails	I05					
Castrate	I06					
Iron Shots	I07					
Antibiotic Shots	I08					
Antibiotic Oral	I09					
Coccidiostats	I10					
Other treatment	I99					

J Number of New Health Problems

Date (MM/DD)							
Scours	J01						
Nervous System	J02						
Deformity	J03						
Lame or Joint	J04						
Respiratory	J05						
Other Known	J99						
Unknown	J98						

K Number of Piglet Deaths

Date (MM/DD)						
Scours	K01					
Nervous System	K02					
Deformity	K03					
Lame or Joint	K04					
Respiratory	K05					
Other Known	K99					
Unknown	K98					
Laid On	K06					
Starve	K07					

Fig 2.— Farrowing diary card, front and back.

Table 1.— Descriptive characteristics and findings from 712 farms participating in the 1990 National Swine Survey

Female breeding herd size*	No. of farms
0–49	181
50–99	177
100–499	301
500+	53
Type of operation	
Farrow-to-finish	557
Feeder pig producer	132
Breeding stock producer	20
Grower-finisher†	3
Type of farrowing management	
All-in, all-out	385
Continuous farrowing	327
Animals monitored	**No. of Animals**
Females (sows & gilts)	
Total monitored	33,519
Farrowed during study	27,932
Weaned during study	26,920
Cohort††	21,712
Died during study	216
Pigs	
Total born alive	313,576
Total weaned	224,370
Cohort††, plus net fostered	42,504

*Includes replacement gilts not yet bred, but of breeding age; sows and gilts bred and gestating; sows nursing pigs; sows weaned less than two weeks, but not rebred; and open sows weaned two weeks or more (excludes cull sows).
†These herds participated in the NAHMS study, but did not contribute preweaning morbidity/mortality data.
††Cohort animals are those that farrowed and weaned during the study.

dance with the size characteristics of the swine industry in that state. Except in states with relatively small numbers of hog farms (e.g., Alabama, Colorado, California, Maryland, North Carolina, Pennsylvania, Oregon and Virginia) farms were not eligible to participate in the study if they expected to farrow fewer than 10 litters within the upcoming 3 months. In these cases, slightly less than 100% of the hogs are represented in that state.

Data Collection

Initially, 3184 producers were contacted to participate in the study. The study was conducted in two phases, which were repeated quarterly (Fig 2). In Phase I, 1690 of the 3184 producers agreed to complete a General Farm Management Survey. In Phase II, 712 of the producers agreed to record disease frequency as the number of new cases (death or disease) per litter on diary cards (Fig 3) and complete three additional surveys.

Data Reliability

In an effort to ensure that the data collected were reliable, national staff epidemiologists and swine extension personnel trained veterinary medical officers (VMOs) and NAHMS coordinators. This training included instruction in swine production, basic epidemiology and interview techniques. Trainers used example scenarios and exercises to improve the ability of the data collectors to capture data. VMOs visited and interviewed participating producers before data collection began and during the data collection period, and the VMOs trained producers to record data reliably.

Data Analysis

A protocol was established to standardize data for computer entry. Data were screened to remove or correct entries that were outside expected ranges. A data validation routine was also used to provide consistent examination across all records.[8] For example, a few sows were reported as having weaned 24 pigs. Examination of the diary cards showed that multiple litters were fostered on and off of the sow. These records were deleted for some analyses.

Table 2.— Sows farrowed in 1989 for 18 states in the 1990 NAHMS study

State	Sows farrowed (thousands)	Relative rank	Number of herds in survey
Iowa	2860	1	140
Illinois	1235	2	57
Minnesota*	1005	3	51
Indiana	910	4	55
Nebraska*	895	5	68
North Carolina*	610	6	40
Ohio	466	7	49
Wisconsin	280	8	32
Michigan	268	9	33
Georgia	256	10	16
Tennessee	186	11	25
Pennsylvania*	171	12	28
Virginia	95	13	13
Alabama	61	14	13
Colorado	49	15	22
Maryland	40	16	16
California	31	17	30
Oregon	21	18	24
Total			712

*Source: USDA:APHIS:VS

Frequency of occurrence of morbidity/mortality were converted to a standard denominator (per 100 pigs per week) so that data from small herds could be compared to data from large herds and/or to allow for fluctuations in herd size within the same herd. The data were weighted according to the various sampling fractions. Weighting allows these results to be applied to 95% of the national hog population.

Results

The NAHMS study indicated that the national overall average for preweaning mortality was 15.03% (Table 3). Forty percent of litters, however had no preweaning mortality.

Table 3.— National populations estimates for farrowing and weaning per-litter productivity based on data collected from monitored farms

Measure of Productivity	Cohort Data
Born per litter	10.77 ±0.06
born alive per litter	9.89 ±0.05
percent born alive per litter	91.86% ±0.25
stillborn per litter	0.73 ±0.03
percent stillborn per litter	6.81% ±0.22
mummies per litter	0.14 ±0.02
percent mummies per litter	1.33% ±0.15
Deaths per litter	1.48 ±0.08
percent preweaning mortality	15.03% ±0.83
age at death	5.99 days ±0.16
percent of litters with a death	62.72% ±1.92
Weaned per litter	8.38 ±0.08
percent weaned	84.97% ±0.83
age at weaning	28.79 days ±0.57
weight at weaning	6.96 kg ±0.13

Causes and Age Distribution of Preweaning Morbidity and Mortality

Piglets are most likely to become ill and/or to die during the first 7 days post-parturition (PP) (Figs 4-6).

Morbidity: Scours (undifferentiated diarrhea) was the primary overall cause of morbidity in every age group (Fig 5).

- 42% of all scours cases occurred during days 1-3 PP (7 new cases per week for a producer with an average inventory of 100 pigs); and
- 23% of all scours cases occurred during days 4-7 PP (3.5 new cases per week for a producer with an average inventory of 100 pigs).

Mortality: Thirty percent to 40% of litters had no preweaning mortality. In litters with preweaning mortality, trauma was the main cause in pigs of all ages (43.2%, Fig 6). Starvation caused an additional 20% of pig deaths in all age groups (Fig 6). "Unknown" causes were the third leading cause of piglet mortality across all age groups (13.1%, Fig 6). Scours was the fourth leading cause of piglet mortality, causing 10.8% of all pig deaths, primarily among 4- to 7-day-old and 8- to 14-day-old pigs (Fig 6). The "other known" category, which accounted for 9.8% of mortality across all age groups (Fig 6), elicited so many different responses it was not feasible to develop a separate category in the database for each response, which included, for example, "poor doer," "run over by tractor," "twisted gut," "eaten by sow," and "fell into catfish pond." Preweaning mortality due to all causes was estimated to have killed 16 million United States pigs in 1990.

Influence of sow parity on preweaning morbidity and mortality

Litters from second-parity sows had the lowest mortality rate, while fifth-parity sows had the highest (Fig 7). The percent of litters with piglet mortality increased up through the fifth parity (Fig 7), as did liveborn litter size. Liveborn litter size, however, is recognized as a factor in preweaning mortality.[2,3] Liveborn litter sizes increased as parity increased (Fig 8), with fifth-parity sows having the highest numbers of liveborn pigs. Third-parity sows, however, had the number weaned (Fig 8). Parity effects on liveborn litter size may, therefore, contribute to the effects of parity on preweaning mortality. Future studies using the National Swine Survey data will investigate further the effects of parity and other factors on preweaning morbidity and mortality using multivariate analysis, which is beyond the scope of the present paper.

Discussion

While many investigators have studied piglet mortality, few have examined causes of morbidity. Most previous studies have focused on individual conditions,[4] or have examined

morbidity on individual farms.[5] None have examined morbidity on a broad scale on a number of farms, so it is difficult to compare previous findings to the National Swine Survey data.

Moreover, recent studies have examined the accuracy of using producer-recorded data for research on preweaning mortality.[6,7] These studies, which used the PigCHAMP® database, indicated that if producers are not trained to collect data or lack the benefit of veterinary input, the data is likely to be biased in certain areas. For the National Swine Survey, great care was taken:

- to ensure that the respondent rate represents a statistically valid sampling procedure;
- to train producers to collect valid data;
- to monitor the accuracy of the data; and
- to provide multiple data validity checks.

Therefore, although producer recording errors are still possible, they were minimized as much as economically possible in this study. Efforts to improve the validity of producer observations would have required daily veterinary visits and postmortem examinations. We expect the data that resulted from the NAHMS study may underreport clinical disease and may misclassify some causes of death.

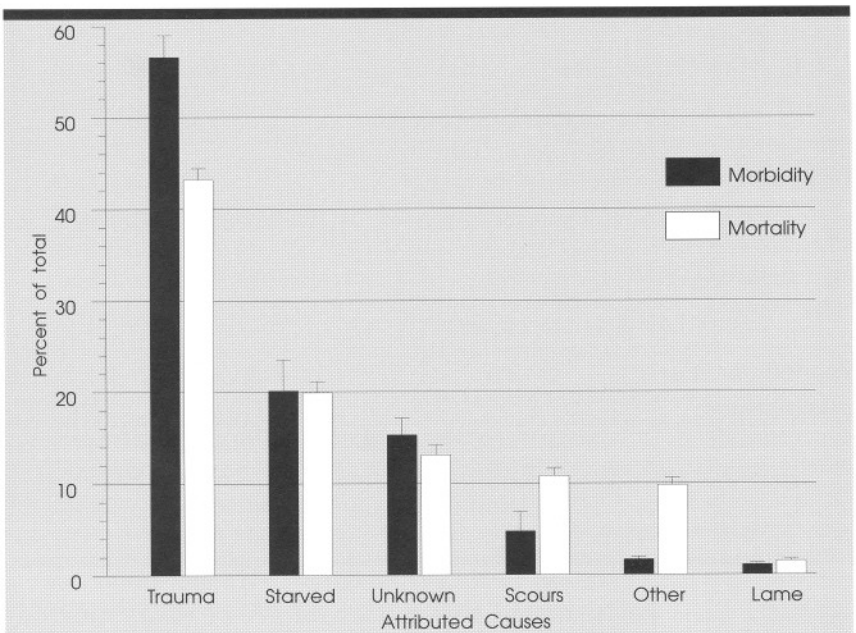

Fig 3.— Preweaning morbidity and mortality by cause.

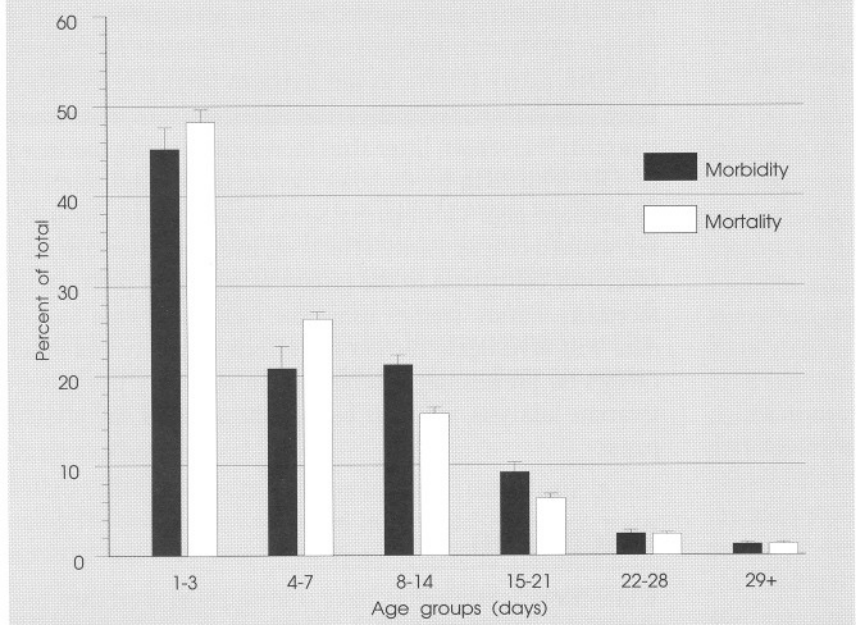

Fig 4.— Preweaning morbidity and mortality by age group.

Response Rate

The initial response rate to the General Farm Management Survey (GFMS) was 52% (1690 out of 3184 producers contacted). Those that agreed to participate generally tended to be those with larger hog populations and higher numbers of farrowings in the preceding 3 months, as well as expecting a higher number of farrowings in the next half-year.

Only 43% (712 of 1690) of producers who completed the GFMS participated in the on-farm monitoring phase of the study. The most common reason given for not participating was "lack of time." Producers who chose to participate were significantly more likely to use individual record cards and computer-based record keeping systems ($P = .001$) than those who chose not to participate. Participants and nonparticipants were similar in all other areas assessed.

The expected response rate to mailed surveys is 20%-50%. It could be argued that a project with individual contact from NAHMS coordinators and VMOs should achieve a higher response rate. However, the amount of work and time involved in an on-farm monitoring program is greater than that required by mailed surveys, so perhaps a lower response rate is not surprising.

Ramifications of NAHMS data

The major contributors to piglet morbidity/mortality are associated with basic husbandry skills (as opposed to diseases):

- Trauma/starvation are main causes of piglet deaths. Some researchers

have reported the possibility that no clear distinction exists among causes of death[8] and that mortality the producer attributes to trauma might actually be related to starvation. These two mortality causes might be "alternative endpoints of a single process," (Fraser D. Proc Am Assoc Swine Pract, Nashville, TN. Mar 1-3, 1992: pp. 283-294) and may after further investigation be combined into a single "starvation/trauma" syndrome.

- Mortality appears to be associated with sow parity: older sows have a higher percent of preweaning mortality and wean fewer pigs. The liveborn litter size/pigs weaned per litter must be considered along with preweaning mortality to establish an optimum parity structure for a herd.

To reduce preweaning mortality, we need to concentrate on the first 3 days of a piglet's life:

- Most illnesses and deaths occur during the first 3 days of life, and the risk of morbidity/mortality decreases as pigs get older.
- Scours, the most commonly identified morbidity problem, is a greater problem among very young pigs.

  Producers should be encouraged to:

  —weigh litters and make note of extremely small pigs (< 2.5 lb, 1.1 kg)

  —compensate for variation in pig birth weights (i.e., cross-foster to minimize variation in pig birth weights within litters)

  —ensure adequate colostral intake

  —optimize the piglet's environment (i.e., warm, dry, draft-free).

- Producer education must continue to decrease the number of piglet morbidity/mortality causes that are recorded as "unknown."
- Producers should be encouraged to give special attention to sows and litters that may be predisposed to high preweaning mortality:

  —those with larger litters and/or lower birth weights,

  —higher-parity sows.

- Practitioners should compare herds they work with to the national herd. How does the client's herd stack up? Is it competitive? Where can management improvements be made?
- Practitioners can use the mortality/morbidity distributions cited here to suggest areas on which to concentrate diagnostic efforts, especially when

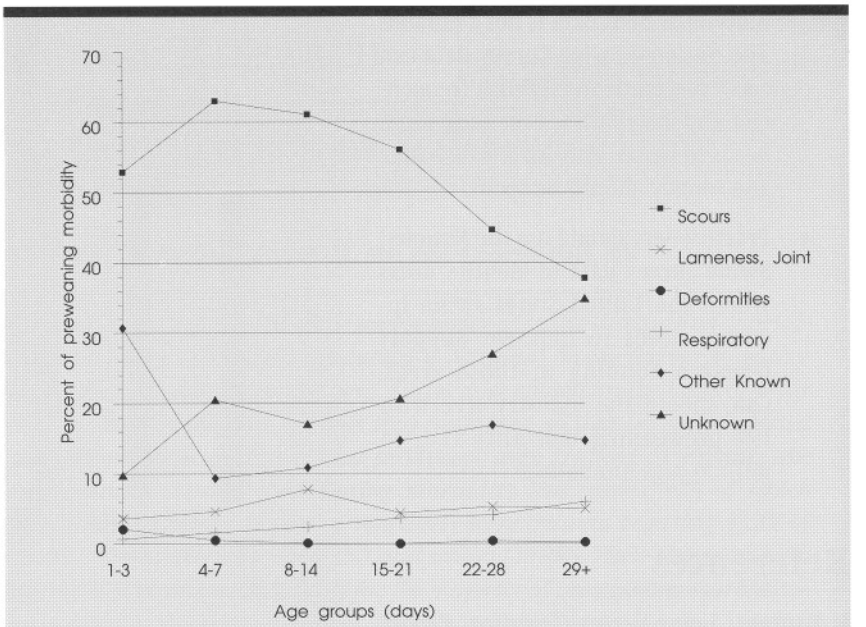

Fig 5.— Causes of preweaning morbidity by age group.

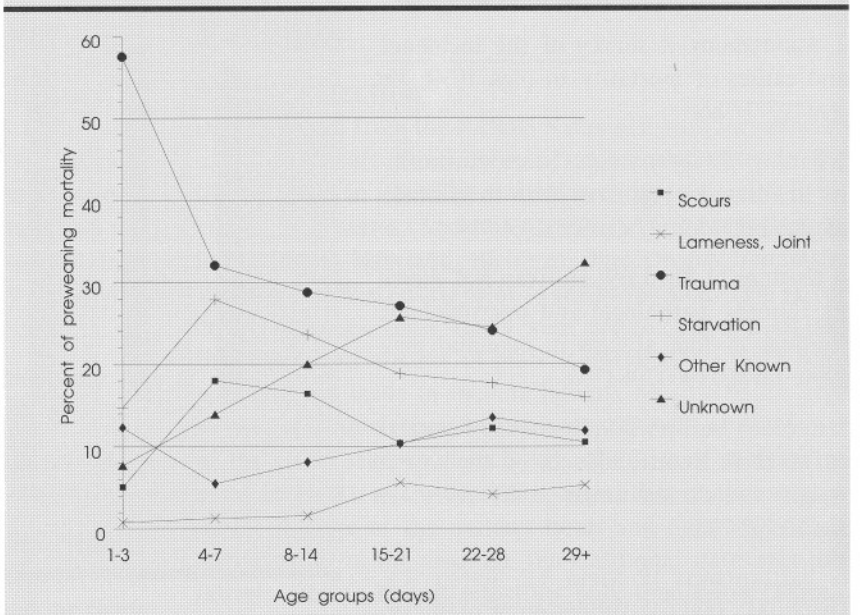

Fig 6.— Causes of preweaning mortality by age group.

individual herd data is not available. The National Swine Survey data can serve as a guide to establish frequencies and distributions for individual herds to better prioritize where time and money should be spent.

- Practitioners should use the National Swine Survey data to identify areas where the United States swine industry needs to improve. Support research funding in those areas. Can/should the industry live with 15% preweaning mortality (i.e., 16 million pigs annually)?

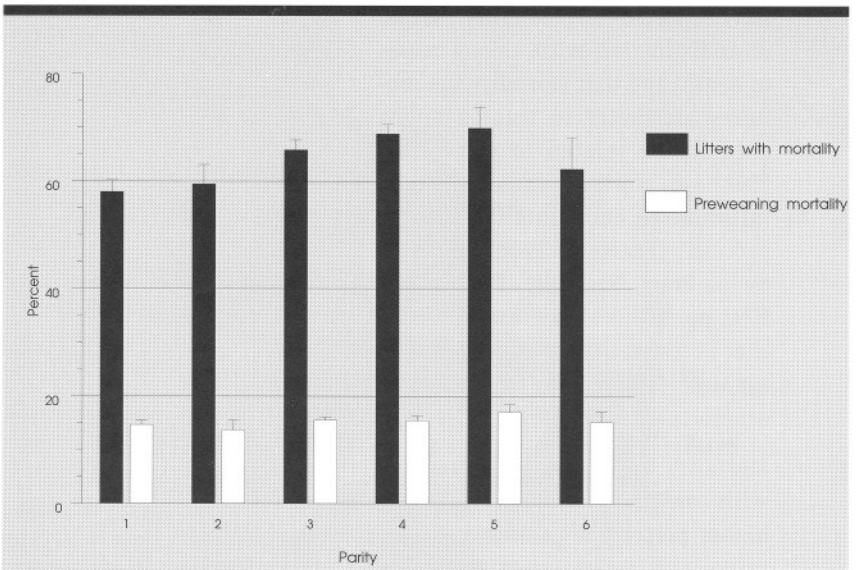

Fig 7.— Preweaning mortality by parity.

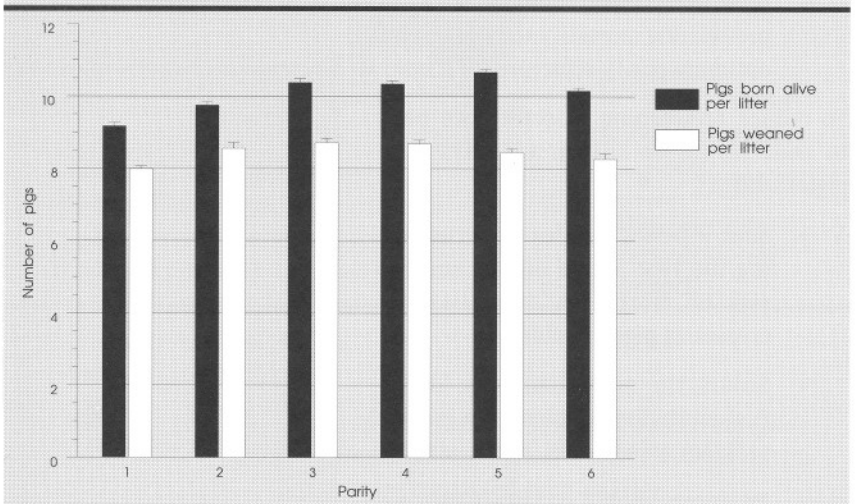

Fig 8.— Pigs born alive and weaned per litter by parity.

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Other topics in this series will investigate the opportunity costs (lost profit) that result from preweaning mortality, costs of preventive practices, the relationship of confinement facilities to preweaning illness and death, how sow productivity relates to the National Swine Survey data, and the relationship between preventive practices and morbidity/mortality rates.