ORIGINAL RESEARCH

Economic cost of preweaning mortality: A report of the NAHMS national swine survey

Anthony C Crooks, PhD; H Scott Hurd, DVM, PhD; David A Dargatz, DVM, MS; and George W Hill, MS

Summary *— We used data collected for the National Animal Health Monitoring Systems' (NAHMS) National Swine Survey to estimate the number and associated opportunity costs of piglet mortalities to producers of various herd sizes and in various regions of the United States in 1990. Opportunity costs are the profit opportunities that were lost by United States producers with each pig death event. Herds participating in the NAHMS National Swine Survey were stratified by herd size and by region so that we could account for cost advantages efficiencies that accrue to herds in certain regions and to the largest herds. We used the costs and returns data to calculate the associated income lost from each mortality, and predicted the increase in income that would result from reduced preweaning mortality in each herd size and region. We provide estimation methods that may be adjusted to suit a particular farm situation. Practitioners can use this information to perform preliminary cost:benefit analysis of intervention strategies intended to reduce preweaning mortality.*

In today's increasingly competitive world markets, the goal of production agriculture has changed from obtaining maximum yields to achieving maximum production efficiency. Producers that continue to lower their operating costs will thrive while their less efficient neighbors will be forced out of the industry. In food pig production, one determinant of production efficiency is preweaning mortality. To optimize production efficiency, producers must know the economic consequences of preweaning mortality so that they can evaluate the costs and benefits of various control options. Unfortunately, literature delineating the economic costs associated with preweaning mortality is relatively scarce. Several investigators used general assumptions about national prevalence, costs of prevention and treatments, and an understanding of the physiological effects of a particular disease;[2] some studies were more quantitative in nature but regional in orientation;[3] while others focused on one specific health problem.[4,5]

The National Animal Health Monitoring System (NAHMS) conducted a National Swine Survey to compile data on preweaning mortality.[6,7] We used these data to estimate the economic costs of piglet mortality for United States swine producers. This is the first comprehensive, national effort to explore the scope, severity and economic ramifications of disease and inadequate management in the United States swine industry.

Centers for Epidemiology and Animal Health.
USDA : APHIS : VS, Fort Collins, Colorado.

This is the second of a six-part series of articles presenting the results of the NAHMS National Swine Survey

Methods

Mortality opportunity costs are profit opportunities lost by the producer as the result of each pig death. The net difference between the costs of raising a piglet to market weight and revenues gained by selling it at the market price (i.e. net profit) is lost to the producer if the pig dies prematurely. Opportunity costs, therefore, are not "out-of-pocket" costs to the producer, but represent profits the producer would have realized had the event (death) not occurred.

Opportunity costs: The difference between the costs and returns associated with raising an animal to maturity and selling it at market price (i.e. cash profits per animal).

Relative cost advantages and/or relative efficiencies: cost benefits that accrue to larger enterprises (due to economies of scale) and to pork producers in certain regions (such as midwestern producers, who have access to lower-priced feed or southeastern producers, who do not have to spend as much on building costs, heating costs, etc.)

Data Stratification

Relative cost advantages accrue to larger herds and herds in certain geographic regions. In 1990, farrow-to-finish herds of at least 10,000 head had 8.8% lower variable cash expenses and 62% lower capital replacement costs compared to the

smallest herds on a per-cwt live-animal basis.[8] It was important, therefore, to account for herd size and regional differences when we calculated the estimates of the cost of preweaning mortality. We stratified each of the 712 herds that participated in the NAHMS National Swine Survey into one of four herd sizes:

- 49 or fewer breeding females;
- 50-99 breeding females;
- 100-199 breeding females;
- 200 or more breeding females;

and into one of the following regions:

- North Central (Ohio, Michigan, Indiana, Illinois, Wisconsin, Iowa, Minnesota and Nebraska);
- Southeast (Pennsylvania, Virginia, Maryland, North Carolina, Tennessee, Georgia and Alabama);
- Other states (Colorado, California, Oregon) (Table 1).[7]

Table 1.— Percentage of sample farms and breeding females in each herd size group and region.

Herd size (number of sows and gilts)	Percentage by region							
	North Central		Southeast		Other		Total	
	Farms	Population	Farms	Population	Farms	Population	Farms	Population
1-49	11	8	8	2	6	<1	25	10
50-99	17	19	3	2	2	<1	22	21
100-199	22	26	4	2	1	<1	28	28
200+	18	29	6	11	2	<1	25	41
Total	**68**	**82**	**21**	**17**	**11**	**1**	**100**	**100**

Analysis Assumptions

Assumptions made for this analysis included:

- preweaning mortality can be reduced by up to 10%, and this reduction can be achieved without incurring significant additional cost;
- the 10% surviving pigs would cost no more *or less* to raise to market weight than any other pig in their cohort;
- market weight is the national average of 249 lb; and
- the 10% surviving pigs would sell for the same price as others in their cohort.

Analysis Calculations

To estimate the opportunity costs of preweaning mortality, we accounted for both the costs associated with raising a pig to maturity and the returns from selling it at market prices. The Economic Research Service, USDA, publishes annual average costs and returns for farrow-to-finish operations for:

- herd size; and
- for region,

but not for region by herd size.[8] We calculated estimates of regional costs and returns by herd size for the North Central and Southeast regions by applying weighted average regional cash expenses to national estimates for each herd size group. National average cash expenses were used for the "Other States" region (Table 2). After we had accounted for variability due to herd size and region, we calculated (Table 3)[8] average preweaning mortality opportunity costs (i.e. lost profits) for farrow-to-finish operations with Calculation 1.

Weighted average: an average computed by counting each occurrence of each value, not merely a single occurrence of each value.

In order to quantify the opportunity costs of each cause of preweaning mortality for an individual farm, we used data from the National Swine Survey to estimate the average number of preweaned pigs per litter that died by region and herd size. We then used Calculation 2 to calculate the opportunity costs of each cause of preweaning mortality on a per-farm basis (i.e. an estimate of the increase in income that might be realized if preweaning mortality was reduced) for various herd sizes by regions. (Table 3)

You can use Calculation 2, inserting values that suit the specific circumstances of your clients, to estimate the opportunity cost of preweaning mortality for a specific enterprise. This opportunity cost value can then be used to perform preliminary cost : benefit analyses of interventions meant to reduce preweaning mortality.

Calculation 1.— Definition of mortality opportunity cost.
(Mortality opportunity cost ≡ Cash profits.)

Total cash receipts per cwt live weight	–
Total variable costs per cwt live weight	=
Cash profits per cwt live weight	

Results and Discussion

The weighted average of the number of dead pigs/litter for all herd sizes and regions in the United States is 1.5 dead pigs

Calculation 2.— Annual potential increase in profits.

price/cwt	–
total variable costs/cwt	–
δ ($0.00)*	x
2.49 cwt/head	x
average number of dead piglets per litter†	x
number of sows (gilts) on farm	x
2.1 litters per female per year‡	x
10 percent (0.10) mortality reduction	=
Annual potential increase in profits	

* δ represents the additional cost/cwt required to reduce this cause of preweaning mortality by this percentage. A value of $0.00 has been used because actual costs are widely variable.

† for each specific cause of mortality

‡ Data from PigCHAMP® and other survey data were used to estimate an average of 2.1 litters per mated female per year are produced in herds in the United States.[9-10]

per litter, which expands to an annual total of 16 million preweaning deaths in the United States in 1990 (Table 3).

We calculated the dollar values for increased income potential if preweaning mortality was reduced by 10% for three herd size and region strata (Table 4). (For each herd size stratus, we used the midrange number of sows and gilts. For example, 25 sows were used to represent the 1-49 herd size stratum.)

It is important to remember that 1990 was a 'banner year' for hog producers. Average annual prices for barrows and gilts were approximately 25% higher in 1990 relative to the 2 previous years and 8% higher than in 1991. Greater market returns imply that the opportunity cost of piglet mortality will also be greater. We used a 5-year average of returns less variable costs to provide a reasonably conservative estimate of the increased profit potential of reduced mortality.

Assumption implications

Assumption 1: Up to 10% of preweaning mortality is preventable without significantly increased costs.

We have reported potential increased income for 10% preventable preweaning mortality (Table 4), because we believe that this percentage of preweaning mortality could be prevented without incurring significant extra cost (i.e. δ = $0.00). We acknowledge that this assumption can be disputed.[11,12] We base this assumption on the evidence that in 30%-40% of all litters, there is no preweaning mortality,[7] and that 63% of the preweaning mortality that does occur is caused by trauma and starvation. In fact, beyond a certain point, saving pigs costs money. Economic theory suggests that as preweaning mortality decreases, the cost of saving each additional pig increases. In particular, variable costs would be expected to rise *at an accelerated rate* as the preweaning mortality rate approaches zero.[11] Reductions in mortality greater than 10% are likely to incur additional costs (i.e. δ > $0.00). The magnitude of δ has not been estimated here, because it is subject to the specific technology and management strategies of a given enterprise. We hope that future risk factor analysis will provide data from which δ can be calculated.

True opportunity costs are only those costs that result from *preventable* ocurrences. For example, piglets born below a certain weight are simply nonviable regardless of the care they are given. The variability in current health and management technologies makes it difficult to determine what percentage of piglet mortality is absolutely unpreventable. The opportunity cost of preweaning mortality is a value that must be determined on a farm-by-farm basis, after considering the technologies in place, financial status, and lifestyle choices of a particular producer. We

Table 2.— Variable cash expenses and profit by region and herd size.

Region	Herd size: number of animals in breeding herd			
	1-49	50-99	100-199	200+
	Total variable costs (in 1990) per cwt			
North Central	$37.90	$37.85	$35.76	$35.89
Southeast	41.82	41.77	39.46	39.60
Other states	38.50	38.45	36.32	36.45
	Cash receipts less total variable costs per cwt			
North Central	$9.80	$9.85	$11.94	$11.81
Southeast	5.88	5.93	8.24	8.10
Other states	9.20	9.25	11.38	11.25
	*Cash receipts less total variable costs per animal (at 2.49 cwt/head)**			
North Central	$24.40	$24.53	$29.73	$29.41
Southeast	14.64	14.77	20.52	20.17
Other states	22.91	23.03	28.34	28.01

* Values assume a cash receipt of $47.70/cwt (five-year average from 1986–1990) and were used to form assumptions about the potential profit realized with raising a pig from farrowing to marketing. This defines the opportunity cost of each preweaning mortality.

encourage you to use the calculations given in Methods to calculate the opportunity costs that would result from decreased preweaning mortality, inserting the values for:

- price;
- variable cash expenses;
- % mortality reduction; and
- δ (additional cost of mortality reduction)

that you deem to be realistic.

Assumption 2: Each saved piglet would cost no more or less to raise than others in its cohort.

This assumption was based in part on the responses of participants in the NAHMS National Swine Survey which indicated that facility use, in general, is not as efficient as it could be (Table 5).

Thus, while the total costs of production would increase with each saved pig (due to additional feed, labor, and other resources) not all costs would increase. As long as additional facilities are not required, per-pig fixed costs are reduced with each additional pig marketed (e.g. the farrowing barn is already operational, the interest on the loan has already been negotiated, and taxes and insurance for the operation will not change with respect to the number of pigs marketed).

Assumption 3: All saved hogs would sell for the same price as others in their cohort.

This assumption is reasonable if only a few United States farms significantly reduced preweaning mortality. However, a large number of surplus hogs (e.g. all 16 million of the pigs that died before weaning in 1990[6]) arriving at market at the same time (with all other factors remaining constant) would cause prices to decline significantly. To assess the impact of the economic cost of mortality on the United States swine industry at large, we would need to adjust for the lowered hog prices that would result from marketing these additional hogs. To completely account for the impact of these additional hogs on market prices and production costs, we would need to use a dynamic model that could quantify (through time):

- the price of live hogs;
- the retail prices and domestic consumption of pork, beef, poultry, and fish; and

Table 3.— Average number of mortalities per litter by herd size, region and health problem.[8]

Region	Health problem	Average mortalities per litter by herd size (Number of Sows and Gilts) 1-49	50-99	100-19	200+
Midwest	Trauma	0.77	0.71	0.64	0.57
	Starvation	0.30	0.38	0.35	0.23
	Scours	0.30	0.18	0.17	0.14
	Nervous disorders	<0.01	<0.01	<0.01	<0.01
	Deformity	0.01	0.01	0.02	0.01
	Lameness/Joint	0.01	0.02	0.02	0.02
	Respiratory disease	<0.01	0.02	<0.01	<0.01
	Other known	0.14	0.09	0.12	0.20
	Unknown	0.13	0.19	0.20	0.15
	All causes	**1.67**	**1.61**	**1.52**	**1.33**
South-East	Trauma	0.68	0.71	0.74	0.46
	Starvation	0.58	0.33	0.24	0.08
	Scours	0.07	0.13	0.08	0.06
	Nervous disorders*	<0.01	<0.01	0.01	<0.01
	Deformity	<0.01	0.02	0.02	<0.01
	Lameness/Joint	0.02	0.03	0.02	0.03
	Respiratory disease	<0.01	<0.01	<0.01	<0.01
	Other known	0.14	0.08	0.11	0.12
	Unknown	0.36	0.18	0.27	0.21
	All causes	**1.87**	**1.48**	**1.50**	**0.97**
Other states	Trauma	0.75	0.71	0.65	0.54
	Starvation	0.36	0.37	0.34	0.19
	Scours	0.26	0.18	0.16	0.12
	Nervous disorders	<0.01	<0.01	<0.01	<0.01
	Deformity	0.01	0.01	0.02	0.01
	Lameness/Joint	0.01	0.02	0.02	0.02
	Respiratory disease	<0.01	0.02	<0.01	<0.01
	Other known	0.14	0.09	0.12	0.18
	Unknown	0.17	0.19	0.20	0.16
	All causes	**1.71**	**1.60**	**1.52**	**1.23**

*In some herd-size strata, no herds reported nervous disorders as a cause of death. We believe that if we expanded the study to include *all* United States herds there would be deaths due to nervous disorders reported in every herd size stratum and region. We therefore used an average from other herd sizes to estimate these values.

- the recursive impacts of these retail prices on the demand for livestock.

Such a sophisticated framework might add to our understanding of the market implications of reduced mortality, but it lies beyond the scope of this paper. Our intention is to report the impact of reduced preweaning mortality on potential income for *individual producers*, which would have no effect on national hog prices.

Table 4.— Increased profit potential due to a 10% reduction in preweaning mortality by herd size and region.[8†]

Region	Cause of mortality	Increased profit potential by herd size (sows)			
		25	75	150	500
North-Central	Trauma	$100	$279	$609	$1800
	Starvation	39	149	333	729
	Scours	39	71	159	434
	Nervous disorders	<1	1	3	20
	Deformity	1	5	18	37
	Lameness / Joint	2	7	21	53
	Respiratory disease	1	7	2	12
	Other known	18	35	113	623
	Unknown	17	74	186	456
	All causes	**217**	**629**	**1444**	**4166**
South-East	Trauma	53	168	487	984
	Starvation	45	77	157	166
	Scours	5	30	55	127
	Nervous disorders*	<1	4	7	1
	Deformity	1	5	11	14
	Lameness / Joint	2	7	12	64
	Respiratory disease	1	<1	<1	10
	Other known	11	20	74	258
	Unknown	28	43	178	451
	All causes	**146**	**355**	**982**	**2075**
Other states	Trauma	92	263	588	1625
	Starvation	43	137	309	567
	Scours	31	65	145	346
	Nervous disorders	<1	1	4	14
	Deformity	1	5	17	31
	Lameness / Joint	2	7	19	61
	Respiratory disease	1	6	2	12
	Other known	17	33	108	526
	Unknown	21	69	182	488
	All causes	**208**	**587**	**1374**	**3671**

*calculated by averaging mortality, within the southeast region, at the 75-sow level.
† Based on Calculation 2, with a value of δ=$0.00 used because actual costs are widely variable.

Practitioners should approach the problem of preweaning mortality as they would any other economic decision: by weighing the projected benefits of each mortality-reducing strategy against its anticipated costs. The 'best' of the mortality-reducing innovations must compete with every other input that is vying for the time, finances, and energy of the producer (e.g. new building or machinery purchases, new marketing strategies, etc.). Some economists favor the concept of "optimal death loss," i.e. determining the percentage of preweaning mortality at which the cost of saving additional pigs is no longer offset by the added revenues those pigs will bring in.

Controlling preweaning mortality

The factors associated with preweaning mortality have been extensively researched.[13] Producers have some control over the following factors, which contribute to preweaning mortality or survival:

- genetics: sow breeds (genetics) influence such things as litter size and relative obesity, both of which affect preweaning mortality.[14,15] Some have suggested, however, that significant advances in piglet survival will come mainly through nongenetic means;[16]
- environmental factors, such as:
  - season (higher mortality is observed in fall and winter[17]);
  - ambient temperature of the farrowing barn (the preferred range is 15-22°C[18]);
  - farrowing pen size[19]; and
  - floor surfaces (a concrete surface with straw bedding is preferred[20]);
- management plays a significant role in preweaning mortality. For example, mortality attributed to crushing might also be related to starvation.[13] The following management techniques have been shown to reduce the incidence of preweaning mortality:
  - cross-fostering: distributing the piglets across a contempo-

rary group of sows to standardize the number of piglets per litter;[21]
— inducing parturition using prostaglandin compounds, timing each farrowing to occur when careful supervision is available;[22] and
— using farrowing crates[23] and creches (warm, well-bedded boxes in which the piglets are placed immediately after birth to prevent them from being crushed by the sow).[24]

This analysis is intended as a starting place for further applied economic analysis. It may provide a method and some data for veterinarians to evaluate the cost : benefit of strategies intended to reduce preweaning mortality. Further analysis should attempt to quantify that portion of mortality that is preventable and the added variable costs of inputs required to reduce mortality. We must also consider the industry-wide implications of reduced preweaning mortality on hog production, particularly the economic impact on those industries with direct purchase linkages to the farm (direct effects) and to the indirect effects that ripple through the rest of the economy (e.g. feed dealers, veterinarians, trucking firms, etc.) as a consequence of piglet mortality.

Fixed costs: Production costs that must be paid whether or not a facility is producing output, including:

- insurance
- taxes
- depreciation
- interest (on loans)

Variable costs: costs that vary with the number of pigs raised, rising and falling as output rises and falls, such as:

- feed
- labor
- veterinary expenses
- utilities

Miscellaneous farm expenses: most costs not included in the above two categories, including:

- fees and dues
- accountants, lawyers

Acknowledgements:

The authors would like to acknowledge the contributions of:

Dr. Dennis DiPietre, University of Missouri-Columbia, and Drs. Anita Blaine and Stephen Ott, Centers for Epidemiology and Animal Health, USDA:APHIS:VS, Fort Collins, Colorado.

References

1. Tasker, JB. 1987. Foreword. In: Mather, EC and JB Kaneene, (eds.) *Economics of Animal Diseases.* Michigan State University, W.K. Kellogg Foundation, East Lansing, MI, pg. vi.

2. Straw, B and Ralston, N 1987. Comparative costs and methods for assessing production impact of common swine diseases. In: Mather, E.C. and J.B. Kaneene, (eds.) Economics of animal diseases. Michigan State University, W.K. Kellogg Foundation, East Lansing, MI, pg. 165-180.

3. Owen, WJ 1987. Initial analysis of a valid food animal disease database for Iowa. *Iowa State Journal of Research* 62:293-311.

4. Hoblet, KH, Miller, GY, and Neale, GB. 1987. Economic assessment of a pseudorabies epizootic, breeding herd removal/repopulation, and downtime in a commercial swine herd. *JA VMA* 190:405-409.

5. Rodrigues, CA, Gardner, IA, and Carpenter, TE. 1990. Financial analysis of pseudorabies control and eradication in swine. *JA VMA* 197:1316-1323.

6. USDA. 1992. National swine survey data base. United States Dept. of Agriculture, Animal Plant Health Inspection Service, Veterinary Services, Fort Collins, CO. Released for distribution 15 January 1992.

7. Tubbs, RC, HS Hurd, D Dargatz, and G.Hill. 1992. Preweaning morbidity and mortality in the United States swine herd. *Swine Health and Prod* 1:21-28.

8. USDA. Selected years 1988-1992. Economic indicators of the farm sector: costs of production — livestock and dairy, 1986-1990. United States Dept. of Agriculture, Economic Research Service, Commodity Economics Division, Washington, D.C.

9. Marsh WE, Van Lier P, Dial GD. 1991. A profile of swine production in North America: I. PigCHAMP® breeding herd data analysis for 1990. University of

Table 5.— Efficiency of facility use as reported in NAHMS National Swine Survey

	Farrowing barn	Nursery	Finisher unit
Capacity filled*	80%	70%	80%
Sq ft not used†	229.2	593.5	1701.1

* Measured by the ratio of number of animals currently in the unit divided by the number of animals at full capacity.

† Calculated by multiplying the number of available animal spaces by the reported allocated space per animal.[6]

Minnesota Swine Center. *Rec Adv in Swine Prod and Health.* 217–222.

10. Wilson MR, Friendship RM, McMillan I, Hacker RR, Piepar R and Swaminathan S. 1986. A survye of productivity relationship in Canadian swine herds. *J Anim Sci* 62:576-582

11. McInerney, JP, Howe, KS, and Schepers, JA. 1992. A framework for the economic analysis of disease in farm livestock. *Prev Vet Med* 13:137-154.

12. Kaneene, JB and Hurd, HS. 1990. The national Animal Health Monitoring System in Michigan. III. Cost estimates of selected dairy cattle diseases. *Prev Vet Med* 11:127-140.

13. Vaillaincourt, JP. 1990. Validation of a swine production database and its use in a study of temporal patterns in preweaning mortality. Unpublished PhD dissertation. University of Minnesota, St. Paul, MN.

[1 4]. USDA. 1992. Personal conversation with Hosein Shapouri, Agricultural Economist, U. S. Dept. of Agriculture, Economic Research Service, Commodity Economics Division, Washington, DC, 28 January 1992.

14. Simenson, E and Karlberg, K. 1980. A survey of preweaning mortality in pigs. *Nord Vet Med.* 32:194-200.

15. Mersmann, HJ, Pond, WG, Stone, RT, et al. 1984. Factors affecting growth and survival of neonatal genetically obese and lean swine: cross-fostering experiments. *Growth* 48:209-220.

16. Bichard, M and David, PJ. 1986. Producing more pigs per sow per year: Genetic contributions. *J Anim Sci.* 63:1275-1279.

17. Nielson, NC, Christensen, K, Bille, N, et al. 1974. Preweaning mortality in pigs. 1. Herd investigations. *Nord Vet Med.* 26:137-150.

18. de la Farge, B. 1981. La Climatisation des porcheries. Troisieme partie: le chauffage. *Techni-porc* 4:44, as cited by Vaillaincourt, J.P. 1990. Validation of a swine production database and its use in a study of temporal patterns in preweaning mortality. Unpublished PhD dissertation. University of Minnesota, St. Paul, MN.

19. Simensen, E. 1971. Environmental factors in pig production: A survey. Institute of Agricultural Structure, Agricultural College of Norway 60:61.

20. Vellenga, L, van Veen, HM, Hoogerbrugge, A. 1983. Mortality, morbidity, and external injuries in piglets housed in two different housing systems. I. Farrowing house. *Vet Quart* 5:101-106.

21. Marcatti, A, Barbosa, AS, Silva, IJ, et al. 1986. Cross-fostered effects on the performance of suckling piglets. Proc IPVS 61.

22. Britt, JH. 1986. Improving sow productivity through management during gestation, lactation and after weaning. *J Anim Sci* 63:1288-1296.

23. Glastonbury, JRW. 1976. A survey of preweaning mortality in pig. *Aus Vet Jrnl* 52:272-276.

24. Friend, DW and Elliot, JI. 1981. Farrowing as an aid to sow management. *Can Jour Anim Sci* 61:1071-1074.