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Design and implementation of the United States National Animal Health Monitoring System 1995 National Swine Study

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Abstract

The United States Department of Agriculture's National Animal Health Monitoring System 1995 National Swine Study was designed to estimate management, health and productivity parameters on pig operations in the United States. Sixteen major swine-producing states that accounted for nearly 91% of June 1, 1995 swine inventory and nearly three-fourths of United States swine producers were included in the study. In the initial phase of the study, National Agricultural Statistics Service enumerators collected information from 1477 producers involved in all phases of swine production (farrowing, nursery, and grower/finisher). Of these, 405 operations with ≥ 300 finisher pigs (with at least one finisher pig ≥ 54 kg) participated in the subsequent component of the study, which involved on-farm visits by state and federal veterinary medical officers and animal health technicians, and which concentrated on the grower/finisher phase of production. Of those eligible to take part in the second phase of the study, participation was higher among independent producers (48.3%) than among contract producers (15.3%). Participation was also higher among operations that used advanced record-keeping systems (such as record cards for individual breeding hogs or a computer-based record-keeping system). Thus, study results could have been influenced by response biases. As a biosecurity measure, $40.5 \pm 2.1\%$ of operations restricted entry to employees only. For operations that permitted non-employees to enter the premises, relatively few enforced other biosecurity measures on visitors ($0.4 \pm 0.1\%$ required feed-delivery personnel and livestock handlers to shower before entering the premises; $3.3 \pm 0.9\%$

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required a footbath; and 7.0 ± 1.5% required feed-delivery personnel and livestock handlers not to have visited another operation with pigs on that day). The most common method of waste storage (used by 49.9 ± 3.8% of operations with ≥ 300 finisher pigs) was below-floor slurry or deep pit.

Keywords: Pig-information systems; NAHMS; Data management; Environment; Biosecurity

1. Introduction

The United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Veterinary Services (VS), National Animal Health Monitoring System (NAHMS) was created to address the animal health information needs of producers, consumers, agribusiness, academia, and health regulatory officials in the United States (Bush and Gardner, 1995; Hueston, 1990; King, 1990). NAHMS national studies are statistically designed to provide valid estimates focused on the national level. They include on-farm data collection and biological sampling. Producer participation is voluntary and the information provided by producers is strictly confidential. The 1995 National Swine Study was the fifth national study of the NAHMS program, and the second NAHMS national study of the United States pork industry.

The 1995 National Swine Study had two distinct phases, each with its own purpose. The principal objectives of the study's first phase were to provide statistically valid national estimates of parameters related to swine management on operations throughout the major pork-producing regions of the United States, and to examine changes and trends in the United States swine industry from the previous to the current NAHMS national swine survey. The main objective of the study's second component, which was limited to operations with ≥ 300 finisher pigs, was to fill information gaps specifically on the grower/finisher phase of swine production in the United States. The objective of this paper is to provide background information on the design and implementation of the 1995 National Swine Study.

2. Materials and methods

2.1. Information-needs assessment

The purpose of the information-needs assessment was to identify information gaps of concern to the pork industry nationally. Early in 1994, the National Pork Producers' Council (NPPC) and the USDA collaborated to send questionnaires to approximately 5000 swine producers to identify the information needs of swine producers. In addition, the NPPC and the USDA polled approximately 1000 other individuals (such as federal and state animal health officials, Cooperative Extension Service personnel, university researchers, employees of pharmaceutical companies, and editors of trade journals). Several focus-group meetings were held in 1994 with participants representing the NPPC, the American Association of Swine Practitioners, university researchers and

animal health officials. The objectives of the 1995 National Swine Study (USDA, 1994) were determined from the most important information needs identified.

From the most important information needs identified, prototypes of data tables were developed. The data-table prototypes served as the basis for creating survey questions. [1]

2.2. Study design

The study design was a joint effort between the USDA:APHIS:VS, Center for Epidemiology and Animal Health (CEAH) (Fort Collins, CO) and the USDA:National Agricultural Statistics Service (NASS). As in previous NAHMS national studies (Heinrichs et al., 1994; Losinger et al., 1997; Tubbs et al., 1993), the 1995 National Swine Survey had two phases. The first phase involved a NASS enumerator visit—in conjunction with the NASS Quarterly Agricultural Survey (QAS)—to collect general information about management and production on swine operations. The second phase of the study focused on the grower/finisher phase of the pork industry. Swine operations that participated in the study's first phase and that had ≥ 300 finisher pigs (with at least one finisher pig ≥ 54 kg) on June 1, 1995 were eligible for the second phase of the study. A federal or state veterinary medical officer (VMO) or animal-health technician (AHT) visited each swine operation participating in the second phase of the study to collect more detailed information on the management practices and health of the operation and to collect fecal, blood and feed specimens for laboratory evaluation for the presence of pathogens.

2.2.1. Sample design and selection

Selection of states included in the study occurred in December, 1994. The goal for national-estimates coverage was to include states that accumulated to at least 70% of the operations and pigs in the United States. All but two states (Texas and South Carolina) having a minimum of either 2% of the swine operations or pigs in the United States (based on December 1, 1993 inventory estimates published by NASS) were included in the study. Swine operations in the 16 states chosen (Fig. 1) were sampled quarterly for the NASS Quarterly Hogs and Pigs Report. These 16 states accounted for 90.7% of the swine inventory and 72.2% of the swine producers in the United States on December 1, 1993 (NASS report number Mt An 4 (12-93)).

For the 1995 National Swine Study, the size and performance of the first NAHMS National Swine Survey (completed in 1990) and the funds available for the present study served as the key indicators for the initial review of the target sample size. In the 1990 study, satisfactory results were achieved with 1661 respondents to the baseline questionnaire and 712 operations participating in subsequent visits by a VMO or AHT (Tubbs et al., 1993). Therefore, a target of 700 swine producers participating in the second phase of the 1995 National Swine Survey was set. Since participation in the second phase of

[1] Copies of survey instruments may be obtained by writing to Centers for Epidemiology and Animal Health; USDA:APHIS:VS; 555 South Howes Street, attn: NAHMS; Fort Collins, CO 80521, USA; or via internet at NAHMS_info@aphis.usda.gov.

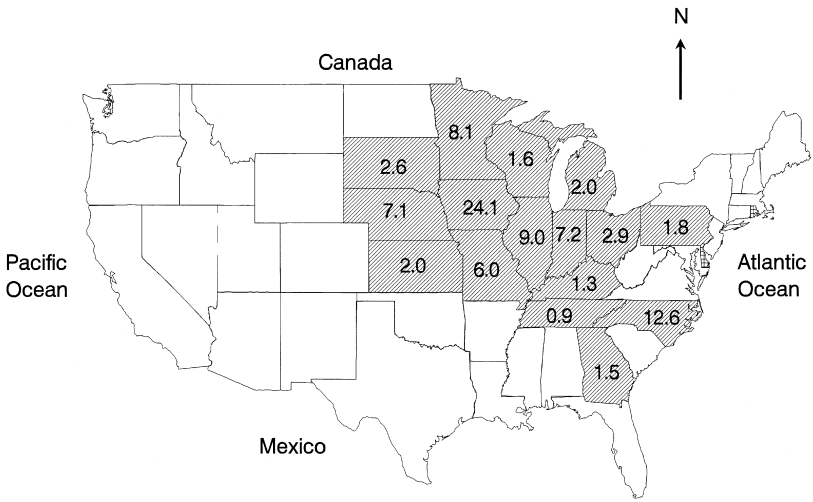

Fig. 1. States participating in the United States National Animal Health Monitoring System 1995 National Swine Study, and percent of United States swine inventory on June 1, 1993 (Total = 90.7% of United States swine inventory). Source: United States National Agricultural Statistics Service Report Number Mt An 4(12-93).

the study was limited to producers with $\geq$ 300 finisher pigs (with $\geq$ 1 finisher pig $\geq$ 54 kg), an important consideration was to predict the number of participants in the first phase of the study that did not meet these criteria. Furthermore, as the first phase of the study was completed in conjunction with the QAS, additional response-rate consideration was required due to the increased burden to respondents. In addition, as sample selection for the QAS was based on both swine and crop strata, predicting the number of QAS respondents with pigs presented a further complication. Initial projections of anticipated response rates at each level of the survey (from the QAS to the final component of the National Swine Survey) suggested that approximately 11 000 records from the QAS sample would have to be selected for the National Swine Survey. Allocation of the sample by state was based on swine inventory and the number of operations in each state.

For the NASS QAS, the total sample of farms selected for the QAS was divided into 11 subsamples (called 'replicates'). Chromy's sample selection procedure (Chromy, 1981) was used to assign operations to replicates. Each quarter, the QAS used five replicates and a predetermined rotation scheme such that two replicates were dropped and two new replicates were added each quarter. For the June, 1995 QAS, all five replicates were new since this was the first sampling period used following the spring list sampling frame update and classification.

2.2.2. Pre-test

Survey instruments for the grower/finisher phase of the study were pre-tested during March, 1995 in 14 of the 16 participating states. Each VS state coordinator visited one swine operation in his or her state, administered the questionnaires, and provided

suggestions on improving the questionnaires to the CEAH. A farm that was medium-to-large (for the state) with finisher pigs was targeted. Comments and suggestions from the pre-test were used to finalize the questionnaires. In addition, NASS pre-tested the questionnaire for the first phase of the 1995 National Swine Study at approximately the same time.

2.2.3. Training

Coordinators from the 16 participating states, and representatives from NASS and the USDA: National Veterinary Services Laboratories (NVSL) received training in April, 1995. The United States Swine Industry was reviewed. Trainees received detailed instructions on administering the survey instruments and carrying out the biological sampling. Other topics included coaching skills, coalition-building, and collaboration with NASS and NVSL. In addition, two pork producers were present at the training to answer questions on how best to approach pork producers for this study. The state coordinators subsequently trained the data collectors in each of their states.

2.2.4. Promotion

Press releases, detailing the overall objectives of the 1995 National Swine Survey, were sent to the agricultural media in early 1995. Prior to the launch of the survey, NASS sent a letter and an informational brochure on the 1995 National Swine Study to producers selected for participation in the survey. The brochure mentioned the endorsement of the study by the American Association of Swine Practitioners and the NPPC. The confidentiality of information provided by individual producers was stressed. Producers participating in the survey were promised fact sheets containing national results. In addition, producers participating in the second portion of the study received reports that documented their responses to key questions and compared their responses to producers nationally.

2.3. Data collection

Data collection for the first phase of the study occurred from June 1 to June 23, 1995. NASS enumerators visited swine operations selected for inclusion in the study and administered a questionnaire on general swine operation management. In addition, the NASS enumerators asked swine operators with ≥ 300 finisher pigs and ≥ 1 finisher pig ≥ 54.4 kg if they would consent to continue in the next phase of the study. The names of consenting operators were turned over to VS.

From July 17 to September 13, 1995, VMOs visited swine operations that had consented to continue in the study to administer a questionnaire that focused on feed and waste management. From November 6, 1995 to January 17, 1996, VMOs visited the producers again to administer a questionnaire that concentrated on quality control, swine health, and marketing.

2.4. Data entry and validation

NASS data entry specialists entered data collected by NASS enumerators into a SAS database and edited the data according to specifications furnished by CEAH (such as

minimum and maximum acceptable values, making certain that subtotals added correctly, and that skip patterns were followed correctly). The identities of all respondents were protected. NASS did not reveal to VS the identity of any operation that did not consent to participate in the second phase of the study with the VMOs.

Data collected by the visiting VMOs and were entered into SAS data sets and edited at the CEAH office in Fort Collins, CO. Editing included assuring that subtotals added correctly, percentages added to 100 (where required), skip patterns were followed correctly, and that data were within expected ranges. If skip patterns had not been followed correctly, the questionnaire was examined to determine whether the leading question had been answered correctly or whether the data for the series of questions within the skip pattern indeed should not have been answered. Data outside expected ranges were verified personally by state coordinators and, where necessary, the VMO. Changes were made when mistakes were noted and correct values were verified.

2.5. Participation analysis

A chief purpose of the participation analysis was to examine whether information reported from the 1995 National Swine Survey might have been biased in some way due to differences between study participants and those operations that had either refused to participate in the study or had been inaccessible when contact was attempted.

For the first phase of the study, participation rates were computed by state. The results were tested for significant differences ($P < 0.05$) using the chi-square test in the SAS FREQ procedure (SAS Institute, 1990).

For the second phase of the study, participation rates by a number of key categorical variables (from the Phase-1 questionnaire) were computed and tested for differences (between Phase-2 participants and Phase-1 participants that were eligible but did not participate in Phase 2) using the chi-square test in the SAS FREQ procedure (SAS Institute, 1990). The SAS *T*-TEST procedure (SAS Institute, 1990) was used to test for differences between means of continuous variables. A similar analysis was used to examine differences between operations that participated in the first visit by a VMO or AHT, but did not participate in the final VMO or AHT visit.

2.6. Weight creation

The purpose of sample weights is to derive accurate population estimates from survey data (Cochran, 1977). An operation's sample weight is the number of swine operations (in the population) that a sampled operation is representing for the purpose of creating national population estimates from the study. Since smaller operations were sampled at a lower rate than large operations, smaller operations generally received a larger sample weight than larger operations.

2.6.1. NASS QAS weight

The initial sample selection weight for the QAS was the NASS list population count of agricultural operations divided by the sample size for the QAS within each NASS design stratum. The initial sample weight was multiplied by an adjustment for list

duplication and out-of-business operations, and by a second adjustment for estimated list incompleteness. Unlike the previous NAHMS National Swine Survey (Tubbs et al., 1993), no area frame was selected to estimate list incompleteness. Instead, NASS provided estimates (for each state) of list incompleteness for each of 6 poststrata based on swine inventory (0, 1 to 99, 100 to 499, 500 to 999, 1000 to 1999, and ≥ 2000).

The sample weights for QAS participants were adjusted for non-response by multiplying their sample weights by the ratio of the sum of weights for QAS eligible operations to the sum of weights for QAS participants within each poststratum and state. Operations that refused to participate in the QAS received a final weight of zero.

2.6.2. Weights for the first portion of the NAHMS national study

All QAS respondents with at least 1 pig were eligible to participate in the first phase of the national study, except for institutional or research farms. For sample-weight adjustment, the 16 states were divided into four regions: West (Kansas, Missouri, Nebraska and South Dakota); Midwest (Illinois, Iowa, Minnesota and Wisconsin); Northeast (Indiana, Michigan, Ohio and Pennsylvania); and Southeast (Georgia, Kentucky, North Carolina and Tennessee). Within each poststratum by region, a response adjustment was made equal to the sum of weights for eligible operations divided by the sum of weights for respondents. The weights were adjusted a second time to force the swine-inventory estimate from the first portion of the NAHMS national study to match the NASS published inventory for each state. This was accomplished by multiplying each participant's weight by the ratio of the NASS published inventory to the NAHMS inventory estimate for each state. Weights of operations that refused to participate in this phase of the study were set to zero.

The distribution of the adjusted respondent weights was examined. Large variation in weights can reduce the precision of survey estimates (Cox and Cohen, 1985). If a small number of respondents have extremely large weights compared to the majority of respondents in the sample, the population estimates will be heavily dependent upon the responses given by the respondents with large weights. Respondent weights exceeding 765 were truncated to a maximum of 765, and their excess weight redistributed equally among the other respondents within their poststratum, following the method of Cox and Cohen (1985).

2.6.3. Weights for the second portion of the NAHMS national study

Operations that participated in the first portion of the NAHMS national study and that had at least 300 finisher pigs of which at least one was ≥ 54 kg were eligible to have their names turned over to VS for the VMO portion of the survey. Eligible operations that agreed to have their names turned over were 'turnover respondents.'

For turnover-weight creation, three regions were defined: one containing two operation-size groups, and the other two having four operation size groups. For turnover respondents, a turnover-response adjustment was made equal to the sum of weights for turnover-eligible operations divided by the sum of weights for turnover respondents within each of the 10 poststrata based on region and operation size group. The final weight from the first portion of the study, multiplied by the turnover response adjustment, yielded a turnover weight for each turnover respondent. Turnover weights were

set to zero for eligible operations that refused to allow their names to be turned over to VS.

Five corporate farms in NC each contributed data as one respondent for the first portion of the study. However, for the second portion of the study, a VMO or AHT visited and provided data for two or three subfarms for each of the five corporate farms. In these cases, the turnover weight for the corporate farm was divided equally among the subfarms.

All swine operations that agreed to have their names turned over to VS for the second portion of the study were eligible to participate in the second portion of the study except for operations that had no finisher pigs at the time of the VMO or AHT visit. Producers who completed the first questionnaire administered by the visiting VMO or AHT were considered 'VMO respondents.' For VMO respondents, a response adjustment was made equal to the sum of turnover weights for VMO-eligible operations divided by the sum of weights for VMO respondents within each poststratum defined for the second portion of the study. The product of this adjustment and the turnover weight yielded the weight used for the second portion of the study.

2.7. National estimates

Population estimates (of means and proportions) and standard error estimates were obtained using SUDAAN, a program specifically designed for survey data analysis (Shah et al., 1996). SUDAAN uses first-order Taylor-series approximation to estimate standard errors (Shah et al., 1996).

3. Results and discussion

3.1. Participation

The NASS procedure selected 10,853 agricultural operations, of which 15.0% refused to participate in the QAS and 55.0% were ineligible for 1995 National Swine Study because they had no pigs. Table 1 summarizes the disposition of the farms chosen. One thousand four hundred seventy-seven swine operations participated in the first phase of

Table 1
Summary of responses to the first phase of the 1995 (U.S.) National Swine Survey

Response	Number	Percent
Inaccessible	211	19
Refused to participate in June Quarterly Agricultural Survey	1629	15.0
No pigs, not eligible for 1995 National Swine Survey	5969	55.0
Out of scope (e.g. institutional and research farms)	21	0.2
Refused to participate in 1995 National Swine Survey	1546	14.2
Completed first phase but ineligible for second phase	546	5.0
Completed first phase but refused to participate in second phase	400	3.7
Completed first phase and agreed to participate in second phase	531	4.9
Total	10853	100.0

the 1995 National Swine Study. Assuming that all of the 211 inaccessible operations had swine and were therefore eligible to participate in the 1995 National Swine Study, the overall participation rate was 45.7%. By state, participation rates ranged from 29.6% in Indiana to 62.3% in Kansas. The most frequently cited reason for refusing to participate in the 1995 National Swine Study was that the producer did not want to commit time to the project (30.5%).

The number of swine operations participating in the second phase of the study (focusing on finisher pigs) was 405 (42.6% of eligible Phase-1 participants)—considerably lower than the initial target of 700. By state, Phase-2 participation rates ranged from 10.5% in North Carolina to 63.2% in Iowa. Regionally, overall participation in the Southeast was 25.5% compared to 43.2% in the Northeastern States and 52.5% in the West and Midwest. Many of the herd-size variables examined (e.g. number of pigs present on June 1, 1995; number of pigs sold from December 1, 1994 to May 31, 1995; number of finisher pigs ≥ 54.4 kg on June 1, 1995) showed no statistically significant differences in Phase-2 participation. However, a few differences were noted among other operation-size indicators. For example, 54.3% of eligible operations with ≥ 100 sows and gilts for breeding on June 1, 1995 participated in the second phase of the study, compared to 33.1% of eligible operations with fewer sows and gilts for breeding. Similarly, the participation rate for operations with ≥ 10 boars for breeding on June 1, 1995 was 52.1%, compared to 39.1% for operations with < 10 boars for breeding. And, 45.6% of eligible operations with ≥ 300 finisher pigs on June 1, 1995 participated in the second phase of the study, compared to 17.3% of eligible operations with < 300 finisher pigs. The redistribution of sample weights of Phase-2 non-respondents to Phase-2 participants by region and swine inventory poststratum reduced bias by region and herd size in the national estimates. However, since the response rates for smaller operations was somewhat lower, their contribution to the variance of estimates was higher than that of larger operations.

The Phase-2 participation rate of contract producers (15.3%) was considerably lower than that of independent producers (48.3%). Since business and marketing arrangements did not form a basis for deriving sample weights for the second part of the study, it is possible that estimates of other variables correlated with business and marketing arrangements in Phase 2 may therefore be biased. Since no data was collected from operations that declined to participate in Phase 1, biases that may exist in Phase-1 estimates due to differences in participation rates by factors other than state and NASS stratum are unknown.

A significantly higher percentage of eligible producers with all-in, all-out management of farrowing and nursery facilities continued in the second phase of the study than did eligible producers with continuous production. However, there was no significant difference in the Phase-2 participation rate between operations that managed their grower/finisher unit as all-in, all-out vs. continuous production. However, since the purpose of the second phase of the study was to estimate parameters related to the health and management of grower/finisher facilities, one probably need not be as concerned about bias due to differences between participants and non-participants in the management of farrowing and nursery facilities as about variables specifically related to the grower/finisher unit.

Phase-2 participants were significantly more likely to use record cards for individual breeding pigs or a home-computer based record-keeping system than were Phase-2 eligible non-participants. Advantages that producers derive from on-farm data bases and knowledge-based analysis programs have been documented (Spahr, 1993). Thus, Phase-2 results potentially could be biased in favor of operations that made use of advanced record-keeping systems.

The mean number of pigs born per litter for Phase-2 participants (10.4) was significantly higher than the mean number of pigs born per litter for Phase-2 eligible non-participants (10.1). For operations with < 10 pigs born per litter, the Phase-2 participation rate was 42.1%, compared to 51.6% of operations with ≥ 10 pigs born per litter. Thus, the Phase-2 results could have been biased in favor of operations with higher-producing sows.

3.2. National estimates

Based on the data collected during the 1995 National Swine Survey, national estimates for the swine industry have been published (USDA, 1995, 1996). The national estimates apply to the 16 states included in the study. A couple of examples are provided here.

3.2.1. Biosecurity measures of pork producers

Introduction of a swine pathogen onto an operation can have severe consequences (Dey and Parham, 1993; Miller et al., 1995). Some diseases may lead to high mortality and reduced production. In addition, chronic subclinical diseases can result in economic losses to producers.

One potential threat is purchased pigs (such as breeding stock or feeder pigs) which may harbor infectious agents. In addition, other animals (such as insects, rodents, birds and other wildlife, and pets) or people can carry disease agents onto the operation. Disease organisms may also be introduced on equipment or feed, and by the wind.

This study showed that $40.5 \pm 2.1\%$ of swine operations restricted entry to the premises to employees only. For operations that did not restrict entry to employees only, $0.4 \pm 0.1\%$ required feed-delivery personnel or livestock handlers to shower before entering the operation, $3.3 \pm 0.9\%$ to use a footbath before entering, and $7.0 \pm 1.5\%$ not to have visited another swine operation that day. For other visitors, $0.6 \pm 0.1\%$ of

Table 2
Of operations that receive new arrivals, percent reporting frequency of placing new arrivals through a separation or quarantine process (1477 respondents, 1995)

Frequency	Breeding Females		Breeding Males		Feeder Pigs	
	Percent	SE	Percent	SE	Percent	SE
Always	37.9	3.1	50.5	2.8	18.6	2.7
Sometimes	11.9	1.8	12.9	1.8	8.7	2.1
Never	50.2	3.2	36.6	2.8	72.7	3.1
Total	100	–	100	–	100	–

operations required a shower before entering the operation, 4.6 ± 1.0% required a footbath before entering, and 8.0 ± 1.4% required the visitors not to have visited another swine operation that day.

The study indicated that 53.5 ± 2.3% of operations received new arrivals of breeding females, 64.5 ± 2.3% received breeding males, and 54.8 ± 2.3% received feeder pigs. Table 2 summarizes the frequency with which new arrivals were placed through a separation or quarantine process. Wood (1992) recommended isolating newly purchased pigs for at least 30 days. The results of the 1995 National Swine Study indicated that the industry had some room for improvement in terms of separating new arrivals of pigs.

3.2.2. Environmental practices

Environmental management is an integral part of swine production (Council for Agricultural Science and Technology, 1996; Hoag and Roka, 1995). Manure management is an important aspect of swine production (Hoag and Roka, 1995). Key environmental and public issues concerning pork production include water, soil and air quality (Council for Agricultural Science and Technology, 1996).

Concerns or regulations about environmental quality led many producers to change or develop management schemes during the 5 years prior to the study (Table 3). Nearly 53% of producers that marketed ≥ 10 000 pigs from December 1, 1994 to May 31, 1995 changed their manure management, and 36.0% changed their dust control programs during the 5-year period. Many of these operations also changed their programs for monitoring groundwater, surface water, and air quality. These changes and those shown for employee training programs indicate an increasing awareness of responsible environmental management.

The type of manure-management system used most often depends on the type of facility on the operation. Hand cleaning was the most common method of manure management used in the farrowing facility and in the grower/finisher unit (Table 4). Pit-holding was used most commonly in the nursery phase.

Nearly 14% of operations reported no manure management system in their farrowing facility, and 4.3 ± 1.0 reported none in the nursery. Almost 15% of operations reported no manure management system in the grower/finisher phase.

Table 3
During the 5 years prior to the June 1995 interview, percent of operations where concerns or regulations about environmental quality led to changes in or development of programs by number of pigs marketed from December 1, 1994 through May 31, 1994 (1477 respondents, 1995)

	All operations		< 2500 marketed		≥ 2500 marketed	
	%	SE	%	SE	%	SE
Groundwater-monitoring program	5.2	0.9	5.1	0.9	15.6	3.2
Surface water-monitoring program	5.7	0.9	5.1	0.9	19.6	4.0
Air quality-monitoring program	2.9	0.6	2.5	0.6	15.5	3.4
Manure-management program	20.9	1.6	19.8	1.7	64.9	4.2
Dust-control program in the buildings	8.7	0.9	8.0	0.9	36.0	4.6
Employee-training program	4.6	0.6	3.9	0.6	33.4	5.2

Table 4
Percent of operations by type of waste-management system used most by production phase (405 US pig-rearing operations, 1995)

	Farrowing		Nursery		Grower/finisher	
	%	SE	%	SE	%	SE
No waste management system	13.8	2.0	4.3	1.0	14.8	1.9
Pit-holding	25.5	2.1	33.7	2.4	23.2	1.9
Mechanical scraper/tractor	12.0	1.6	17.6	2.2	24.9	2.0
Hand cleaned	38.2	2.6	29.9	2.9	27.2	2.4
Flush-under slats	5.3	0.8	9.4	1.3	2.4	0.5
Flush-open gutter	3.0	0.9	2.1	0.7	3.4	1.0
Other	2.2	0.5	3.0	0.8	4.1	0.8
Total	100	–	100	–	100	–

Operations that continued in the second phase of the study were asked more detailed questions about waste storage and management. The most common method of storage was below-floor slurry or deep pit ($49.9 \pm 3.8\%$ of operations), followed by anaerobic lagoon without a cover ($20.9 \pm 2.5\%$) and below-ground slurry storage ($19.4 \pm 3.1\%$). For grower/finisher operations that disposed of waste on owned or rented land, $12.8 \pm 2.2\%$ of operations used irrigation to dispose of waste, $57.9 \pm 3.7\%$ of operations used broadcast/slurry spreader, $46.0 \pm 3.8\%$ used slurry (surface application), and $21.9 \pm 3.0\%$ used slurry (subsurface injection). Subsurface applications may prevent environmental odor problems and are less likely to cause surface water contamination.

4. Conclusions

The 1995 National Swine Study provided information from swine operations representing nearly 91% of United States swine inventory. Baseline measurements related to management practices such as biosecurity measures and environmental practices were collected and summarized.

References

Bush, E.J., Gardner, I.A., 1995. Animal health surveillance in the United States via the national animal health monitoring system (NAHMS). Epidémiol. Santé Anim. 27, 113–126.

Chromy, J.R., 1981. Variance estimators for a sequential sample selection procedure. In: Krewsky, D., Platek, R., Rao, J.N.K. (Eds.), Current Topics in Survey Sampling. Academic Press, New York, NY, pp. 329–343.

Cochran, W.G., 1977. Sampling Techniques, 3rd edn. Wiley, New York, NY, 428 pp.

Council for Agricultural Science and Technology, 1996. Integrated Animal Waste Management. Task Force Report No. 128. Center for Agricultural Science and Technology, 4420 West Lincoln Way, Ames, IA 50014 USA, 87 pp.

Cox, B.G., Cohen, S.B., 1985. Methodological Issues for Health Care Surveys. Marcel Dekker, New York, NY, pp. 204–205.

Dey, B.P., Parham, G.L., 1993. Incidence and economics of tuberculosis in swine slaughtered from 1976 to 1988. J. Am. Vet. Med. Assoc. 203, 516–519.

Heinrichs, A.J., Wells, S.J., Hurd, H.S., Hill, G.W., Dargatz, D.A., 1994. The national dairy heifer evaluation project: a profile of heifer management practices in the United States. J. Dairy Sci. 77, 1548–1555.

Hoag, D.L., Roka, F.M., 1995. Environmental policy and swine manure management: waste not or want not?. Am. J. Alternative Agric. 10, 163–166.

Hueston, W.D., 1990. The national animal health monitoring system: addressing animal health information needs in the USA. Prev. Vet. Med. 8, 97–102.

King, L.J., 1990. The national animal health monitoring system: fulfilling a commitment. Prev. Vet. Med. 8, 89–95.

Losinger, W.C., Garber, L.P., Hill, G.W., Dornseif, S.E., Rodriguez, J.M., Frye, W.B., 1997. Design and implementation of the United States National Animal Health Monitoring System 1994–1995 Cattle on Feed Evaluation, and an evaluation of the impact of response bias. Prev. Vet. Med. 31, 1–14.

Miller, G.Y., Forster, D.L., Tsai, J., Bowman, G., 1995. Productivity and profitability differences between pseudorabies-infected and pseudorabies-noninfected farrow-to-finish swine herds. J. Am. Vet. Med. Assoc. 206, 446–451.

Shah, B.V., Barnwell, B.G., Bieler, G.S., 1996. SUDAAN User's Manual, Version 6.40, 2nd edn. Research Triangle Institute, Research Triangle Park, NC, 492 pp.

Spahr, S.L., 1993. New technologies and decision making in high producing herds. J. Dairy Sci. 76, 3269–3277.

Statistical Analysis Systems Institute, 1990. SAS® Procedures Guide, Version 6 edn. SAS Institute, Cary, NC, 705 pp.

Tubbs, R.C., Hurd, H.S., Dargatz, D., Hill, G., 1993. Preweaning morbidity and mortality in the United States swine herd. Swine Health Prod. 1 (1), 21–28.

United States Department of Agriculture, 1994. USDA Identifies Pork Industry's Information Gaps. N171.1294. USDA:APHIS:VS, CEAH, Fort Collins, CO, 2 pp.

United States Department of Agriculture, 1995. Swine '95 Part I: Reference of 1995 Swine Management Practices. N186.995. USDA:APHIS:VS, CEAH, Fort Collins, CO, 22 pp.

United States Department of Agriculture, 1996. Part II: Reference of 1995 U.S. Grower/Finisher Health and Management Practices. N201.696. USDA:APHIS:VS, CEAH, Fort Collins, CO, 24 pp.

Wood, R.L., 1992. Erysilepas. In: Leman, A.D., Straw, B.E., Mengeling, W.L., D'Allaire S., Taylor, D.J. (Eds.), Diseases of Swine, 7th edn. Iowa State University Press, Ames, IA, pp. 475–486.