United States
Department of
Agriculture

Animal and
Plant Health
Inspection
Service

Veterinary
Services

National
Animal Health
Monitoring
System

February 2005

Dairy 2002

Johne's Disease on U.S. Dairy Operations, 2002

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, sexual orientation, or marital or family status. (Not all prohibited bases apply to all programs). Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, Room 326-W, Whitten Building, 1400 Independence Avenue, SW, Washington, DC 20250-9410 or call (202) 720-5964 (voice and TDD). USDA is an equal opportunity provider and employer.

Mention of companies or commercial products does not imply recommendation or endorsement by the USDA over others not mentioned. USDA neither guarantees nor warrants the standard of any product mentioned. Product names are mentioned solely to report factually on available data and to provide specific information.

USDA:APHIS:VS:CEAH
NRRC Building B, M.S. 2E7
2150 Centre Avenue
Fort Collins, CO 80526-8117
970.494.7000
E-mail: NCAHSweb@aphis.usda.gov
http://www.aphis.usda.gov/nahms

#N427.0205

ACKNOWLEDGEMENTS

This report has been prepared from material received and analyzed by the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Veterinary Services (VS) during a study of animal health and health management on U.S. dairy operations.

The Dairy 2002 study was a cooperative effort between State and Federal agricultural statisticians, animal health officials, university researchers, extension personnel, producers, and operators. We want to thank the hundreds of industry members who helped determine the direction and objectives of this study by participating in focus groups.

Thanks also to the National Agricultural Statistics Service (NASS) enumerators, State and Federal veterinary medical officers (VMOs), and animal health technicians (AHTs) who visited the operations and collected the data. Their hard work and dedication to the National Animal Health Monitoring System (NAHMS) are invaluable. The roles of the producer, area veterinarian in charge (AVIC), NAHMS coordinator, VMO, AHT, and NASS enumerator were critical in providing quality data for Dairy 2002 reports. Thanks also to the personnel at the Centers for Epidemiology and Animal Health (CEAH) for their efforts in planning, designing, overseeing data collection, performing data analysis, and generating and distributing valuable reports from Dairy 2002 data.

Additional biological sampling and testing were afforded by the generous contributions of collaborators for the Dairy 2002 study, including:

- USDA:APHIS, National Veterinary Services Laboratories
- USDA:ARS, National Animal Disease Center
- USDA:ARS, Beltsville Animal Research Center
- USDA:ARS, Russell Research Center
- Colorado State University, College of Veterinary Medicine and Biomedical Sciences
- BIOCOR Animal Health
- IDEXX Laboratories, Inc.
- The University of California College of Veterinary Medicine, Davis
- TREK Diagnostic Systems
- Antel BioSystems, Inc.

All participants are to be commended, particularly the producers whose voluntary efforts made the Dairy 2002 study possible.

Director
Centers for Epidemiology and Animal Health

Suggested bibliographic citation for this report:
USDA. 2005. Johne's Disease on U.S. Dairy Operations, 2002
USDA:APHIS:VS: CEAH, National Animal Health
Monitoring System, Fort Collins, CO #N427.0205

Contacts for further information:
Questions or comments on Dairy 2002 study methods or
requests for additional data analysis:
Dr. Jason Lombard: 970.494.7000

Information on reprints or other NAHMS reports:
Ms. Anne Berry: 970.494.7000

E-mail: NCAHSweb@aphis.usda.gov

Table of Contents

Introduction 1
Johne's Disease 1
Study Development 2
Terms Used In This Report 4

Section I: Population Estimates 6
A. Johne's Disease 6
1. Changes in producer familiarity with Johne's disease, 1996 to 2002 6
2. Clinical signs of Johne's disease within herds 7
3. Producer testing for Johne's disease 13
4. Whole-herd testing and removal of test-positive animals 20

B. Herd-Level Management Factors 25
1. Background 25
2. Johne's disease prevention 28
3. Source of heifers 29
4. Biosecurity for new arrivals 31
5. Testing new arrivals 32
6. Equipment sharing 32
7. Johne's disease management practices 32

Section II: Johne's Disease Risk Assessment 41
A. Background 41

B. Calving Area 42
1. Multiple use of calving area 42
2. Manure contamination 45
3. Other calving areas 46
4. Sick-cow access to calving area 48
5. Suspect cows in calving areas 49
6. Allowing calves access to dams for more than 3 hours 50
7. Allowing dams to nurse calves 52
8. Udder manure contamination 53
9. Calving areas average total risk scores 55
10. Calving area observation—6 a.m. to 6 p.m. 57
11. Calving area observation—6 p.m. to 6 a.m. 58
12. Individual calving pens 60
13. Employee contact 61

C. Preweaned Heifer Calves 63
1. Preweaned heifers on premises 63
2. Use of pooled colostrum 64
3. Source of colostrum 66
4. Use of pooled milk 67
5. Pasteurization of pooled milk 70
6. Housing 71
7. Cow-manure contamination in milk, feed, water, or housing areas 73
8. Preweaned heifer calves average total risk scores 75

D. Postweaned Heifer Calves 77
1. Postweaned heifers on premisies 77
2. Postweaned heifer calf housing 78
3. Cow-manure contamination of feed, water, or housing areas 80
4. Shared feed, water, or housing 82
5. Shared pasture with cows 86
6. Manure spread on pasture or harvested forage 88
7. Manure contamination of equipment used to feed postweaned heifers 90
8. Postweaned heifer calves average total risk scores 92

E. Bred Heifers 93
1. Bred heifers on premises 93
2. Bred-heifer housing 95
3. Cow-manure contamination in feed, water, or housing areas 98
4. Shared feed, water, or housing 99
5. Shared pasture with cows 103
6. Manure spread on pasture or harvested forage 106
7. Manure contamination of equipment used to feed bred heifers 108
8. Bred heifer average total risk scores 109

F. Cows 111
1. Cow-manure contamination of feeders and waterers 111
2. Manure spread on pasture or harvested forage 113
3. Cow-manure contamination of feed storage area and feeding equipment 116
4. Cow-access to manure storage areas 118
5. Cows average total risk scores 119

G. Total Risk Assessment Scores 121

Section III: Johne's Disease Testing
A. Testing Methods 123
1. Background 123
2. Individual fecal culture 124
3. Environmental fecal culture 124
4. Serum ELISA 125
5. Milk ELISA 125

B. NAHMS Dairy 2002 Johne's Disease Individual Animal Test Results 126
1. Background 126
2. MAP fecal culture 127
3. MAP serum ELISA 128
4. MAP milk ELISA 129
5. MAP environmental fecal culture 129

C. NAHMS Dairy 2002 Test Comparisons 130
1. Serum and milk ELISA agreement 130
2. Fecal culture and serum ELISA agreement 131
3. Fecal culture and milk ELISA agreement 132
4. Test comparison summary 134

D. Johne's Disease Prevalence 134
1. Animal-level prevalence—historical summary 134
2. Herd-level prevalence—historical summary 136
3. Within-herd prevalence 138
4. Apparent within-herd prevalence comparison 143

Section IV: Methods 144
A. Needs Assessment 144

B. Sampling and Estimation 145
1. State selection 145
2. Operation selection 145
3. Population inferences 145

C. Data Collection 146
1. Phase I 146
2. Phase II 146

D. Data Analysis 147
1. Validation and estimation 147
2. Response rates 147

Appendix I: Sample Profile 149
A. Responding Sites 149

Appendix II: U.S. Milk Cow Population and Operations 150

Appendix III: Fecal Culture Laboratory Methods 151

Appendix IV: Categorization of Test Results 153

Appendix V: Study Objectives and Related Outputs 154

Appendix VI: References 155

Appendix VII: Additional Resource Information on Johne's Disease 162

Introduction

Johne's Disease

Bovine paratuberculosis (Johne's disease) is caused by the bacterium *Mycobacterium avium* subspecies *paratuberculosis* (MAP). In addition to cattle and other ruminants, many species of domestic and wild animals worldwide have been diagnosed with Johne's disease.

MAP infection is associated with large economic losses in dairy cattle. What's more, the suggestion by some authors that MAP may play a role in Crohn's disease in humans has led to increased awareness of the organism in the scientific community. MAP, along with other microorganisms, has been isolated from patients with Crohn's disease. Viable MAP has been cultured from pasteurized retail milk samples in the United Kingdom and in the United States.

The first reported incident of Johne's disease—originally thought to be an intestinal form of tuberculosis—occurred in Germany in the early 1800s. The disease was later described by Drs. Frothingham and Johne. The first reported case of Johne's disease in the United States occurred in Pennsylvania in 1908. Clinical signs of Johne's disease include decreased milk production, weight loss, and diarrhea. However, because MAP incubation can be lengthy, clinical signs may not be seen within the productive life of an animal.

The low sensitivity of available Johne's disease diagnostic tests is one of the challenges in controlling the disease. For example, Johne's disease is diagnosed definitively by organism identification methods such as fecal culture or tissue biopsy. However, due to intermittent shedding of the organism in feces, a single fecal culture may detect only 30 to 40 percent of infected animals tested.

Another common method of Johne's disease diagnosis is the serum-based enzyme-linked immunosorbent assay (ELISA). Serum ELISAs have a faster turnaround than fecal cultures and are less expensive to conduct. The sensitivity of serum ELISAs, depending on the stage of disease, ranges from 15 to 87 percent when compared to concurrent fecal culture. Milk ELISAs also are available and have been shown to be comparable to serum ELISAs in relative sensitivity and specificity.

Despite problems associated with diagnosis, many States have developed and adopted a Bovine Johne's Disease Control Program. As of October 2004, 42 States had a recognized Johne's control plan, and 7 States were developing one. The Voluntary Bovine Johne's Disease Control Program uses diagnostic testing as a method of classifying herds. However, the program's emphasis is education and management.

Simulation models consistently indicate that improving management practices is more effective in reducing MAP transmission than simply removing test-positive animals. For example, because of the low sensitivity of available Johne's disease tests, infectious animals are often left in a herd. Therefore, combining management changes with a test-and-cull program may be the best approach to eliminating Johne's disease from an operation.

The National Animal Health Monitoring System (NAHMS) Dairy '96 study was the first national study to estimate cow- and herd-level prevalence of Johne's disease. During the study, serum samples were collected from 25 to 40 cows per participating operation and tested for

MAP antibodies; 31,745 cows from 967 herds were tested. Apparent prevalence was determined by dividing the number of test-positive animals by the total tested. Adjusted prevalence was estimated by correcting the apparent prevalence for imperfect test sensitivity and specificity. Apparent and adjusted cow-level prevalences were estimated at 2.5 and 3.4 percent, respectively.

The sampling plan for herd-level testing was designed to detect herd-level prevalence of at least 10 percent, with 90-percent confidence. A herd was classified as infected if two animals tested positive or if one animal tested positive and at least 5 percent of cull cows showed clinical signs. Using these criteria, the herd-level prevalence was estimated at 21.6 percent.

Study Development

In 2002, the National Animal Health Monitoring System (NAHMS) conducted a study of dairy operations in the United States. NAHMS Dairy 2002 was conducted in 21 major dairy States (see map on next page) and was designed to provide information to both participants and industry from operations representing 83.0 percent of U.S. dairy operations and 85.7 percent of U.S. dairy cows. Phase I data were collected from 2,461 operations by National Agricultural Statistics Service enumerators from December 31, 2001, through February 12, 2002. For Phase II of the Dairy 2002 study, data were collected from a subset of Phase I participants (1,013 operations with 30 or more dairy cows). Of these operations, 815 participated in an on-farm risk assessment of management practices believed to contribute to the transmission of MAP, the causative agent of Johne's disease. State and Federal veterinary medical officers (VMOs) and animal health technicians (AHTs) collected the data from February 25 through April 30, 2002. Data from both phases of collection are presented in this report. The methods used and a profile of responding operations can be found at the end of this report.

Instead of repeating the design of the '96 study, the NAHMS Dairy 2002 study focused on estimating within-herd prevalence of Johne's disease. Johne's disease within-herd prevalence estimates were used to measure associations of specific management procedures. In order to estimate prevalence, a statistical subset of cows was tested by both serum ELISA and fecal culture (see Section IV: Methods p 144). Other objectives of Dairy 2002 included evaluating environmental sample culture for Johne's disease, milk ELISA, and differences in production parameters by test category. Further information on NAHMS studies and reports is available online at:
http://www.aphis.usda.gov/nahms

USDA:APHIS:VS:CEAH
NRRC Building B, M.S. 2E7
2150 Centre Avenue,
Fort Collins, CO 80526-8117
970.494.7000

Dairy 2002 Participating States

Shaded States = Participating States

Terms Used In This Report

Clinical signs of Johne's disease: Chronic diarrhea and weight loss that does not respond to treatment despite a normal appetite, although these signs are not specific for Johne's disease.

Cow: Female dairy bovine that has calved at least once.

ELISA: Enzyme-linked immunosorbent assay.

Heifer: Female dairy bovine that has not yet calved.

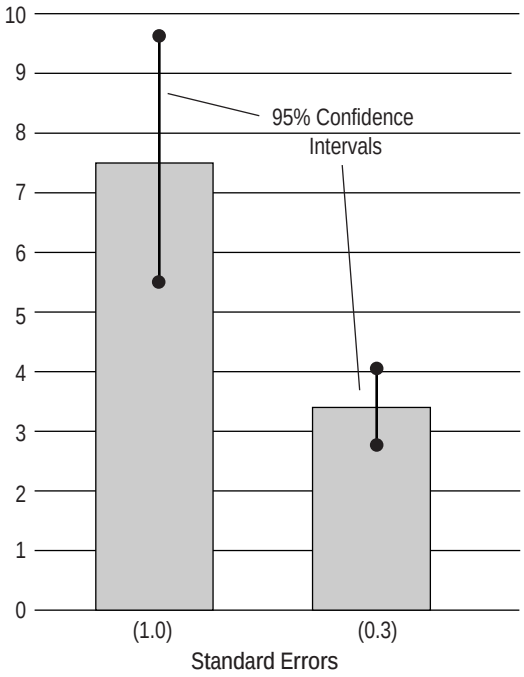
Herd size: Herd size is based on January 1, 2002, dairy cow inventory. Small herds are those with less than 100 head; medium herds are those with 100 to 499 head; and large herds are those with 500 or more head.

HEY: Herrold's egg yolk medium for culture of MAP.

MAP: *Mycobacterium avium* subspecies *paratuberculosis*, the causative agent of Johne's disease.

Population estimates: Estimates in this report are provided with a measure of precision called the standard error. A 95-percent confidence interval can be created with bounds equal to the estimate, plus or minus two standard errors. If the only error is sampling error, the confidence intervals created in this manner will contain the true population mean 95 out of 100 times. In the example to the right, an estimate of 7.5 with a standard error of 1.0 results in limits of 5.5 to 9.5 (two times the standard error above and below the estimate). The second estimate of 3.4 shows a standard error of 0.3 and results in limits of 2.8 and 4.0. Alternatively, the 90-percent confidence interval would be created by multiplying the standard error by 1.65 instead of 2. Most estimates in this report are rounded to the nearest tenth. If rounded to 0, the standard error was reported. If there were no reports of the event, no standard error was reported.

Examples of a 95% Confidence Interval



Prevalence:

Apparent prevalence: Proportion of animals with positive test results; provides an estimate of the true prevalence of a disease without correcting for the imperfect sensitivity and specificity of a diagnostic test.

True prevalence: Level of disease in a population, which is typically unknown but often estimated based on diagnostic testing of elements of the population.

Regions:
West: California, Colorado, Idaho, New Mexico, Texas, Washington
Midwest: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, Wisconsin
Northeast: New York, Pennsylvania, Vermont
Southeast: Florida, Kentucky, Tennessee, Virginia

Sample profile: Information that describes characteristics of the sites from which Dairy 2002 data were collected.

Sensitivity (Se): The probability that a test correctly identifies infected animals.

Specificity (Sp): The probability that a test correctly identifies uninfected animals.

Total inventory: All dairy cattle present on the site on January 1, 2002.

Section I: Population Estimates

NOTE: Unless otherwise specified, percentages in the following tables refer to operations with 30 or more dairy cows that were included in Phase II of the study (see Methods p 144). Operations with any dairy cows were included from Phase I.

A. Johne's Disease

1. Changes in producer familiarity with Johne's disease, 1996 to 2002

Although Johne's disease was first discovered in the late 1800s and has since been reported in most countries around the world, results of the National Animal Health Monitoring System (NAHMS) Dairy '96 study revealed that almost 10 percent of dairy producers had not heard of Johne's disease. Dairy '96 also revealed that just 17.7 percent of producers were fairly knowledgeable about the disease, indicating a need to increase Johne's disease education efforts. Since 1996, numerous articles in dairy publications have focused on educating producers about the disease. Results from the Dairy 2002 study indicate that producers are getting the message. The study reported that only 1.0 percent of producers had not heard of Johne's disease and 45.3 percent were fairly knowledgeable. Herd-size differences in producers' knowledge about Johne's disease within study years were negligible.

a. Percentage of operations by level of familiarity with Johne's disease in 1996 and 2002, by herd size

	Herd Size (Number of Dairy Cows)							
	Small (Less than 100)		Medium (100-499)		Large (500 or More)		All Operations	
	1996	2002	1996	2002	1996	2002	1996	2002
Familiarity	Pct. (Std. Error)	Pct. (Std. Error)	Pct. (Std. Error)	Pct. (Std. Error)	Pct. (Std. Error)	Pct. (Std. Error)	Pct. (Std. Error)	Pct. (Std. Error)
Had not heard of before	9.7 (1.3)	0.7 (0.3)	9.2 (1.5)	1.8 (0.7)	21.7 (5.5)	2.0 (1.1)	9.9 (1.1)	1.0 (0.3)
Recognized name only	37.0 (2.2)	12.7 (1.8)	28.8 (2.6)	8.2 (1.4)	31.4 (5.8)	6.3 (2.0)	35.3 (1.8)	11.4 (1.4)
Knew some basics	36.9 (2.1)	42.1 (2.8)	38.6 (2.8)	44.5 (3.0)	31.6 (5.5)	33.9 (3.8)	37.1 (1.8)	42.3 (2.1)
Fairly knowledgeable	16.4 (1.6)	44.5 (2.8)	23.4 (2.6)	45.5 (2.9)	15.3 (3.7)	57.8 (4.0)	17.7 (1.3)	45.3 (2.1)
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

As reported in the NAHMS 1996 and 2002 dairy studies, a higher percentage of operations in the Midwest region were fairly knowledgeable about Johne's disease compared to operations in the West region.

b. Percentage of operations by level of familiarity with Johne's disease in 1996 and 2002, by region

	Region							
	West		Midwest		Northeast		Southeast	
	1996	2002	1996	2002	1996	2002	1996	2002
Familiarity	Pct. (Std. Error)	Pct. (Std. Error)	Pct. (Std. Error)	Pct. (Std. Error)	Pct. (Std. Error)	Pct. (Std. Error)	Pct. (Std. Error)	Pct. (Std. Error)
Had not heard of before	21.9 (2.6)	4.6 (1.8)	5.3 (1.3)	0.7 (0.3)	15.6 (2.4)	0.2 (0.2)	15.5 (6.3)	2.7 (2.0)
Recognized name only	35.6 (3.1)	15.2 (3.6)	32.3 (2.4)	10.1 (1.8)	41.7 (3.5)	15.2 (2.9)	38.0 (7.9)	1.6 (1.0)
Knew some basics	31.5 (3.0)	48.2 (4.6)	41.6 (2.5)	37.6 (2.9)	30.2 (3.0)	46.6 (4.0)	27.2 (6.0)	58.4 (8.3)
Fairly knowledgeable	11.0 (1.8)	32.0 (4.1)	20.8 (1.9)	51.6 (3.0)	12.5 (2.3)	38.0 (3.9)	19.3 (5.2)	37.3 (8.1)
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

2. Clinical signs of Johne's disease within herds

Overall, 47.8 percent of operations had ever observed at least one cow in their herd with clinical signs of Johne's disease. The majority of large operations (70.9 percent) observed at least one cow with clinical signs, compared to 58.4 percent of medium operations and 43.1 percent of small operations.

a. Percentage of operations that had ever observed at least one cow in their herd with clinical signs of Johne's disease, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		Medium (100-499)		Large (500 or More)		All Operations	
Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
43.1	(3.1)	58.4	(3.3)	70.9	(4.3)	47.8	(2.4)

b. Percentage of operations that had ever observed at least one cow in their herd with clinical signs of Johne's disease, by region

Region							
West		Midwest		Northeast		Southeast	
Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
42.9	(5.2)	51.3	(3.3)	41.8	(4.6)	48.5	(7.9)

The majority of operations (69.6 percent) observed no cows in their herd with clinical signs of Johne's disease during the 12 months prior to the 2002 study interview. A higher percentage of small operations observed no cows with clinical signs compared to medium and large operations. One out of two large operations (50.3 percent) reported that 0.1 to 4.9 percent of their herd displayed clinical signs during the 12 months prior to the interview.

c. Percentage of operations by percentage of herd with clinical signs of Johne's disease during the 12 months prior to the 2002 study interview and by herd size

	Herd Size (Number of Dairy Cows)							
	Small (Less than100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Percentage of Herd with Clinical Signs	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
0.0	74.4	(2.7)	58.4	(3.3)	47.5	(4.3)	69.6	(2.1)
0.1 to 4.9	16.3	(2.2)	37.1	(3.3)	50.3	(4.4)	22.5	(1.8)
5.0 to 9.9	6.2	(1.7)	3.1	(1.0)	0.8	(0.3)	5.2	(1.2)
10.0 to 14.9	2.9	(1.2)	1.4	(1.1)	0.3	(0.2)	2.5	(0.9)
15.0 or more	0.2	(0.2)	0.0	(--)	1.1	(0.8)	0.2	(0.2)
Total	100.0		100.0		100.0		100.0	

In the West region, 80.7 percent of operations had not observed clinical signs of Johne's disease during the 12 months prior to the 2002 study interview compared to 66.3 percent of operations in the Midwest region.

d. Percentage of operations by percentage of herd with clinical signs of Johne's disease during the 12 months prior to the 2002 study interview and by region

	Region							
	West		Midwest		Northeast		Southeast	
Percentage of Herd with Clinical Signs	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error
0.0	80.7	(3.0)	66.3	(3.1)	74.8	(3.8)	62.2	(8.1)
0.1 to 4.9	19.2	(3.0)	23.6	(2.7)	18.1	(2.6)	35.1	(8.0)
5.0 to 9.9	0.1	(0.1)	7.8	(2.0)	2.5	(1.2)	0.8	(0.8)
10.0 to 14.9	0.0	(--)	2.0	(1.0)	4.6	(2.7)	1.3	(1.3)
15.0 or more	0.0	(--)	0.3	(0.3)	0.0	(--)	0.6	(0.5)
Total	100.0		100.0		100.0		100.0	

e. For operations that ever observed clinical signs of Johne's disease, percentage of operations by number of years* since first observing clinical signs of Johne's disease

Years	Percent	Standard Error
0 to 9	72.9	(2.9)
10 to 19	20.2	(2.7)
20 to 29	6.4	(1.4)
30 to 39	0.2	(0.1)
40 to 49	0.3	(0.3)
Total	100.0	

*Results may be affected by the number of years an individual operation was in business

For operations that had ever observed clinical signs of Johne's disease in their herd, the majority of operations (72.9 percent) observed clinical signs within the past 10 years. Very few operations observed clinical signs of Johne's disease in their herd more than 30 years ago, which might be a reflection of how long the operations have been in business rather than actual disease occurrence.

Since 1994, the percentage of operations that observed clinical signs of Johne's disease in their herd for the first time has increased. Although an increased incidence of Johne's disease is possible, it is more likely that producers are now more aware of the disease due to factors such as increased education efforts.

f. For operations that first observed clinical signs of Johne's disease between 1994 and 2002, percentage of operations by year clinical signs were first observed

Year	Percent	Standard Error
1994	3.1	(1.0)
1995	9.5	(2.4)
1996	10.0	(2.3)
1997	17.2	(3.1)
1998	10.6	(2.5)
1999	18.6	(3.4)
2000	12.8	(2.5)
2001	13.0	(3.2)
2002*	5.2	(2.0)
Total	100.0	

*Partial-year observations

The source of the first cow in the herd to exhibit clinical signs of Johne's disease differed by herd size. A higher percentage of medium operations (65.6 percent) reported that the first cow with clinical signs was a purchased animal compared to small operations (44.4 percent). However, there were no regional differences between the percentage of operations where the first cow with clinical signs was home-raised and operations where the first cow with clinical signs was purchased.

g. Percentage of operations by source of the first cow with clinical signs of Johne's disease, by herd size

	Herd Size (Number of Dairy Cows)							
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or more)		**All Operations**	
Source	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
Home-raised	55.6	(4.9)	34.4	(4.4)	49.3	(5.5)	49.4	(3.6)
Purchased	44.4	(4.9)	65.6	(4.4)	50.7	(5.5)	50.6	(3.6)
Total	100.0		100.0		100.0		100.0	

h. Percentage of operations by source of the first cow with clinical signs of Johne's disease, by region

	Region							
	West		Midwest		Northeast		Southeast	
Source	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error
Home-raised	52.2	(7.8)	50.8	(4.8)	47.7	(7.0)	37.3	(11.9)
Purchased	47.8	(7.8)	49.2	(4.8)	52.3	(7.0)	62.7	(11.9)
Total	100.0		100.0		100.0		100.0	

The highest percentage of operations (43.5 percent) reported that the youngest cow in the herd with clinical signs of Johne's disease was 3 years of age.

i. Percentage of operations by age of youngest cow in the herd with clinical signs of Johne's disease

Age (Years)	Percent	Standard Error
1	1.3	(0.6)
2	8.2	(2.1)
3	43.5	(3.4)
4	22.8	(2.9)
5	12.4	(2.1)
6	8.6	(1.8)
7	3.2	(1.1)
Total	100.0	

The majority of operations (63.6 percent) reported that home-raised cows were the source of the youngest cows to display clinical signs of Johne's disease. Since clinical signs may not be observed prior to shedding MAP, purchased cows may infect home-raised calves.

j. Percentage of operations by source of youngest cow in herd with clinical signs of Johne's disease

Source	Percent	Standard Error
Home-raised	63.6	(3.3)
Purchased	36.4	(3.3)
Total	100.0	

Common clinical signs associated with Johne's disease include weight loss and diarrhea while maintaining a normal appetite.

3. Producer testing for Johne's disease

During the 12 months prior to the 2002 study interview, a higher percentage of large and medium operations (38.3 percent and 39.5 percent, respectively) performed any testing for Johne's disease, compared to 20.4 percent of small operations. Overall, 25.7 percent of operations tested for Johne's disease.

a. Percentage of operations that tested for Johne's disease during the 12 months prior to the 2002 study interview, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Percent	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
20.4	(2.5)	39.5	(3.3)	38.3	(4.0)	25.7	(1.9)

A larger percentage of operations in the Midwest region (29.7 percent) tested for Johne's disease during the 12 months prior to the 2002 study interview compared to operations in the West region (15.8 percent).

b. Percentage of operations that tested for Johne's disease during the 12 months prior to the 2002 study interview, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Percent	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
15.8	(2.9)	29.7	(3.1)	21.9	(2.6)	20.1	(5.7)

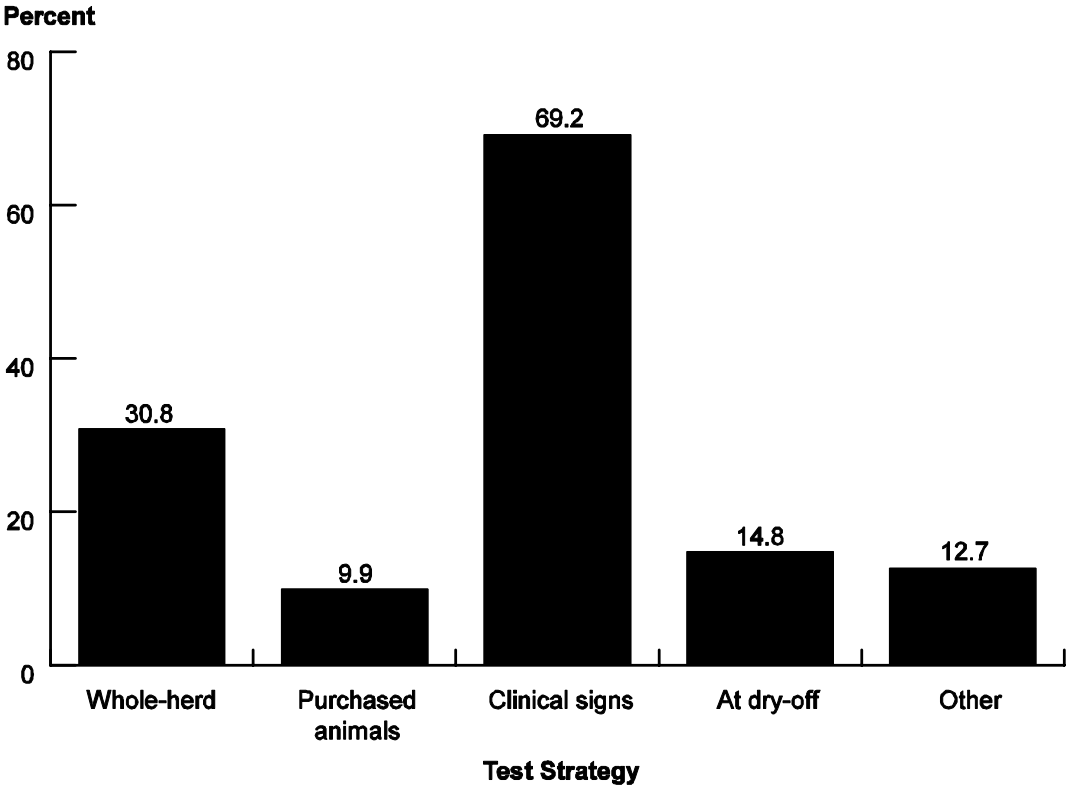
For operations that tested for Johne's disease during the 12 months prior to the 2002 study interview, the majority (69.2 percent) tested cows with clinical signs of Johne's disease. Whole-herd testing was performed on 30.8 percent of operations. "Other" strategies included testing at pregnancy exam, random sampling of cows, testing cows that recently calved, and testing older cows. The percentage of operations that tested at dry-off increased as herd size increased.

c. For operations that tested for Johne's disease during the 12 months prior to the 2002 study interview, percentage of operations by testing strategy* and herd size

	Herd Size (Number of Dairy Cows)							
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or more)		**All Operations**	
Test Strategy	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
Whole herd	35.7	(6.8)	24.8	(5.0)	19.5	(5.7)	30.8	(4.3)
Purchased animals	9.7	(4.1)	10.3	(3.4)	9.6	(3.1)	9.9	(2.7)
Clinical signs	67.1	(6.5)	73.4	(4.4)	64.3	(7.0)	69.2	(4.1)
At dry off	4.8	(2.9)	27.3	(5.4)	35.8	(7.0)	14.8	(2.8)
Other	10.0	(3.6)	16.3	(3.9)	17.6	(5.3)	12.7	(2.6)

* Operations may have selected more than one strategy

For Operations that Tested for Johne's Disease During the 12 Months Prior to the 2002 Study Interview, Percentage of Operations by Testing Strategy*



*Operations may have selected more than one strategy

The percentage of operations that tested cows with clinical signs of Johne's disease was similar across all four regions. A higher percentage of operations in the Midwest and Northeast regions (35.1 percent and 27.9 percent, respectively) performed whole-herd testing than did operations in the West region (2.5 percent).

d. For operations that tested for Johne's disease during the 12 months prior to the 2002 study interview, percentage of operations by testing strategy* and region

	Region							
	West		Midwest		Northeast		Southeast	
Test Strategy	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error
Whole herd	2.5	(2.5)	35.1	(6.0)	27.9	(7.0)	17.4	(10.7)
Purchased animals	4.8	(4.2)	8.7	(3.6)	16.6	(5.4)	1.3	(1.3)
Clinical signs	68.4	(9.7)	73.5	(5.4)	55.5	(7.3)	75.2	(11.8)
At dry off	11.6	(5.7)	16.4	(4.0)	14.2	(3.9)	0.0	(--)
Other	24.4	(9.4)	7.9	(2.9)	25.0	(6.1)	8.7	(6.5)

* Operations may have selected more than one strategy

The most common method of testing for Johne's disease in cattle is serum-based enzyme-linked immunoabsorbent assay (ELISA). Overall, 67.6 percent of operations that tested for Johne's disease used only a serum ELISA to test at least one cow during the 12 months prior to the 2002 study interview. Only 5.7 percent used only fecal culture to diagnose Johne's disease. Approximately one-fourth of operations (26.7 percent) used both fecal culture and serum ELISA to test for Johne's disease.

e. For operations that tested for Johne's disease during the 12 months prior to the 2002 study interview, percentage of operations that used fecal culture, serum ELISA, or both, by herd size

	Herd Size (Number of Dairy Cows)							
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or more)		**All Operations**	
Test	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
Fecal culture only	5.3	(2.5)	5.4	(1.7)	12.1	(4.0)	5.7	(1.6)
Serum ELISA only	71.2	(5.5)	61.9	(5.0)	67.2	(6.4)	67.6	(3.7)
Both	23.5	(5.2)	32.7	(5.0)	20.7	(5.9)	26.7	(3.5)
Total	100.0		100.0		100.0		100.0	

No operations in the Southeast region used only fecal culture to test for Johne's disease during the 12 months prior to the 2002 study interview. A higher percentage of operations in the West region (22.9 percent) used only fecal culture compared to operations in the Midwest region (2.4 percent).

f. For operations that tested for Johne's disease during the 12 months prior to the 2002 study interview, percentage of operations that used fecal culture, serum ELISA, or both, by region

	Region							
	West		**Midwest**		**Northeast**		**Southeast**	
Test	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
Fecal culture only	22.9	(8.2)	2.4	(1.1)	12.3	(5.3)	0.0	(--)
Serum ELISA only	56.4	(9.8)	77.1	(4.5)	45.3	(7.1)	57.9	(14.4)
Both	20.7	(7.7)	20.5	(4.4)	42.4	(6.9)	42.1	(14.4)
Total	100.0		100.0		100.0		100.0	

Overall, 91.7 percent of operations did not use fecal culture to test for Johne's disease during the 12 months prior to the 2002 study interview. Very few operations (1.4 percent) used fecal-culture testing for 25.0 percent or more of their herd. Only 8.8 percent of all operations used serum ELISAs to test 50 percent or more of their herd.

g. Percentage of operations by percentage of herd tested using fecal culture and serum ELISA during the 12 months prior to the 2002 study interview

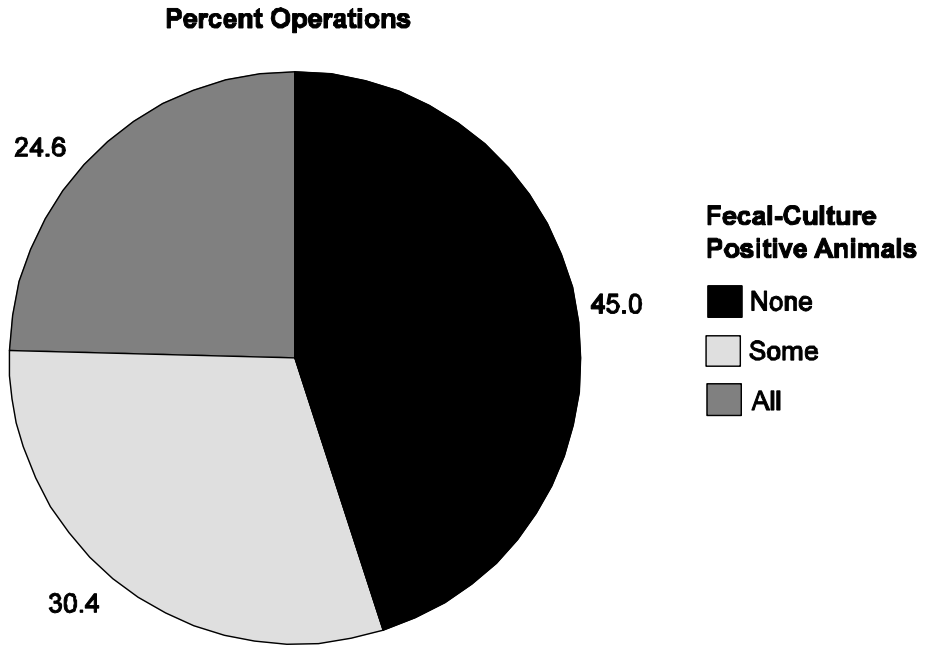
	Fecal Culture		Serum ELISA	
Percent Herd	Percent	Standard Error	Percent	Standard Error
0.0	91.7	(1.0)	75.8	(1.9)
0.1 to 24.9	6.9	(0.9)	14.1	(1.6)
25.0 to 49.9	0.4	(0.2)	1.3	(0.5)
50.0 to 74.9	0.1	(0.1)	1.9	(0.6)
75.0 to 99.9	0.0	(0.0)	3.4	(0.8)
100.0	0.9	(0.4)	3.5	(0.9)
Total	100.0		100.0	

For operations that tested at least one animal by fecal culture, the percentage of operations where all tested animals were fecal-culture-positive decreased when six or more animals were tested compared to when fewer than six animals were tested. Overall, 45.0 percent of operations reported that no animals tested fecal-culture positive.

h. For operations that tested at least one animal by fecal culture, percentage of operations by level of animals testing fecal-culture positive and by number of animals tested during the 12 months prior to the 2002 study interview

	Number Animals Tested							
	1		2-5		6 or More		Overall	
Fecal-Culture Positive Animals	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error
None	46.7	(12.0)	33.4	(10.4)	51.2	(11.0)	45.0	(6.7)
Some	0.0	(--)	33.7	(11.7)	48.3	(11.0)	30.4	(6.5)
All	53.3	(12.0)	32.9	(12.5)	0.5	(0.5)	24.6	(5.5)
Total	100.0		100.0		100.0		100.0	

For Operations That Tested at Least One Animal by Fecal Culture, Percentage of Operations by Level of Animals Testing Fecal-Culture Positive

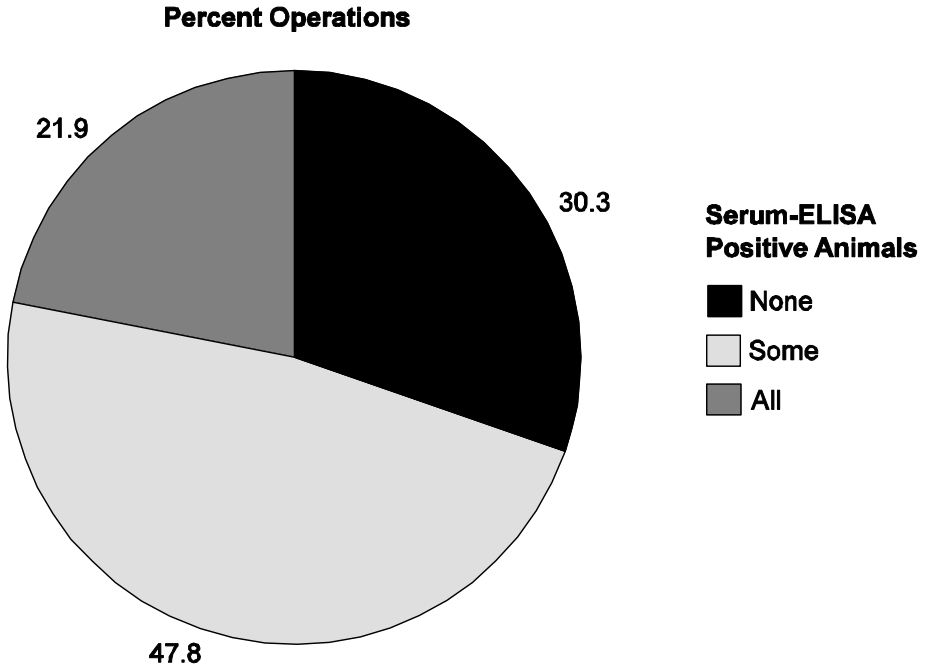


For operations that tested six or more animals by serum ELISA, only 3.4 percent of operations had all animals test serum-ELISA positive. Regardless of the number of animals tested, 30.3 percent of operations had no animals test serum-ELISA positive. For operations that tested at least one animal by serum ELISA, over one-fifth of operations (21.9 percent) had 100 percent of cows test positive. Many operations tested cows with clinical signs of MAP infection (see Producer testing for Johne's disease p14), which may account for the large percentage of operations where all cows tested by serum ELISA were positive.

i. For operations that tested at least one animal by serum ELISA, percentage of operations by level of animals testing serum-ELISA positive and by number of animals tested during the 12 months prior to the 2002 study interview.

	Number Animals Tested							
	1		2-5		6 or More		Overall	
Serum-ELISA Positive Animals	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error
None	50.0	(11.5)	28.4	(8.5)	22.7	(5.0)	30.3	(4.4)
Some	0.0	(--)	28.9	(8.5)	73.9	(5.3)	47.8	(4.6)
All	50.0	(11.5)	42.7	(9.4)	3.4	(2.2)	21.9	(4.2)
Total	100.0		100.0		100.0		100.0	

For Operations That Tested at Least One Animal by Serum ELISA, Percentage of Operations by Level of Animals Testing Serum-ELISA Positive



A small percentage of operations (4.6 percent) had at least one fecal-culture positive animal during the 12 months prior to the 2002 study interview, compared to 16.9 percent of operations that had at least one serum-ELISA positive animal.

j. Derived percentage of operations testing positive during the 12 months prior to the 2002 study interview using values from previous tables

	Operations Tested (Column A)	**Operations Tested Positive** (Column B)	**Operations Positive** (Columns A x B)
Test	**Percent Table 3g**	**Percent Tables 3h and 3i**	**Percent**
Fecal culture	8.3	55.0	4.6
Serum ELISA	24.2	69.7	16.9

4. Whole-herd testing and removal of test-positive animals

Field studies assessing the true benefit of whole-herd testing and the culling of test-positive animals have not been published. However, models simulating control programs have been developed, such as a Johne's-disease-control simulation that compared the efficacy of ideal management practices and test-and-cull programs as they relate to controlling the disease.[1]

The simulation model indicated that test-and-cull programs reduced herd-level disease prevalence (percentage of the herd infected) when initial prevalence was 10 percent, but disease reduction using test-and-cull was slower compared to management procedures that reduced MAP transmission. In addition, combining test-and-cull programs and ideal management procedures reduced herd prevalence faster than when either method was implemented separately. In an economic analysis model, a test-and-cull program was profitable when the herd prevalence was higher than 5 percent.[2]

A simulation model of Johne's disease control, using herd and prevalence data from The Netherlands and Pennsylvania, suggested that implementing calf-management tools was the only way to reach a low true-mean prevalence within 20 years.[3] In the absence of control measures, mean-herd prevalence increased over time in both The Netherlands and Pennsylvania simulations. It was reported that test-and-cull strategies had only a minor effect on Johne's disease herd prevalence when combined with improved management practices. When the model was used to evaluate herds typical of Pennsylvania, findings indicated that contract rearing of heifers and improved calf hygiene were associated with decreased herd prevalence of Johne's disease. However, the model did not consider the potential disease exposure to calves due to commingling of heifers from different operations at contract facilities.

A recent report of a simulation model designed to evaluate both the epidemiologic and economic efficiency of control programs in midsize U.S. dairy farms also indicated shortcomings with test-and-cull strategies.[4] The

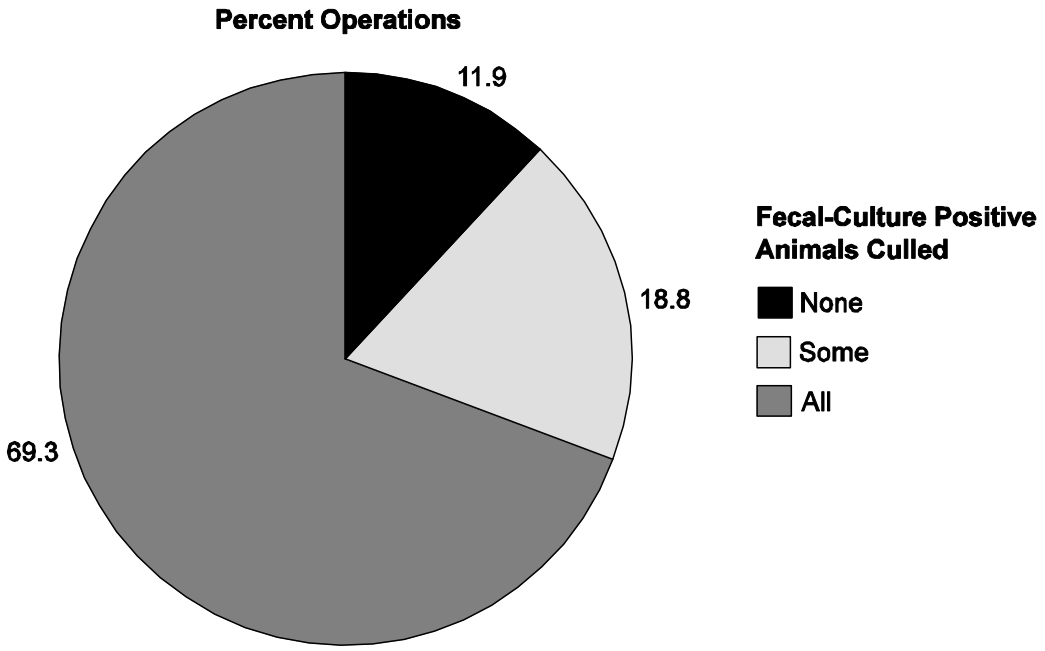
model predicted that test-and-cull strategies alone did not reduce the prevalence of MAP in cattle and were costly to producers. The model indicated that improved calf hygiene was the most effective control strategy for MAP. Vaccination did not reduce the prevalence of MAP in this study, but the increase in age at which cows became infectious and the reduction in probability that cows would become infectious (shed MAP) led to decreased economic losses from the disease.

For operations that had at least one cow test fecal-culture positive during the 12 months prior to the 2002 study interview, 69.3 percent removed all test-positive cows. For operations that tested six or more animals, all operations culled at least some of the fecal-culture positive animals. Approximately one-fourth of operations (25.6 percent) with two to five fecal-culture positive animals culled no test-positive animals. All operations that had only one fecal-culture positive animal culled the test-positive animal.

a. For operations that had at least one cow test fecal-culture positive during the 12 months prior to the 2002 study interview, percentage of operations by level of fecal-culture positive animals culled and by number of animals that tested positive

	Number Fecal-Culture Positive Animals							
	1		2-5		6 or More		Overall	
Positive Animals Culled	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error
None	0.0	(--)	25.6	(13.7)	0.0	(--)	11.9	(6.9)
Some	0.0	(--)	28.5	(15.0)	43.7	(25.2)	18.8	(8.0)
All	100.0	(--)	45.9	(14.6)	56.3	(25.2)	69.3	(9.2)
Total	100.0		100.0		100.0		100.0	

For Operations That Had at Least One Cow Test Fecal-Culture Positive During the 12 Months Prior to the 2002 Study Interview, Percentage of Operations by Level of Test-Positive Animals Culled

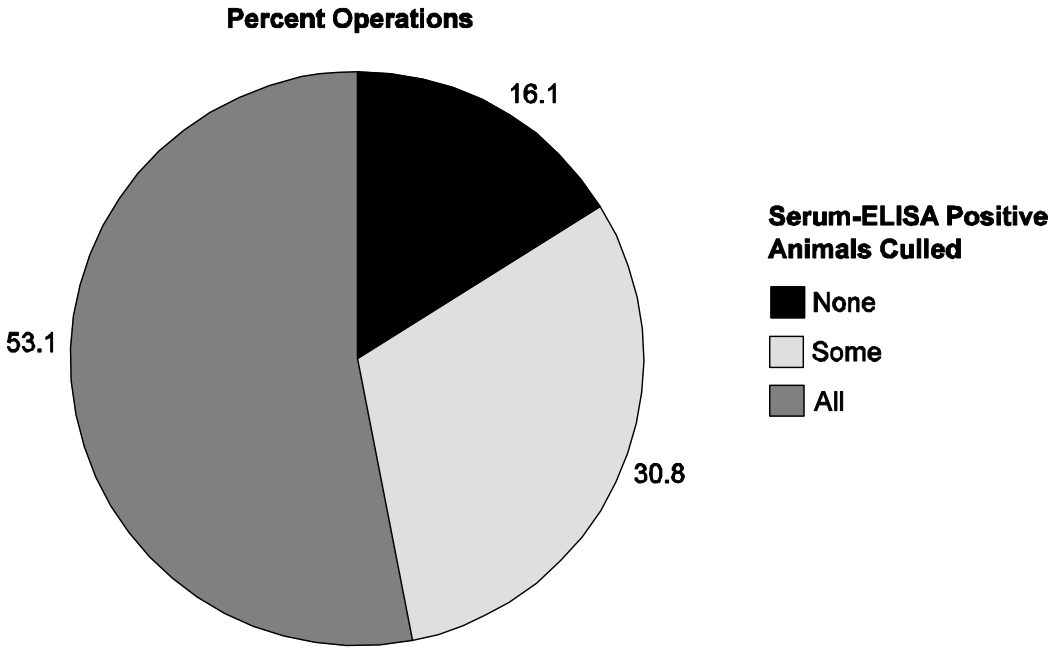


For operations that had at least one cow test positive via serum ELISA during the 12 months prior to the 2002 study interview, the majority (53.1 percent) culled 100 percent of test-positive cows. Approximately one-sixth of operations (16.1 percent) culled no ELISA-positive cows during the 12 months prior to the interview.

b. For operations that had at least one cow test positive by serum ELISA during the 12 months prior to the 2002 study interview, percentage of operations by level of serum-ELISA positive animals culled and by number of animals that tested positive

	Number Serum-ELISA Positive Animals							
	1		2-5		6 or More		Overall	
Positive Animals Culled	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error
None	9.6	(6.5)	18.8	(5.8)	17.4	(7.2)	16.1	(3.8)
Some	0.0	(--)	29.1	(7.6)	58.7	(8.9)	30.8	(4.9)
All	90.4	(6.5)	52.1	(7.9)	23.9	(7.8)	53.1	(5.4)
Total	100.0		100.0		100.0		100.0	

For Operations That Had at Least One Cow Test Serum-ELISA Positive During the 12 Months Prior to the 2002 Study Interview, Percentage of Operations by Level of Test-Positive Animals Culled



The percentage of operations participating in Johne's disease certification, control, or herd-status programs* increased since the Dairy '96 study. However, there was no difference in program participation by herd size within in each study year.

c. Percentage of operations participating in a Johne's disease control program,* as reported in the Dairy '96 and Dairy 2002 studies, by herd size

	Herd Size (Number of Dairy Cows)							
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or more)		**All Operations**	
Dairy Study	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
1996	1.0	(0.4)	0.5	(0.4)	0.4	(0.4)	0.9	(0.3)
2002	9.5	(1.7)	16.5	(2.3)	11.3	(2.3)	11.2	(1.4)

*Questions in 1996 and 2002 studies differed. In 1996, participants were asked if they were currently in a Johne's disease certification program. In 2002, participants were asked if they participate in a Johne's disease herd-status, control, or certification program (Federal, State, or developed by a veterinarian specific to their operation).

For the 2002 study, a higher percentage of operations in the Northeast region (15.9 percent) participated in a program* than operations in the West region (3.9 percent).

d. Percentage of operations participating in a Johne's disease control program,* as reported in the Dairy '96 and Dairy 2002 studies, by region

	Region							
	West		Midwest		Northeast		Southeast	
Dairy Study	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error
1996	0.0	(--)	0.8	(0.4)	1.4	(0.8)	0.2	(0.2)
2002	3.9	(1.6)	10.8	(2.0)	15.9	(2.5)	6.0	(3.2)

*Questions in 1996 and 2002 studies differed. In 1996, participants were asked if they were currently in a Johne's disease certification program. In 2002, participants were asked if they participate in a Johne's disease herd-status, control, or certification program (Federal, State, or developed by a veterinarian specific to their operation).

Approximately half of operations (51.0 percent) had participated in a Johne's disease program for fewer than 3 years.

e. For operations participating in a Johne's disease control program at the time of the 2002 study interview, percentage of operations by months of participation

Months	Percent	Standard Error
Fewer than 12	19.9	(5.5)
12 to 23	19.0	(5.0)
24 to 35	12.1	(3.8)
36 to 47	25.9	(6.3)
48 to 59	8.2	(3.5)
60 to 71	4.5	(2.4)
72 to 83	0.4	(0.3)
84 or more	10.0	(3.6)
Total	100.0	

B. Herd-Level Management Factors

1. Background

Evaluating management factors associated with the presence of Johne's disease on dairy operations is complicated because of the long incubation period of the disease and difficulties associated with diagnosis. Operations with Johne's disease may make changes in management to prevent transmission of disease, while operations without Johne's disease may have practices in place that would allow transmission to occur at a high rate if the disease were present.

A survey of management practices found an association between calf housing after weaning and apparent herd-level prevalence of Johne's disease.[5] In higher-prevalence herds, calves tended to be moved to calf barns or hutches rather than to pens in the cow barn. This observation suggests that calf barns or hutches were in close proximity to cows, calf-to-calf transmission had occurred, or that management changes had been made in higher-prevalence herds to decrease disease transmission. Herd size and location also were found to be significant factors. Larger herds in certain districts were more likely to have a higher prevalence of MAP infection compared to smaller herds in those districts or small or large herds in other districts.

An evaluation of 27 management factors on dairy operations in England found that dairy

Photo: Jason Lombard

operations where Channel Island breeds predominated and dairy operations with farmed deer had an increased risk of MAP infection.[6] However, the association of farmed deer and increased prevalence of MAP infection is tenuous, since only 0.4 percent of operations reported having farmed deer. Other significant but inconsistent associations with the presence of MAP infection included purchasing replacement animals privately, not feeding hay to calves, not purchasing course-mix concentrate feed, and not using individual calving pens.

An analysis of 33 New York dairy herds identified several management factors associated with Johne's disease.[7] Findings indicated that commercial herds were significantly more likely to be infected with MAP than registered or both registered and commercial herds, and that exposing young animals to the feces of older animals via contaminated equipment and manure-fertilized forage increased the likelihood of herd infection. Interestingly, herds where barns were cleaned once a day were less likely to be infected than herds where barns were cleaned three or more times a day. This finding was unexpected—since frequent barn cleanings should reduce exposure to MAP—but may be due to management changes associated with the infection status of herds.

A study evaluating 121 herds in Michigan and 97 risk factors for MAP infection found five risk factors significantly associated with MAP infection.[8] Risk factors included using an exercise lot for lactating cows and washing cows' udders prior to parturition. Protective management practices included cleaning calf hutches/pens after each use and applying lime to pasture.

During the NAHMS Dairy '96 study, more than 1,000 herds from across the United States were evaluated for Johne's disease risk factors, herd managers' familiarity with Johne's disease, prior diagnosis of Johne's disease, and Johne's disease herd status. After removing vaccinated herds from the risk factor analysis, Johne's disease herd status was positively associated with larger herd sizes, region of the country, larger percentages of cows born on other operations, and group housing for periparturient cows and calves prior to weaning.[9]

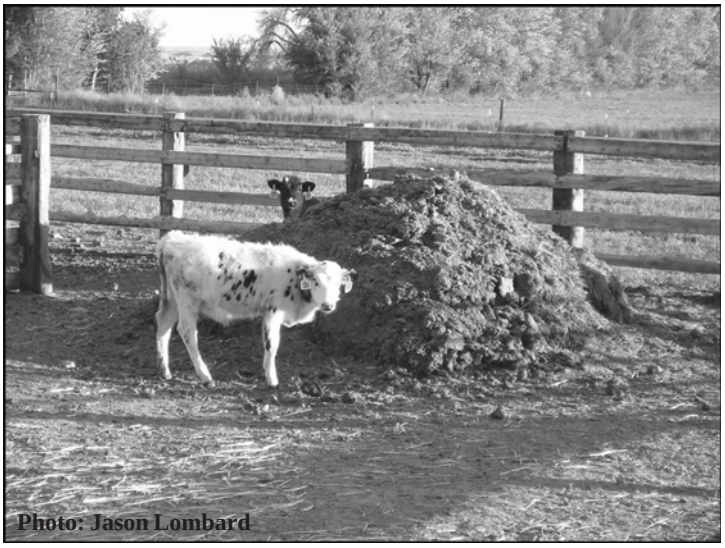


Photo: Jason Lombard

Large operations (500 or more animals) were more

likely to add purchased animals than smaller operations.[10] Since purchasing infected animals is a common method of introducing Johne's disease into a herd,[11] it follows that large operations are more likely to be infected.

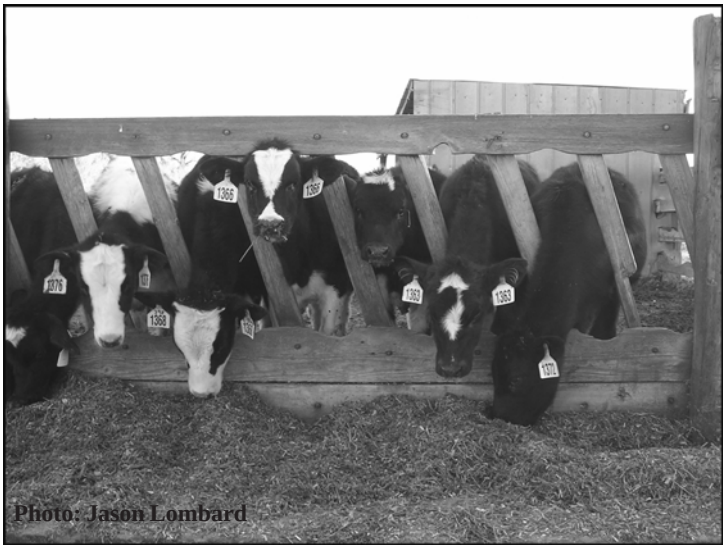


Photo: Jason Lombard

Regional differences in MAP infection may be explained by the fact that management practices, facilities, and environmental conditions differ across the United States. In addition, group housing of periparturient cows is believed to increase the risk of Johne's disease transmission.[9 12] However, group housing of calves has not been previously identified as a risk factor, even though experimentally-infected calves occasionally shed MAP in their feces, which could lead to calf-to-calf transmission.[13]

It also has been reported that herd owners who were more familiar with Johne's disease were more likely to wash cows' teats and udders prior to collecting colostrum or allowing calves to suckle.[9] Discouragingly, this was the only management practice associated with increased producer knowledge of Johne's disease.

Not surprisingly, operations participating in NAHMS Dairy '96 that had a prior diagnosis of Johne's disease were more likely to have purchased a greater percentage of cows born on other operations and were also more likely to remove the calf from its dam in a shorter time than herds that had not had a prior diagnosis. The association between prior diagnosis and time after birth for separation of a calf from its dam provided evidence that prior diagnosis can affect management practices.

An evaluation of 90 Canadian dairy herds and 27 control practices found that introducing new animals was the only management factor associated with higher prevalence of Johne's disease,[14] echoing other findings.[6 9]

Although MAP does not multiply in the environment, there are conditions that favor the long-term viability and retention of MAP in the environment. Disinfectants, drying, and direct sunlight reduce the survival time of the organism.[15] A more recent study found that dry soil and high soil temperature were the most significant factors in reducing recovery of MAP from soil.[16]

A study of the distribution of clinical Johne's disease in Wisconsin relative to soil types found

an association with acid soils, while disease was self-limiting in regions with alkaline soils.[17] Another study reported increased Johne's disease prevalence was associated with acidic soil and increased soil iron content and that application of lime to pasture areas was associated with reduced risk of Johne's disease.[18] Since MAP requires iron and an acid medium for effective growth in culture, it is biologically plausible that the organism survives longer in acidic soil with high iron content.

Soil types and Johne's disease prevalence also were evaluated in Indiana.[19] Herds located in areas with sandy loam or loam soils were more likely to be within the cluster of greater-than-the-median seroprevalence, while herds with silt loam soils were less likely to be included in that cluster.

MAP can survive for months in fecal slurries and water, although high slurry temperatures tend to decrease survival.[20 21] The long survival time of MAP and the practice of using manure for fertilizing pastures which may be grazed could lead to increased environmental contamination and an increased risk of disease transmission.

An experimental study evaluating the ability of chlorine water treatments to kill MAP reported log reductions in the number of viable organisms, but killing was incomplete when initial inoculums contained 10^6 cfu/ml of MAP. [22]

2. Johne's disease prevention

A common belief is that most dairy operations acquired Johne's disease by purchasing an infected animal.[11] Studies evaluating risk factors for MAP infection have found associations between herd additions and presence of Johne's disease.[6 9 14] Although biosecurity recommendations regarding purchase of herd additions have been published, dairy producers in the United States and other countries have not embraced these practices.[23 24 25]

Operations undergoing expansion can decrease the probability of acquiring Johne's disease by selecting replacement animals from well-managed herds that have not had clinical cases or have performed diagnostic testing for Johne's disease.[24] Unfortunately, only 9.1 percent of expanding operations required Johne's disease testing prior to purchasing animals in 1996,[26] and only 9.8 percent did so in 2002.[10] The lack of testing prior to bringing purchased cattle onto an operation is not restricted to Johne's disease; 66.3 percent of dairy operations in 1996 required no testing of purchased animals for any disease, as compared to 75.5 percent in 2002.[10 26]

3. Source of heifers

Heifers were born and raised on a smaller percentage of large operations (80.3 percent) than on medium and small operations (97.0 percent and 99.2 percent, respectively). The percentage of operations where heifers were born on the operation but raised elsewhere increased as herd size increased. These operations sent heifers primarily to contract heifer raisers. Heifers not born on the operation were a source of heifers on 6.7 percent of operations. These categories are not mutually exclusive. For example, some producers may have reported that they raised some heifers on the operation and also sent heifers off-farm to be raised, which is why the total percentage of operations exceeds 100 percent.

a. Percentage of operations* by source of dairy heifers and herd size

	Herd Size (Number of Dairy Cows)							
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or more)		**All Operations**	
Heifer Source	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
Born and raised on operation	99.2	(0.3)	97.0	(0.6)	80.3	(2.2)	98.1	(0.3)
Born on operation, raised elsewhere	2.1	(0.5)	5.8	(0.9)	23.1	(2.2)	3.6	(0.4)
Born elsewhere	6.1	(0.8)	8.3	(1.1)	9.8	(1.6)	6.7	(0.7)

*Operations with any dairy cows

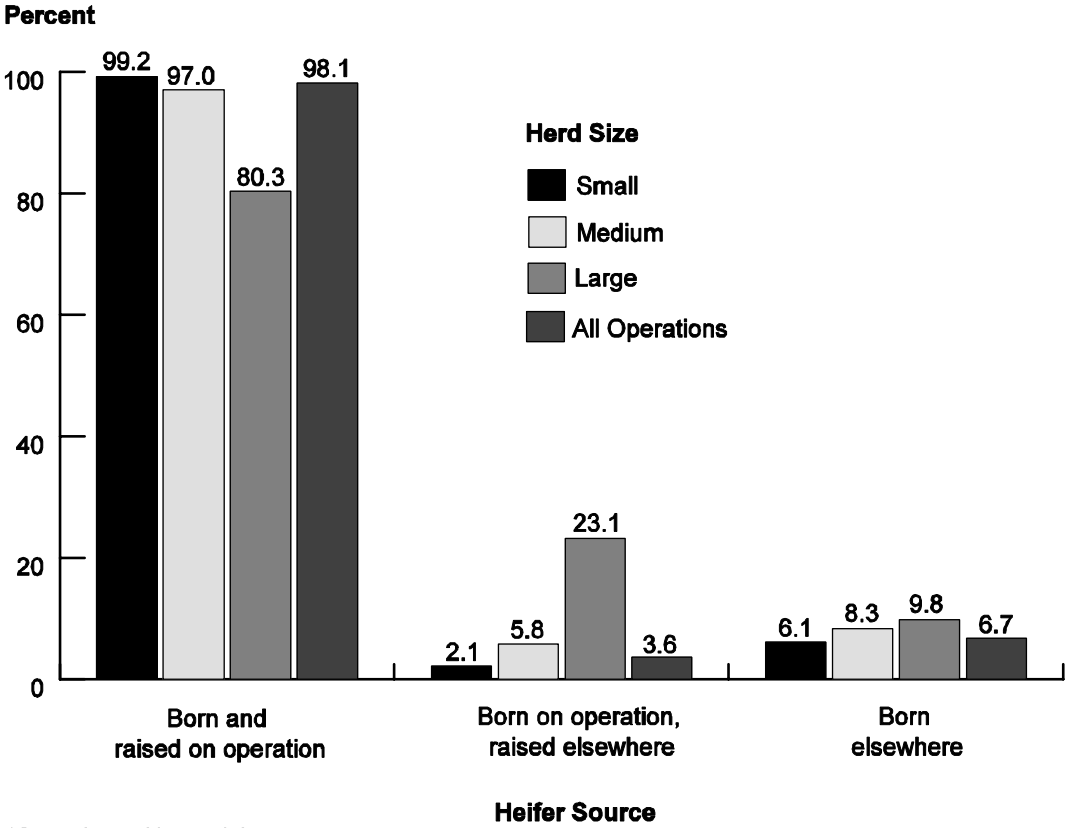
More operations in the West region (10.9 percent) raised heifers elsewhere compared to operations in all other regions.

b. Percentage of operations* by source of dairy heifers and region

	Region							
	West		**Midwest**		**Northeast**		**Southeast**	
Heifer Source	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Born and raised on operation	91.5	(1.2)	98.5	(0.4)	98.9	(0.4)	98.9	(0.5)
Born on operation, raised elsewhere	10.9	(1.5)	2.5	(0.5)	4.4	(1.0)	1.7	(0.8)
Born elsewhere	6.3	(1.2)	6.1	(0.9)	8.9	(1.5)	2.6	(1.1)

*Operations with any dairy cows

Percentage of Operations* by Source of Dairy Heifers and Herd Size



*Operations with any dairy cows

4. Biosecurity for new arrivals

New additions can introduce new diseases or add to the disease burden of the herd. Careful scrutiny of the source of new additions and brief isolation or quarantine once the animals are on the dairy are good management practices. During 2001, bred heifers and lactating cows were the classes of cattle brought onto the most operations, with 15.8 percent of all operations reporting that bred heifers were added and 16.4 percent of operations reporting that lactating cows were added. Any class of beef or dairy cattle was brought onto 45.7 percent of all operations. There was little change between 1995 and 2001 in the percentage of producers who reported that "any" cattle were brought onto their operations. However, more bulls were brought onto operations in 2001 than in 1995 (13.7 percent of operations reported adding weaned dairy bulls in 2001, and 2.3 percent of operations reported adding weaned beef bulls in 2001).

a. Percentage of operations that brought the following classes of cattle onto the operation

Class of Cattle	1991 NDHEP	Std. Error	Question Variation	Dairy '96*	Std. Error	Question Variation	Dairy 2002*	Std. Error
Calves not yet weaned	9.6	(1.2)		5.0	(0.7)		5.1	(0.7)
Heifers weaned but not yet bred	11.2	(1.3)		7.3	(0.7)		6.7	(0.7)
Bred heifers not yet calved	19.3	(1.6)		18.5	(0.9)		15.8	(0.9)
Lactating cows	25.8	(2.0)		19.9	(1.0)		16.4	(1.0)
Dry cows	10.0	(1.4)		7.1	(0.8)		5.9	(0.6)
Bulls	22.4	(1.7)		8.7	(0.7)	Dairy bulls (weaned)	13.7	(0.9)
						Beef bulls (weaned)	2.3	(0.4)
Other cattle	3.3	(0.7)	Other heifers/ cows	1.9	(0.4)	Beef heifers and cows	1.5	(0.3)
			Steers (weaned)	2.0	(0.3)	Steers (weaned)	1.1	(0.3)
Any cattle	53.3	(2.1)		43.9	(1.3)		45.7	(1.4)

*Operations with any dairy cows

5. Testing new arrivals

There was no difference between Dairy ’96 and Dairy 2002 in the reported percentage of operations that required testing for MAP infection prior to bringing animals onto the operation.

a. For operations that brought animals onto the operation, percentage of operations that required testing for MAP prior to bringing animals onto the operation

Herd Size (Number Dairy Cows)	Dairy ‘96	Std. Error	Dairy 2002	Std. Error
Less than 100	8.5	(1.3)	8.3	(1.4)
100 to 499	11.0	(2.3)	12.7	(1.9)
500 or more	9.6	(2.9)	12.2	(1.9)
All operations	9.1	(1.1)	9.8	(1.1)

*Operations with any dairy cows

6. Equipment sharing

Equipment shared with other livestock operations also can introduce disease. During the 12 months prior to the 2002 study interview, 38.0 percent of operations shared heavy equipment (tractors, feeding equipment, manure spreaders, trailers, etc.) with other livestock operations.

a. Percentage of operations* that shared any heavy equipment (tractors, feeding equipment, manure spreaders, trailers, etc.) with other livestock operations during the 12 months prior to the 2002 study interview

Percent Operations	Standard Error
38.0	(2.1)

*Operations with any dairy cows

7. Johne’s disease management practices

In order to control an infectious disease agent, likely routes and risks of transmission must be determined. Biocontainment methods are used to control the transmission of disease agents already present on an operation, whereas biosecurity methods are used to prevent the introduction of disease. Risk assessments have been developed to evaluate the potential for MAP transmission within a herd, with farm-specific management plans designed to address the identified risks.

Preventing MAP infection is accomplished by decreasing exposure of younger animals to infected manure, colostrum, and milk. Decreasing these exposures is generally accomplished through specific on-farm preventive management practices. Other farm-specific management practices, including test-and-cull and vaccination, are used to reduce contamination of the environment by identifying and eliminating infected animals from the herd and by reducing the amount of MAP excreted.

Simulation models indicate that testing for Johne's disease is not as effective in controlling the disease as implementing management changes.[1 3 4] The low sensitivity of available MAP tests is the primary reason test-and-cull programs lack efficacy. Low test sensitivity results in infectious animals remaining in a herd. Combining management changes with a test-and-cull program is the quickest approach to eliminating MAP from an operation.

Management strategies have been developed for Johne's disease control programs.[27 28 29 30 31 32] Since it is assumed that calves are at greatest risk for MAP infection, they are the focus of control and management programs. Most researchers believe that calves are infected by ingesting feces infected with MAP, although contaminated feed, colostrum, and milk also may be significant sources of infection. Implementing calf-management procedures that reduce exposure to these sources of infection is the primary focus of Johne's disease control programs.

There are several management practices that can decrease the probability of neonates ingesting MAP. For example, calf contact with MAP-contaminated manure may be reduced by providing separate maternity housing and not allowing sick animals (especially those with clinical signs of Johne's disease) in maternity areas.

In 2002, 53.1 percent of operations provided separate maternity housing compared to 45.4 percent of operations in 1996.

a. Percentage of operations* where maternity housing was separate from housing used for lactating dairy cows, by herd size

Herd Size (Number Dairy Cows)	**Dairy '96**	**Std. Error**	**Dairy 2002**	**Std. Error**
Less than 100	39.1	(1.3)	43.5	(1.6)
100 to 499	72.6	(2.1)	81.6	(1.7)
500 or more	94.5	(1.8)	91.9	(1.5)
All operations	45.4	(1.2)	53.1	(1.3)

*Operations with any dairy cows

Separating calves from cows and their manure immediately after calving reduces the potential of newborn calves ingesting MAP. NAHMS 1991 and 1996 dairy studies showed a dramatic change in the routine timing of heifer separation from the dam. This change may be attributed to wording differences in the studies, but it is more likely that it occurred because of the impact of dairy educators. Although the trend toward removing newborn calves before any nursing occurs continued during the 1996 and 2002 studies (47.9 percent and 52.9 percent of operations, respectively), many producers still allow calves to nurse from their dams.

b. Percentage of operations by age at which newborn calves were separated from their dams

Age	1991 NDHEP	Std. Error	Question Variation	Dairy '96*	Std. Error	Dairy 2002*	Std. Error
0 hours (before any nursing)	28.0	(1.7)	Immediately (no nursing)	47.9	(1.3)	52.9	(1.3)
Less than 12 hours	39.6	(1.7)	After nursing,but less than 12 hours	20.8	(1.0)	22.5	(1.1)
12-24 hours	22.0	(1.4)		17.4	(1.1)	15.9	(1.0)
More than 24 hours	10.4	(1.0)		13.9	(1.0)	8.7	(0.8)
Total	100.0			100.0		100.0	

*Operations with any dairy cows

Separating calves from cows and their manure immediately after calving reduces the potential of newborn calves ingesting MAP.

As reported in the 1996 and 2002 studies, the percentage of operations on which preweaned heifers had contact with weaned calves has decreased. In the 1996 study, 33.0 percent of operations reported such contact, compared to 22.8 percent in 2002 study. The percentage of bred heifers not yet calved that had contact with preweaned heifers also declined between the 1996 and 2002 studies.

c. Percentage of operations where, after separation from the mother, preweaned heifers had physical contact* with the following

Age Group	1991 NDHEP	Std. Error	Dairy '96*	Std. Error	Dairy 2002**	Std. Error
Weaned calves less than approximately 4 months of age	31.5	(2.0)	33.0	(1.3)	22.8	(1.2)
Calves from approximately 4 months of age to breeding	10.4	(1.3)				
Bred heifers not yet calved	4.6	(0.9)	18.8	(1.1)	13.3	(0.9)
Cattle	10.2	(1.3)	20.2	(1.1)	15.4	(1.0)

*Nose-to-nose contact or sniffing, touching, licking each other, including through a fence
**Operations with any dairy cows

Calves allowed to suckle to obtain colostrum are more likely to ingest manure containing MAP via hide, udder (colostrum), and teat contamination. In the 2002 study, approximately one-third of operations (30.5 percent) relied on first nursing for colostrum delivery to calves.

d. Percentage of operations by method of feeding first colostrum to newborn heifers

Age	1991 NDHEP	Std. Error	Dairy '96*	Std. Error	Dairy 2002*	Std. Error
First nursing	33.7	(1.7)	33.5	(1.2)	30.5	(1.2)
Hand-fed from bucket or bottle	64.0	(1.7)	62.5	(1.2)	64.8	(1.3)
Hand-fed using esophageal feeder	2.3	(0.6)	3.6	(0.4)	4.4	(0.5)
No colostrum	0.0	(0.0)	0.4	(0.2)	0.3	(0.1)
Total	100.0		100.0		100.0	

*Operations with any dairy cows.

Pooling colostrum from more than one cow increases the risk of spreading milk-borne pathogens to more than one calf. Overall, 27.0 percent of operations pooled colostrum. A much higher percentage of large operations (70.6 percent) pooled colostrum than did medium operations (37.4 percent) and small operations (22.1 percent).

e. For operations that normally hand-fed colostrum, percentage of operations* that pooled colostrum from more than one cow, by herd size

Percent Operations							
Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Percent	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
22.1	(1.4)	37.4	(2.0)	70.6	(2.4)	27.0	(1.1)

*Operations with any dairy cows

Pasteurizing colostrum is being investigated as a method to reduce MAP transmission. Only 0.6 percent of operations pasteurized colostrum. A higher percentage of large operations (3.6 percent) fed pasteurized colostrum than did medium and small operations (0.8 percent and 0.4 percent, respectively).

f. For operations that normally hand-fed colostrum, percentage of operations* that pasteurized colostrum, by herd size

Percent Operations							
Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Percent	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
0.4	(0.2)	0.8	(0.3)	3.6	(0.9)	0.6	(0.2)

*Operations with any dairy cows

Milk has been shown to contain MAP. Contamination during milk collection also can increase the amount of MAP a calf ingests. Waste milk was fed to dairy heifer calves on 87.2 percent of operations. Waste milk was pasteurized prior to feeding on only 1.0 percent of operations. However, a higher percentage of large operations (11.3 percent) pasteurized waste milk than did medium operations (1.0 percent) and small operations (0.5 percent). Pasteurizing waste milk significantly reduces—and in some cases eliminates—pathogens in milk, thus reducing calves' exposure to these pathogens. Since consumption of contaminated waste milk can occur repeatedly over time—resulting in multiple doses of MAP—an individual calf's exposure to MAP can be overwhelming. Pasteurization, even without complete destruction of MAP, can result in a significant decrease in the quantity of organism ingested and potentially the number of infected calves.

g. Percentage of operations* that pasteurized waste milk fed to dairy heifer calves, by herd size

	Percent Operations							
	Herd Size (Number of Dairy Cows)							
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Pasteurized	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Yes	0.5	(0.2)	1.0	(0.4)	11.3	(1.6)	1.0	(0.2)
No	87.0	(1.1)	85.3	(1.6)	74.2	(2.4)	86.2	(0.9)
Not fed waste milk	12.5	(1.1)	13.7	(1.5)	14.5	(2.0)	12.8	(0.9)
Total	100.0		100.0		100.0		100.0	

*Operations with any dairy cows

Although it has been an important component of control strategies for many years, vaccinating against MAP is a controversial management tool in the United States. Vaccination of young animals has been shown to reduce the number of clinically affected cattle in a herd,[33 34] but there are discrepancies among studies as to whether vaccine reduces the number of infected animals.[33 35] Studies have reported a decrease in the number of animals in a herd with detectable intestinal infections and fecal shedding after vaccination.[35 36 37] However, another study reported no significant difference in fecal shedding between vaccinates and nonvaccinates.[38] Conflicting results in these studies can be explained potentially by the type of vaccine used (live vs. killed) and improvements in diagnostic testing.[38]

Administrating MAP vaccine to cattle may result in granuloma formation at the injection. These granulomas often become abscesses where viable organisms have been found within the granuloma for up to 6 years after administration of a live vaccine.[39] Accidental self-injection also may present a risk to veterinarians administering the vaccine.[40]

Another disadvantage of MAP vaccine is the development of a strong and persistent sensitivity to avian and mammalian tuberculin.[31] Because this sensitization effect interferes with tuberculosis control programs, the vaccine's use is under strict State control. Vaccination has been shown to interfere with diagnostic tests for Johne's disease and may in fact decrease efforts to control MAP. An evaluation of 58 Dutch dairy farms indicated that owners of nonvaccinated herds implemented and maintained more of the preventive measures against infection than did owners of vaccinated herds.[38]

Despite the limitations, vaccination remains a viable tool for controlling Johne's disease in certain infected herds and has been shown to be cost effective due to the reduction of clinically infected animals.[34] However, the small percentage of operations that reported vaccinating for MAP has not changed since 1996.

h. Percentage of operations* that normally vaccinated dairy heifers against MAP

Dairy '96	Std. Error	Dairy 2002	Std. Error
5.4	(0.6)	4.6	(0.5)

*Operations with any dairy cows

Common clinical signs associated with Johne's disease include weight loss and diarrhea while maintaining a normal appetite. Although not definitively diagnosed with Johne's disease, cows with chronic diarrhea that are in infected herds are at a high probability of having the disease. On all operations, a small percentage of dairy cows (2.8 percent) had diarrhea for more than 48 hours. A larger percentage of cows (4.2 percent) on small operations had persistent diarrhea than did cows on medium and large operations (2.2 percent and 2.1 percent respectively).

i. Percentage of dairy cows* that producers identified as having diarrhea for more than 48 hours during 2001, by herd size

Percent Dairy Cows							
Herd Size (Number of Dairy Cows)							
Small (Less than100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error
4.2	(0.4)	2.2	(0.1)	2.1	(0.2)	2.8	(0.2)

*As a percentage of January 1, 2002, dairy cow inventory (for operations with any dairy cows)

Using the same equipment for manure removal and feeding increases the risk of transmitting fecal-borne pathogens. Nevertheless, 58.8 percent of all operations used the same equipment to handle manure and feed cattle.

j. Percentage of operations that ever used the same equipment to handle manure and feed cattle

Percent Operations	Standard Error
58.8	(2.1)

Of operations that used the same equipment to handle manure and feed cattle, 54.2 percent washed the equipment with only water or steam after handling manure, while 5.7 percent washed and chemically disinfected the equipment after handling manure. No cleaning procedures were performed after handling manure on 15.2 percent of operations that used the same equipment for manure and feeding cattle. Inadequate cleaning and/or disinfection of equipment used to handle manure and feed cattle can contaminate feed.

k. For operations that used the same equipment to handle manure and feed cattle, percentage of operations by procedure that best describes what was usually done with equipment after handling manure

Procedure	Percent Operations	Standard Error
Washed equipment with water or steam only	54.2	(2.9)
Chemically disinfected only	0.0	(--)
Washed equipment and chemically disinfected	5.7	(1.5)
Other	24.9	(2.5)
No procedures	15.2	(2.2)
Total	100.0	

Section II: Johne's Disease Risk Assessment

A. Background

As a component of the NAHMS Dairy 2002 study, operations participated in an on-farm risk assessment of management practices believed to contribute to the transmission of MAP. Although many of the risk-assessment questions were directed to the producer (such as herd disease history, testing, and particular management practices) the majority of questions were designed to be answered objectively by the visiting animal health official. The interviewer also had the opportunity to discuss management objectives and ideal standards (specific to each group of cattle) upon which the operation's risk assessment would ultimately be based.

Five different management areas were assessed: calving, preweaned heifer calves, postweaned heifer calves, bred heifers, and cows. Within each of these areas, multiple practices were assessed, either through questions or visual observations. The majority of questions and observations were assigned a risk score for the specific management area in order to account for different risks associated with different age groups. Within each management area, risk scores were summed to produce a total score. The total risk score for each management area was used to quantify potential risk and predict which area(s) was more likely to contribute to MAP transmission.

Each producer received a report of their risk-assessment results, which reiterated management objectives and ideals, summarized their quantitative risk, and served as a potential guideline for concentrating control efforts to modify or eliminate specific high-risk practices on their operation.

This section summarizes the results and provides inferences to the population of operations and animals in the 21 study States. Risk-level description, associated risk score, and percentage of operations within each risk level are presented. Average risk scores for each question or observation are presented as the mean scores from all operations. The mean of the total scores for each management area was calculated and presented as the average total risk score.

B. Calving Area

NOTE: Some tables in this section represent questions or observations where risk levels were not assigned.

1. Multiple use of calving area

Only 15.5 percent of operations never used the area where cows normally calved for more than one cow, giving these operations a risk level of "none" and a risk score of 0. Nearly one out of two operations (47.0 percent) always used calving areas for more than one cow, giving these operations a risk level of "very high" and a risk score of 10.

a. Percentage of operations that used the area where cows normally calved for more than one cow, by risk level

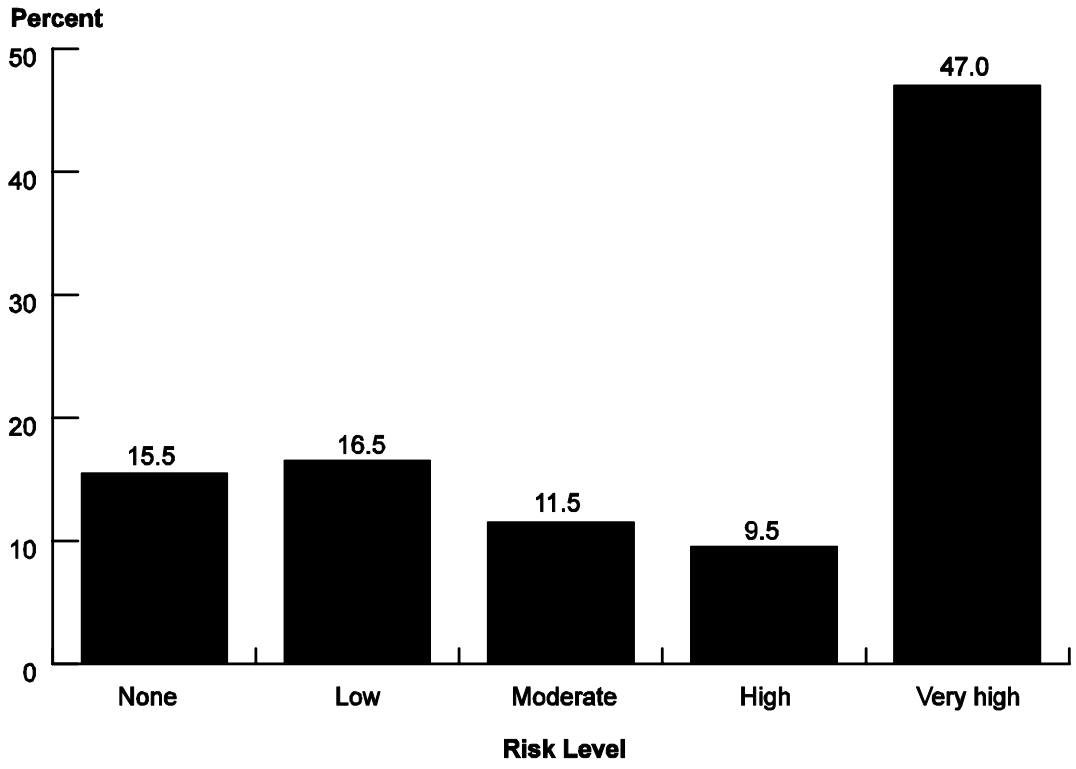
Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never occurs	15.5	(1.9)
Low	3	Occurs less than 1 out of 10 calvings	16.5	(1.8)
Moderate	5	Occurs 1 to 3 times out of 10 calvings	11.5	(1.5)
High	7	Occurs 5 or more times per 10 calvings	9.5	(1.3)
Very high	10	Always occurs	47.0	(2.4)
Total	NA		100.0	

Large operations had the highest percentage of operations (69.5 percent) that always used the area where cows normally calved for more than one cow, putting them at a very high risk level. In contrast, only 7.4 percent of large operations never used the area where cows normally calved for more than one cow, putting them at a risk-level of "none."

b. Percentage of operations that used the area where cows normally calved for more than one cow, by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	18.3	(2.5)	8.3	(1.9)	7.4	(2.3)
Low	17.2	(2.3)	15.4	(2.5)	10.7	(3.4)
Moderate	12.4	(2.0)	9.6	(1.9)	6.5	(2.4)
High	8.4	(1.7)	13.6	(2.5)	5.9	(2.2)
Very high	43.7	(3.1)	53.1	(3.2)	69.5	(4.5)
Total	100.0		100.0		100.0	

Percentage of Operations Where the Area that Cows Normally Calved was Used for More Than One Cow, by Risk Level

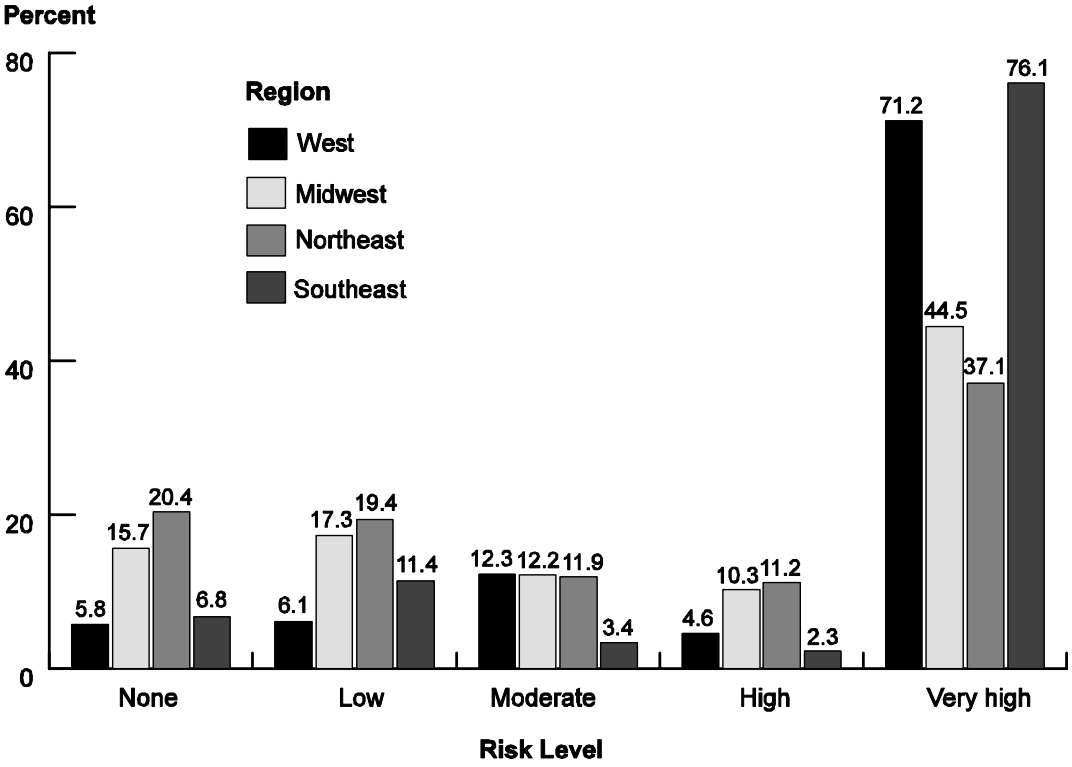


Operations in the Southeast and West regions had the highest percentages of operations (76.1 and 71.2 percent, respectively) that always used the area where cows normally calved for more than one cow.

c. Percentage of operations that used the area where cows normally calved for more than one cow, by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	5.8	(2.2)	15.7	(2.6)	20.4	(3.9)	6.8	(3.9)
Low	6.1	(2.1)	17.3	(2.6)	19.4	(3.4)	11.4	(5.3)
Moderate	12.3	(3.0)	12.2	(2.1)	11.9	(2.9)	3.4	(2.3)
High	4.6	(1.9)	10.3	(1.9)	11.2	(2.7)	2.3	(2.1)
Very high	71.2	(4.0)	44.5	(3.4)	37.1	(4.6)	76.1	(6.5)
Total	100.0		100.0		100.0		100.0	

Percentage of Operations Where the Area that Cows Normally Calved was Used for More Than One Cow, by Risk Level and by Region



Large operations had higher average risk scores (8.0) than small operations (6.1).

d. Average risk score for multiple use of calving area, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
6.1	(0.3)	7.2	(0.2)	8.0	(0.3)	6.4	(0.2)

Operations in the Southeast and West regions had higher average risk scores (8.3 and 8.2, respectively) than operations in the Midwest and Northeast regions.

e. Average risk score for multiple use of calving area, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
8.2	(0.3)	6.3	(0.3)	5.7	(0.4)	8.3	(0.5)

2. Manure contamination

The largest percentage of operations (30.2 percent) was at low risk of manure contamination since calving pens on these operations were being cleaned daily and little visible manure was observed at the time of the assessment. There were no differences across risk levels in the percentages of operations by herd size or region.

a. Percentage of operations by extent of manure buildup in area where cows normally calved, and by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	No manure contamination	15.4	(1.7)
Low	3	Manure cleaned daily, very little visible manure	30.2	(2.2)
Moderate	5	Cleaned one to two times per week, more manure-free area than manure-contaminated area	21.5	(1.9)
High	7	Cleaned one to two times per month, more manure contaminated area than manure-free area	18.2	(1.8)
Very high	10	Cleaned less than one time per month, extensive manure contamination	14.7	(1.5)
Total	NA		100.0	

Average risk scores for manure contamination of the area where cows normally calved were similar across herd sizes and regions.

b. Average risk score for manure contamination of calving area, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
4.6	(0.2)	5.0	(0.2)	5.1	(0.2)	4.7	(0.1)

c. Average risk score for manure contamination of calving area, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
5.0	(0.4)	4.8	(0.2)	4.6	(0.2)	4.1	(0.6)

3. Other calving areas

The majority of operations (67.9 percent) reported that less than 1 out of 10 calvings occurred in an area other than the normal calving area. There were no differences across risk levels in the percentages of operations by herd size or region.

a. Percentage of operations where calves were born in areas other than where cows normally calved, by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never occurs	24.2	(2.1)
Low	3	Occurs less than 1 out of 10 calvings	43.7	(2.4)
Moderate	5	Occurs 1 to 2 times out of 10 calvings	14.2	(1.7)
High	7	Occurs 3 to 4 times out 10 calvings	8.7	(1.4)
Very high	10	Occurs 5 or more times per 10 calvings	9.2	(1.4)
Total	NA		100.0	

Average risk scores were similar across all herd sizes and regions.

b. Average risk score for other calving areas, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
3.6	(0.2)	3.4	(0.2)	3.0	(0.2)	3.6	(0.1)

c. Average risk score for other calving areas, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
3.4	(0.3)	3.6	(0.2)	3.4	(0.3)	3.7	(0.7)

Photo: Jason Lombard

4. Sick-cow access to calving area

Overall, 45.9 percent of operations never used calving areas for holding or treating sick cows.

a. Percentage of operations where the area cows normally calved was also used for holding or treating sick cows, by risk level

Risk Score	Risk Level	Risk-Level Description	Percent	Std. Error
None	0	Never occurs	45.9	(2.4)
Low	3	Occurs less than one time per month	35.4	(2.3)
Moderate	5	Occurs one to five times per month	6.5	(1.1)
High	7	Occurs more than five times per month	1.7	(0.6)
Very high	10	Always	10.5	(1.5)
Total	NA		100.0	

b. Percentage of operations where the area cows normally calved was also used for holding or treating sick cows, by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	41.8	(3.1)	53.4	(3.3)	74.5	(4.1)
Low	38.7	(3.0)	29.2	(3.0)	14.3	(3.2)
Moderate	5.6	(1.4)	8.9	(1.8)	9.2	(2.8)
High	1.4	(0.7)	2.5	(1.2)	2.0	(1.0)
Very high	12.5	(2.1)	6.0	(1.7)	0.0	(--)
Total	100.0		100.0		100.0	

c. Percentage of operations where the area cows normally calved was also used for holding or treating sick cows, by risk level and region

	Region							
	West		**Midwest**		**Northeast**		**Southeast**	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	57.9	(5.0)	43.1	(3.4)	45.4	(4.5)	56.0	(6.7)
Low	25.9	(4.2)	39.2	(3.4)	30.8	(4.0)	34.4	(7.4)
Moderate	6.5	(2.0)	7.6	(1.8)	4.9	(1.1)	3.4	(2.7)
High	4.1	(3.1)	1.6	(0.7)	1.7	(1.0)	0.0	(--)
Very high	5.6	(2.4)	8.5	(1.8)	17.2	(4.0)	6.2	(4.6)
Total	100.0		100.0		100.0		100.0	

The average risk score tended to decrease as herd size increased.

d. Average risk score for sick-cow access to calving area, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
2.8	(0.2)	2.1	(0.2)	1.0	(0.2)	2.6	(0.2)

e. Average risk score for sick-cow access to calving area, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
1.9	(0.3)	2.5	(0.2)	3.0	(0.4)	1.8	(0.4)

5. Suspect cows in calving areas

The majority of operations (84.8 percent) never kept cows suspected of having Johne's disease or showing clinical signs of Johne's disease in areas where cows normally calved.

a. Percentage of operations that kept cows suspected of having Johne's disease or showing clinical signs of Johne's disease in areas where cows normally calved, by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never occurs	84.8	(1.8)
Low	3	Occurs less than one time per month	9.6	(1.4)
Moderate	5	Occurs one to five times per month	0.2	(0.1)
High	7	Occurs more than five times per month	0.0	(--)
Very high	10	Always	5.4	(1.2)
Total	NA		100.0	

b. Average risk score for allowing suspect cows in calving areas, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
0.8	(0.2)	1.0	(0.2)	0.3	(0.1)	0.8	(0.1)

c. Average risk score for allowing suspect cows in calving areas, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
0.2	(0.1)	0.8	(0.1)	0.9	(0.3)	1.6	(0.5)

6. Allowing calves access to dams for more than 3 hours

The highest percentage of operations (29.3 percent) always allowed newborn calves to stay with their dams for more than 3 hours after birth. Approximately one-fourth of all operations (22.6 percent) allowed newborn calves to stay with their dams for more than 3 hours in fewer than 1 out of 10 calvings, and 11.8 percent never allowed calves to stay with dams for more than 3 hours.

a. Percentage of operations where newborn calves stayed with their dams for more than 3 hours after they were born, by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never occurs	11.8	(1.8)
Low	3	Occurs less than 1 out of 10 calvings	22.6	(1.9)
Moderate	5	Occurs 1 to 3 times out of 10 calvings	19.6	(2.0)
High	7	Occurs 5 or more times per 10 calvings	16.7	(1.7)
Very high	10	Always	29.3	(2.2)
Total	NA		100.0	

In the Southeast region, 60.9 percent of operations always allowed calves access to dams for more than 3 hours.

b. Percentage of operations where newborn calves stayed with their dams for more than 3 hours after they were born, by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	8.0	(2.4)	13.6	(2.6)	10.8	(3.1)	4.6	(4.1)
Low	17.3	(3.4)	27.1	(2.9)	19.0	(3.3)	4.9	(3.4)
Moderate	13.9	(3.7)	19.0	(2.8)	24.0	(3.8)	15.1	(6.3)
High	18.9	(3.6)	16.6	(2.5)	16.8	(2.7)	14.5	(7.8)
Very high	41.9	(5.7)	23.7	(2.9)	29.4	(4.5)	60.9	(8.5)
Total	100.0		100.0		100.0		100.0	

c. Average risk score for allowing calves access to dams for more than 3 hours, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
5.7	(0.2)	6.0	(0.2)	5.1	(0.3)	5.8	(0.2)

d. Average risk score for allowing calves access to dams for more than 3 hours, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
6.7	(0.4)	5.3	(0.2)	5.9	(0.3)	8.0	(0.5)

7. Allowing dams to nurse calves

While 20.4 percent of operations reported never allowing dams to nurse calves, only 11.8 percent (table 6a) reported that calves never stayed with dams more than 3 hours. The difference can be explained by noting that some operations that kept calves with their dams for more than 3 hours restrained the calves so they could not suckle. In other cases, it appears that "allowing dams to nurse calves" was misinterpreted as "allowing calves to suckle dams for the entire preweaning period."

a. Percentage of operations that allowed dams to nurse calves, by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never occurs	20.4	(2.0)
Low	3	Occurs less than 1 out of 10 calvings	24.3	(2.0)
Moderate	5	Occurs 1 to 3 times out of 10 calvings	17.4	(2.0)
High	7	Occurs 5 or more times per 10 calvings	11.1	(1.5)
Very high	10	Always	26.8	(1.9)
Total	NA		100.0	

The majority of operations in the Southeast region (66.2 percent) and West region (51.5 percent) always allowed dams to nurse calves and had the highest average risk scores (7.8 and 6.7, respectively).

b. Percentage of operations that allowed dams to nurse calves, by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	14.6	(2.8)	21.7	(2.8)	22.1	(4.3)	9.3	(5.2)
Low	15.6	(3.5)	28.7	(3.1)	21.7	(3.2)	6.8	(3.5)
Moderate	8.2	(2.4)	15.7	(2.6)	24.7	(4.3)	15.1	(7.9)
High	10.1	(3.2)	11.7	(2.1)	12.4	(3.0)	2.6	(2.5)
Very high	51.5	(5.4)	22.2	(2.7)	19.1	(3.2)	66.2	(8.3)
Total	100.0		100.0		100.0		100.0	

Average risk scores were similar across all herd sizes.

c. Average risk score for allowing dams to nurse calves, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
5.0	(0.2)	5.4	(0.2)	5.0	(0.3)	5.1	(0.2)

d. Average risk score for allowing dams to nurse calves, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
6.7	(0.4)	4.7	(0.2)	4.7	(0.3)	7.8	(0.6)

8. Udder manure contamination

The majority of operations (90.7 percent) had either no or slight-to-moderate manure contamination on udders of cows in the calving area, which equates to risk levels of “none” and “low.”

a. Percentage of operations by the extent of manure on a majority of cows’ udders, and by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	No manure contamination	22.0	(2.0)
Low	3	Teats clean, slight to moderate manure on udders of a majority of cows in the calving area	68.7	(2.2)
Moderate	5	Teats clean, moderate to heavy manure on udders of a majority of cows in the calving area	7.3	(1.2)
High	7	Small amount of manure on teats, but udders covered with manure on a majority of cows in the calving pen	1.6	(0.6)
Very high	10	Teats and udders caked with manure on a majority of cows in the calving area	0.4	(0.4)
Total	NA		100.0	

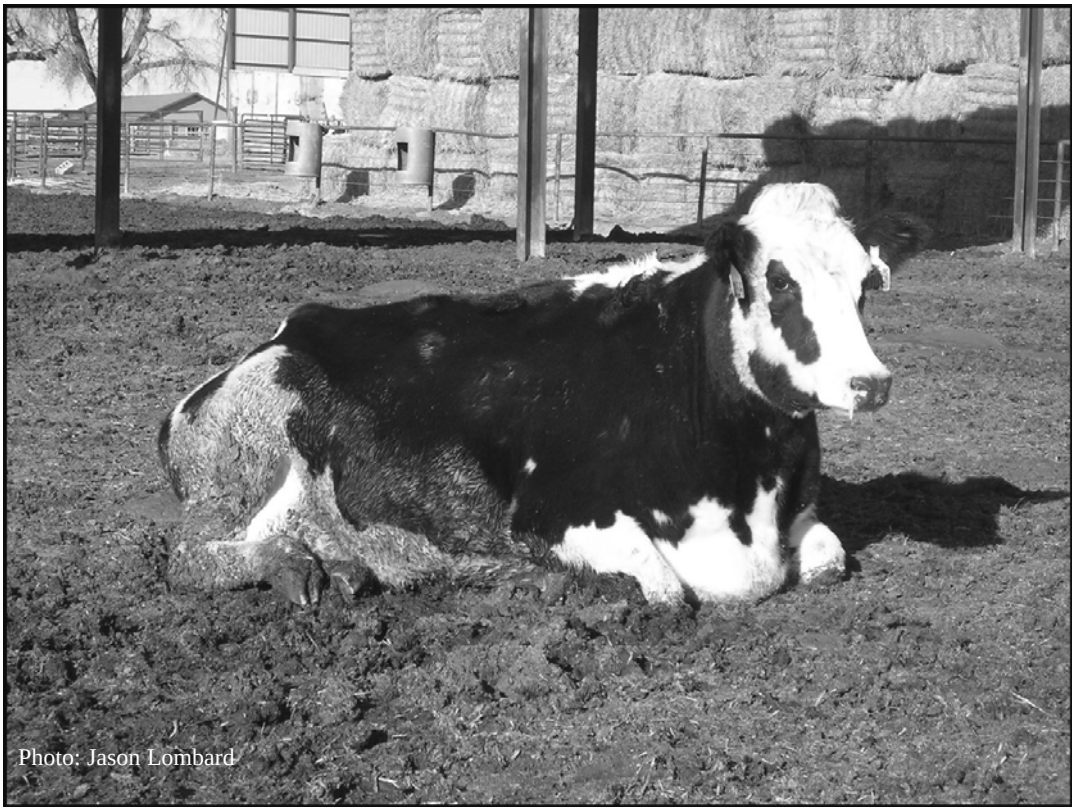


Photo: Jason Lombard

b. Average risk score for manure contamination of udder, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
2.6	(0.1)	2.5	(0.1)	2.3	(0.1)	2.6	(0.1)

c. Average risk score for manure contamination of udder, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
2.5	(0.1)	2.7	(0.1)	2.4	(0.1)	2.7	(0.2)

9. Calving areas average total risk scores

For the eight risk areas evaluated in calving areas, the average total risk score was 31.4. The highest possible risk score was 80. This average was calculated based on operations that answered all eight calving-area-related questions. There were no differences in calving area average total risk scores across herd sizes. However, the Southeast region had a higher average total risk score than the Midwest and Northeast regions.

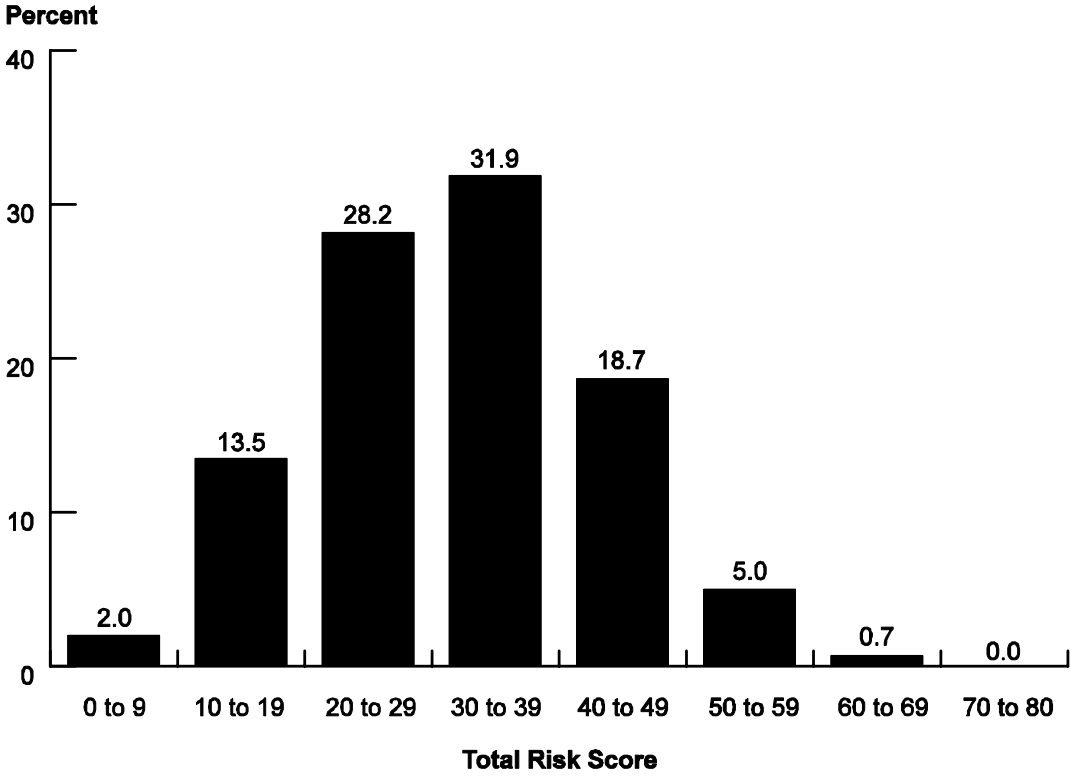
a. Average total risk scores for operation calving areas, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
31.2	(0.7)	32.2	(0.7)	29.9	(0.8)	31.4	(0.5)

b. Average total risk scores for operation calving areas, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
34.8	(1.1)	30.5	(0.8)	30.6	(0.9)	38.0	(1.5)

Percentage of Operations by Total Risk Scores for Calving Areas



Note: The remaining tables in this section summarize questions designed to evaluate economic costs and ascertain best management practices. No risk levels were assigned and therefore not used in calculations.

10. Calving area observation—6 a.m. to 6 p.m.

The highest percentage of operations (43.9 percent) observed calving areas three to five times between 6 a.m. and 6 p.m. The number of daytime observations of calving areas increased as herd size increased.

a. Percentage of operations by average number of times calving areas were observed between 6 a.m. and 6 p.m., and by herd size

	Herd Size (Number of Dairy Cows)							
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Number of Observations	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
1	2.4	(0.8)	5.9	(1.9)	1.4	(1.4)	3.2	(0.7)
2	16.0	(2.3)	9.2	(1.9)	0.6	(0.5)	13.8	(1.7)
3 to 5	46.3	(3.2)	42.1	(3.3)	13.1	(3.1)	43.9	(2.4)
6 to 11	26.3	(2.7)	25.9	(2.8)	26.4	(4.3)	26.2	(2.1)
12 or more	9.0	(1.8)	16.9	(2.6)	58.5	(4.5)	12.9	(1.5)
Total	100.0		100.0		100.0		100.0	

A higher percentage of operations in the West region (31.7 percent) observed calving areas at least hourly between 6 a.m. and 6 p.m. compared to operations in the Midwest and Southeast regions (9.0 percent and 4.1 percent, respectively).

b. Percentage of operations by average number of times calving areas were observed between 6 a.m. and 6 p.m., and by region

	Region							
	West		Midwest		Northeast		Southeast	
Number of Observations	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
1	7.6	(3.8)	2.5	(0.9)	1.9	(1.1)	8.7	(4.1)
2	10.3	(4.3)	15.1	(2.5)	8.9	(2.3)	27.6	(8.1)
3 to 5	26.0	(4.5)	45.2	(3.5)	47.9	(4.7)	41.2	(6.6)
6 to 11	24.4	(3.9)	28.2	(3.1)	24.4	(3.5)	18.4	(4.5)
12 or more	31.7	(3.8)	9.0	(1.7)	16.9	(3.7)	4.1	(2.6)
Total	100.0		100.0		100.0		100.0	

11. Calving area observation—6 p.m. to 6 a.m.

Overall, the highest percentage of operations (33.5 percent) observed calving areas one time between 6 p.m. and 6 a.m. The number of observations increased as herd size increased.

a. Percentage of operations by average number of times calving areas were observed between 6 p.m. and 6 a.m., and by herd size

	Herd Size (Number of Dairy Cows)							
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Number of Observations	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
1	37.6	(3.0)	25.3	(3.1)	9.0	(2.5)	33.5	(2.2)
2	30.8	(2.8)	34.7	(3.1)	8.8	(3.0)	30.8	(2.2)
3 to 5	25.7	(2.5)	27.6	(2.9)	32.2	(4.5)	26.4	(2.0)
6 to 11	5.3	(1.6)	10.1	(1.9)	22.4	(3.8)	7.2	(1.3)
12 or more	0.6	(0.4)	2.3	(1.2)	27.6	(3.9)	2.1	(0.5)
Total	100.0		100.0		100.0		100.0	

Nearly 5 out of 10 operations in the Southeast region (48.9 percent) observed calving areas one time per night. No operations in the Southeast region observed calving areas every hour. Operations in the West region were more likely than any other region to observe calving areas every hour between 6 p.m. and 6 a.m.

b. Percentage operations by average number of times calving areas were observed between 6 p.m. and 6 a.m., and by region

	Region							
	West		Midwest		Northeast		Southeast	
Number of Observations	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
1	24.0	(5.4)	35.6	(3.3)	28.4	(3.6)	48.9	(8.2)
2	20.2	(4.4)	32.3	(3.2)	28.7	(3.4)	40.8	(8.0)
3 to 5	29.0	(4.2)	24.3	(2.8)	34.1	(3.7)	9.8	(5.2)
6 to 11	16.5	(3.5)	6.8	(1.9)	6.5	(2.1)	0.5	(0.4)
12 or more	10.3	(1.8)	1.0	(0.5)	2.3	(1.2)	0.0	(--)
Total	100.0		100.0		100.0		100.0	

12. Individual calving pens

Overall, 41.4 percent of operations had no individual calving pens. Small operations (41.8 percent) had a slightly higher ratio of calving pens (three or more) than other herd sizes.

a. Percentage of operations by ratio of individual calving pens to cows,* and by herd size

	Herd Size (Number of Dairy Cows)							
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Ratio of Calving Pens to Cow Inventory (x100)	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	40.3	(2.9)	42.3	(3.4)	55.1	(4.6)	41.4	(2.3)
1 to 2	17.9	(2.2)	43.7	(3.4)	43.3	(4.6)	25.0	(1.8)
3 to 4	26.8	(2.8)	11.1	(2.3)	0	(--)	22.0	(2.1)
5 or more	15.0	(2.2)	2.9	(1.0)	1.6	(1.6)	11.6	(1.6)
Total	100.0		100.0		100.0		100.0	

* January 1, 2002, dairy cow inventory

b. Percentage of operations by ratio of individual calving pens to cows,* and by region

	Region							
	West		**Midwest**		**Northeast**		**Southeast**	
Ratio of Calving Pens to Cow Inventory (x100)	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	57.5	(4.8)	35.2	(3.2)	46.0	(4.1)	55.4	(8.6)
1 to 2	35.6	(5.0)	25.7	(2.7)	21.6	(2.7)	18.7	(5.6)
3 to 4	6.2	(2.6)	28.0	(3.1)	18.0	(3.5)	6.7	(3.8)
5 or more	0.7	(0.7)	11.1	(2.4)	14.4	(2.9)	19.2	(6.0)
Total	100.0		100.0		100.0		100.0	

*January 1, 2002, dairy cow inventory

13. Employee contact

Overall, 75.0 percent of operations allowed employees to have direct contact with both preweaned heifers and older cattle (other than at calving). Nearly 9 out of 10 medium operations (87.5 percent) allowed employees to have contact with cattle of differing ages.

a. Percentage of operations where employees had direct contact with both preweaned heifers and older cattle (other than at calving), by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Percent	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
70.9	(2.9)	87.5	(2.0)	75.0	(3.8)	75.0	(2.2)

b. Percentage of operations where employees had direct contact with both preweaned heifers and older cattle (other than at calving), by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Percent	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
83.0	(3.4)	70.8	(3.1)	78.5	(4.2)	86.9	(5.3)

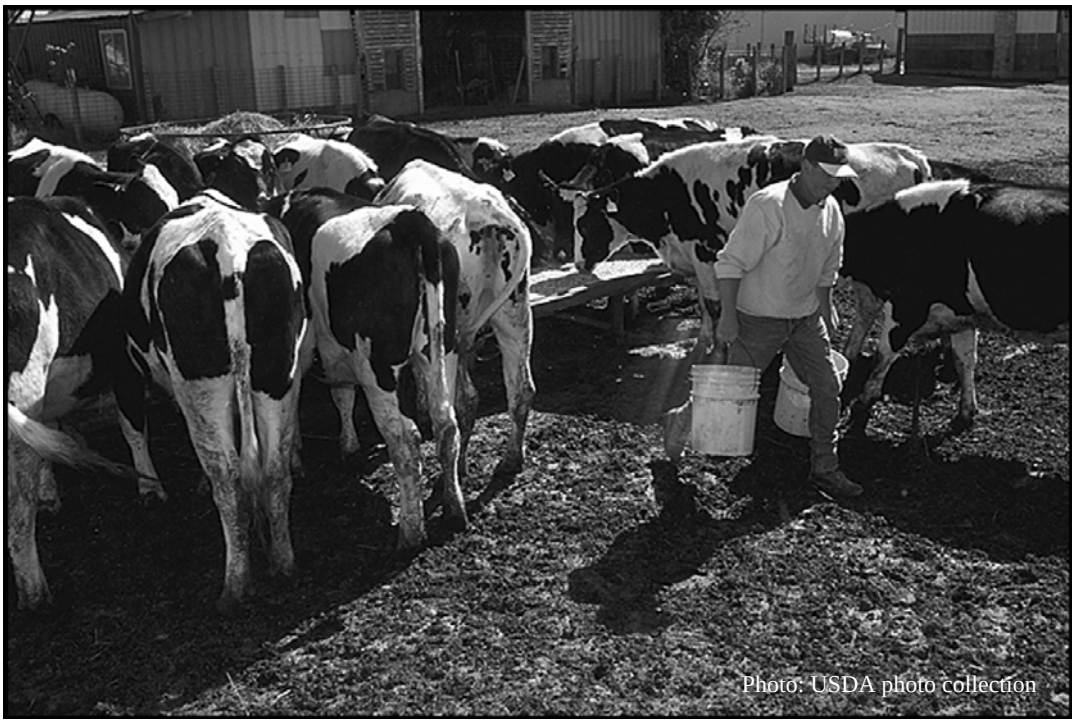


Photo: USDA photo collection

C. Preweaned Heifer Calves

NOTE: Some tables in this section represent questions or observations where risk levels were not assigned.

1. Preweaned heifers on premises

Overall, 92.6 percent of operations retained heifers born on the operation until they were weaned. Large herds had the lowest percentage of operations (63.9 percent) that kept heifers until weaned compared to 9 out of 10 small and medium operations.

a. Percentage of operations that retained heifers born on the operation until weaning, by herd size

Herd size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Percent	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
94.4	(1.8)	92.4	(1.9)	63.9	(4.4)	92.6	(1.4)

A higher percentage of operations in the Midwest and Northeast regions (93.7 percent and 94.6 percent, respectively) retained preweaned heifers compared to operations in the West region (81.7 percent).

b. Percentage of operations that retained preweaned heifers born on the operation until weaning, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Percent	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
81.7	(3.3)	93.7	(2.1)	94.6	(1.8)	90.5	(4.3)

2. Use of pooled colostrum

More than half of operations (56.3 percent) never fed pooled colostrum.

a. Percentage of operations by how often pooled colostrum was fed to preweaned heifers, and by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never fed pooled colostrum	56.3	(2.4)
Low	3	Pooled colostrum fed one to two times per year	14.3	(1.8)
Moderate	5	Pooled colostrum fed one to two times per month	6.8	(1.2)
High	7	Pooled colostrum fed most of the time	12.0	(1.6)
Very high	10	Always fed pooled colostrum	10.6	(1.4)
Total	NA		100.0	

A small percentage of large operations (23.4 percent) never fed pooled colostrum compared to 56.8 percent of medium operations and 57.5 percent of small operations.

b. Percentage of operations by how often pooled colostrum was fed to preweaned heifers, and by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	57.5	(3.1)	56.8	(3.3)	23.4	(4.9)
Low	16.3	(2.3)	8.8	(1.9)	4.8	(3.2)
Moderate	5.9	(1.5)	10.0	(2.1)	4.3	(2.1)
High	10.6	(2.0)	15.0	(2.7)	22.0	(5.0)
Very high	9.7	(1.8)	9.4	(1.9)	45.5	(5.4)
Total	100.0		100.0		100.0	

The majority of operations in the Midwest, Northeast, and Southeast regions never fed pooled colostrum (59.7, 57.3, and 52.6 percent of operations, respectively).

c. Percentage of operations by how often pooled colostrum was fed to preweaned heifers, and by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error
None	31.2	(4.6)	59.7	(3.4)	57.3	(4.2)	52.6	(9.0)
Low	2.4	(1.4)	15.5	(2.6)	12.4	(2.7)	26.1	(9.4)
Moderate	14.6	(4.6)	5.9	(1.6)	7.1	(2.2)	4.3	(3.2)
High	25.6	(6.3)	11.5	(2.3)	10.5	(2.7)	5.6	(2.8)
Very high	26.2	(4.8)	7.4	(1.8)	12.7	(2.7)	11.4	(4.6)
Total	100.0		100.0		100.0		100.0	

NOTE: When calculating average risk scores for colostrum feeding, the number of times colostrum was pooled and the source of colostrum were considered (see p66). If an operation used colostrum from test-negative cows, one point was added to the pooled-colostrum risk score. If unknown-status cows were used, three points were added to the score, and if colostrum from test-positive cows was used, five points were added to the score.

Average risk scores were highest for large operations and operations in the West region.

d. Average risk score for use of pooled colostrum, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
2.5	(0.2)	2.8	(0.2)	6.4	(0.4)	2.7	(0.2)

e. Average risk score for use of pooled colostrum, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
5.2	(0.4)	2.3	(0.2)	2.7	(0.3)	2.5	(0.5)

3. Source of colostrum

The majority of operations (89.2 percent) fed colostrum from cows with an unknown Johne's-disease test status. Very few operations used colostrum from test-positive cows.

a. Percentage of operations by source of colostrum and herd size

	Herd Size (Number of Dairy Cows)							
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Colostrum Source	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
Test-negative cows	9.1	(1.8)	15.6	(2.8)	11.9	(3.1)	10.7	(1.5)
Unknown-status cows	90.8	(1.8)	84.4	(2.8)	88.1	(3.1)	89.2	(1.5)
Test-positive cows	0.1	(0.1)	0.0	(--)	0.0	(--)	0.1	(0.1)
Total	100.0		100.0		100.0		100.0	

A larger percentage of operations in the Midwest and Northeast regions (11.6 percent and 12.7 percent, respectively) fed colostrum from test-negative cows compared to operations in the West and Southeast regions (3.3 percent and 1.9 percent, respectively).

b. Percentage of operations by source of colostrum and region

	Region							
	West		**Midwest**		**Northeast**		**Southeast**	
Colostrum Source	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
Test-negative cows	3.3	(1.9)	11.6	(2.3)	12.7	(2.5)	1.9	(1.4)
Unknown-status cows	96.7	(1.9)	88.4	(2.3)	87.3	(2.5)	96.5	(2.2)
Test-positive cows	0.0	(--)	0.0	(--)	0.0	(--)	1.6	(1.6)
Total	100.0		100.0		100.0		100.0	

4. Use of pooled milk

Fewer than half of operations (46.1 percent) never fed pooled milk.

a. Percentage of operations by how often pooled milk was fed to preweaned heifers, and by risk level

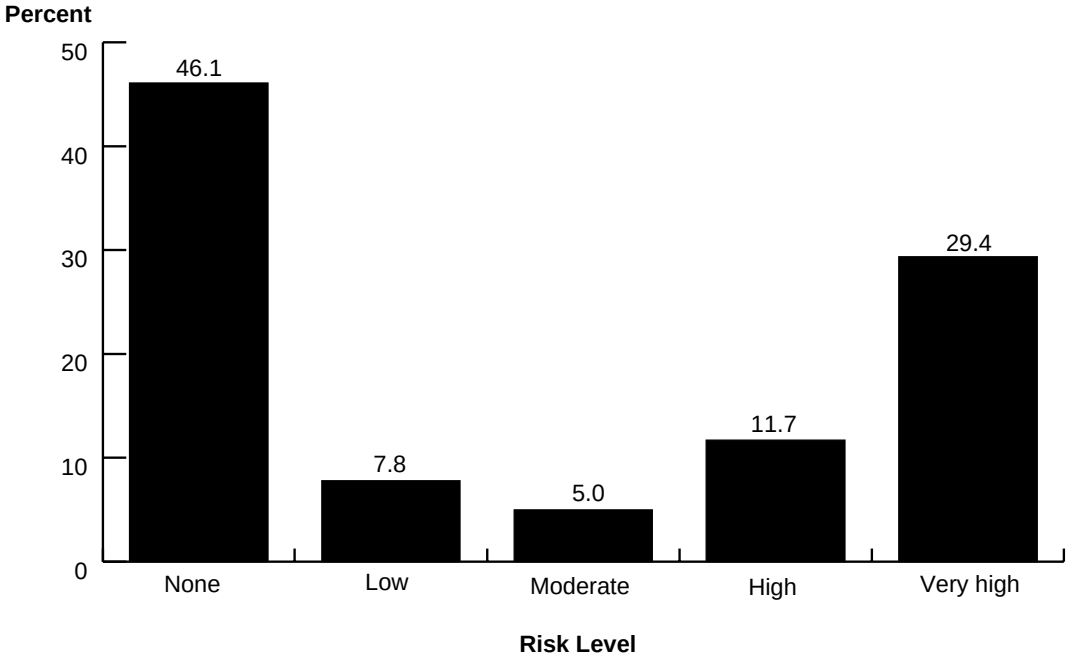
Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never fed pooled milk	46.1	(2.5)
Low	3	Pooled milk fed one to two times per year	7.8	(1.4)
Moderate	5	Pooled milk fed one to two times per month	5.0	(1.0)
High	7	Pooled milk fed most of the time	11.7	(1.7)
Very high	10	Always fed pooled milk	29.4	(2.2)
Total	NA		100.0	

The majority of small and large operations (54.5 percent and 75.6 percent, respectively) fed at least some pooled milk to preweaned heifers.

b. Percentage of operations by how often pooled milk was fed to preweaned heifers, and by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	45.5	(3.3)	50.7	(3.5)	24.4	(4.0)
Low	9.0	(1.8)	5.0	(1.6)	0.5	(0.5)
Moderate	4.8	(1.3)	6.3	(1.7)	0.3	(0.3)
High	13.1	(2.3)	6.7	(1.5)	16.3	(4.7)
Very high	27.6	(2.8)	31.3	(3.2)	58.5	(5.4)
Total	100.0		100.0		100.0	

Percentage of Operations by Risk Level Associated with Frequency of Feeding Preweaned Heifers Pooled Milk



c. Percentage of operations by how often pooled milk was fed to preweaned heifers, and by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	23.8	(6.0)	50.4	(3.5)	43.6	(4.9)	45.4	(8.9)
Low	1.6	(1.4)	10.0	(2.2)	5.8	(2.0)	4.4	(3.1)
Moderate	5.5	(3.1)	5.4	(1.5)	3.9	(1.3)	5.2	(3.6)
High	14.8	(4.1)	9.8	(2.2)	12.4	(3.4)	21.9	(9.4)
Very high	54.3	(6.4)	24.4	(3.0)	34.3	(4.2)	23.1	(7.5)
Total	100.0		100.0		100.0		100.0	

Photo: Jason Lombard

Average risk scores were highest for large operations (7.0) and operations in the West region (6.8), where the majority of operations always fed pooled milk.

d. Average risk score for use of pooled milk, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
4.2	(0.3)	4.1	(0.3)	7.0	(0.4)	4.3	(0.2)

e. Average risk score for use of pooled milk, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
6.8	(0.6)	3.7	(0.3)	4.7	(0.4)	4.3	(0.7)

5. Pasteurization of pooled milk

NOTE: Just over half of operations (53.9 percent) fed pooled milk to calves. In comparison, nearly 9 out of 10 operations (87.2 percent) fed waste milk to calves (table 7g, p38). A potential explanation for this difference is that producers made a distinction between waste milk and pooled milk, although for the study's purposes pooled milk and waste milk were considered the same.

Pooled milk was fed to calves on 53.9 percent of operations, and 0.9 percent of operations pasteurized pooled milk prior to feeding. A higher percentage of large operations (75.6 percent) fed pooled milk to calves and pasteurized pooled milk (13.3 percent).

a. Percentage of operations that pasteurized pooled milk fed to preweaned heifers, by herd size

	Herd Size (Number of Dairy Cows)							
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Pasteurization	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Yes	0.6	(0.4)	0.3	(0.2)	13.3	(3.2)	0.9	(0.3)
No	53.9	(3.3)	49.0	(3.5)	62.3	(4.8)	53.0	(2.5)
Did not feed pooled milk	45.5	(3.3)	50.7	(3.5)	24.4	(4.0)	46.1	(2.5)
Total	100.0		100.0		100.0		100.0	

The West region had the highest percentage of operations (4.4 percent) that fed pasteurized pooled milk. Very few operations in the other regions pasteurized pooled milk fed to preweaned heifers.

b. Percentage of operations that pasteurized pooled milk fed to preweaned heifers, by region

	Region							
	West		**Midwest**		**Northeast**		**Southeast**	
Pasteurization	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Yes	4.4	(1.1)	0.6	(0.5)	0.6	(0.4)	0.0	(--)
No	71.8	(6.0)	49.0	(3.5)	55.8	(4.9)	54.6	(8.9)
Did not feed pooled milk	23.8	(6.0)	50.4	(3.5)	43.6	(4.9)	45.4	(8.9)
Total	100.0		100.0		100.0		100.0	

6. Housing

Half of operations (50.0 percent) never housed preweaned heifers near cows.

a. Percentage of operations that housed preweaned heifers near cows, by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never housed preweaned heifers near cows	50.0	(2.3)
Low	3	Housed near cows only when necessary, only for short periods of time, no run-off possible, and minimal or no direct contact	21.4	(2.1)
Moderate	5	Housed near cows only for short periods of time, where run-off is possible, and minimal direct contact	6.0	(1.2)
High	7	Housed next to cows for short periods of time, where run-off is possible, and direct contact probable	3.9	(1.1)
Very high	10	Always housed near cows	18.7	(2.0)
Total	NA		100.0	

The majority of large operations (86.4 percent) and medium operations (64.3 percent) never housed preweaned heifers near cows.

b. Percentage of operations that housed preweaned heifers near cows, by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	44.1	(3.0)	64.3	(3.4)	86.4	(4.0)
Low	23.0	(2.7)	17.9	(3.0)	8.4	(3.4)
Moderate	5.9	(1.5)	6.6	(1.8)	1.2	(1.2)
High	4.8	(1.5)	1.7	(0.8)	0.0	(--)
Very high	22.2	(2.6)	9.5	(2.0)	4.0	(1.9)
Total	100.0		100.0		100.0	

c. Percentage of operations that housed preweaned heifers near cows, by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	63.9	(6.1)	53.6	(3.3)	39.6	(3.9)	45.5	(9.2)
Low	20.0	(5.9)	23.1	(3.0)	19.3	(3.4)	16.9	(8.4)
Moderate	3.2	(2.0)	6.5	(1.8)	5.7	(2.2)	4.6	(3.1)
High	0.0	(--)	3.1	(1.1)	6.6	(3.1)	4.4	(3.1)
Very high	12.9	(4.1)	13.7	(2.3)	28.8	(4.7)	28.6	(7.9)
Total	100.0		100.0		100.0		100.0	

Average risk scores decreased as herd size increased. Operations in the West region had lower average risk scores (2.0) than operations in the Northeast region (4.2).

d. Average risk score for housing preweaned heifers near cows, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
3.5	(0.2)	1.9	(0.2)	0.7	(0.2)	3.1	(0.2)

e. Average risk score for housing preweaned heifers near cows, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
2.0	(0.4)	2.6	(0.2)	4.2	(0.4)	3.9	(0.7)

7. Cow-manure contamination in milk, feed, water, or housing areas

Nearly two out of three operations (64.1 percent) had no cow-manure contamination in milk, feed, water, or the housing areas used for preweaned heifers.

a. Percentage of operations by cow-manure contamination in milk, feed, water, or the housing areas used for preweaned heifers, and by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	No cow-manure contamination	64.1	(2.3)
Low	3	Trace amounts of manure visible, waterers and feeders cleaned more than once a month	24.6	(2.1)
Moderate	5	Some manure visible, waterers and feeders cleaned less than once a month	8.8	(1.3)
High	7	Large amounts of manure visible, waterers and feeders not cleaned regularly	1.8	(0.8)
Very high	10	Extensive manure contamination	0.7	(0.3)
Total	NA		100.0	

A higher percentage of large operations (86.7 percent) did not have any cow-manure contamination in milk, feed, water, or the housing areas used for preweaned heifers compared to medium and small operations (71.7 percent and 60.8 percent, respectively).

b. Percentage of operations by cow-manure contamination in milk, feed, water, or the housing areas used for preweaned heifers, and by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	60.8	(3.0)	71.7	(3.2)	86.7	(3.5)
Low	26.5	(2.7)	20.5	(2.8)	9.4	(3.0)
Moderate	9.8	(1.7)	6.2	(1.8)	3.9	(1.9)
High	2.3	(1.0)	0.3	(0.3)	0.0	(--)
Very high	0.6	(0.3)	1.3	(0.7)	0.0	(--)
Total	100.0		100.0		100.0	

c. Percentage of operations by cow-manure contamination in milk, feed, water, or the housing areas used for preweaned heifers, and by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	75.6	(5.3)	65.8	(3.3)	53.6	(4.1)	79.0	(5.9)
Low	14.2	(4.1)	23.7	(2.9)	32.2	(4.0)	12.7	(5.0)
Moderate	7.9	(3.3)	8.0	(1.7)	11.2	(2.7)	6.4	(3.7)
High	0.0	(--)	2.1	(1.0)	2.2	(1.6)	0.0	(0.0)
Very high	2.3	(1.7)	0.4	(0.3)	0.8	(0.5)	1.9	(1.8)
Total	100.0		100.0		100.0		100.0	

d. Average risk score for cow-manure contamination in milk, feed, water, or the housing areas used for preweaned heifers, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
1.5	(0.1)	1.1	(0.1)	0.5	(0.1)	1.4	(0.1)

e. Average risk score for cow-manure contamination in milk, feed, water, or housing areas used for preweaned heifers, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
1.1	(0.3)	1.3	(0.1)	1.8	(0.2)	0.9	(0.3)

8. Preweaned heifer calves average total risk scores

Four risk areas were used to calculate total risk scores. The highest possible risk score was 45. Scores from these areas contributed to the average total risk score. Large operations had the highest average total risk score (16.9) for preweaned heifers.

a. Average total risk score for operations housing preweaned heifers, by herd size

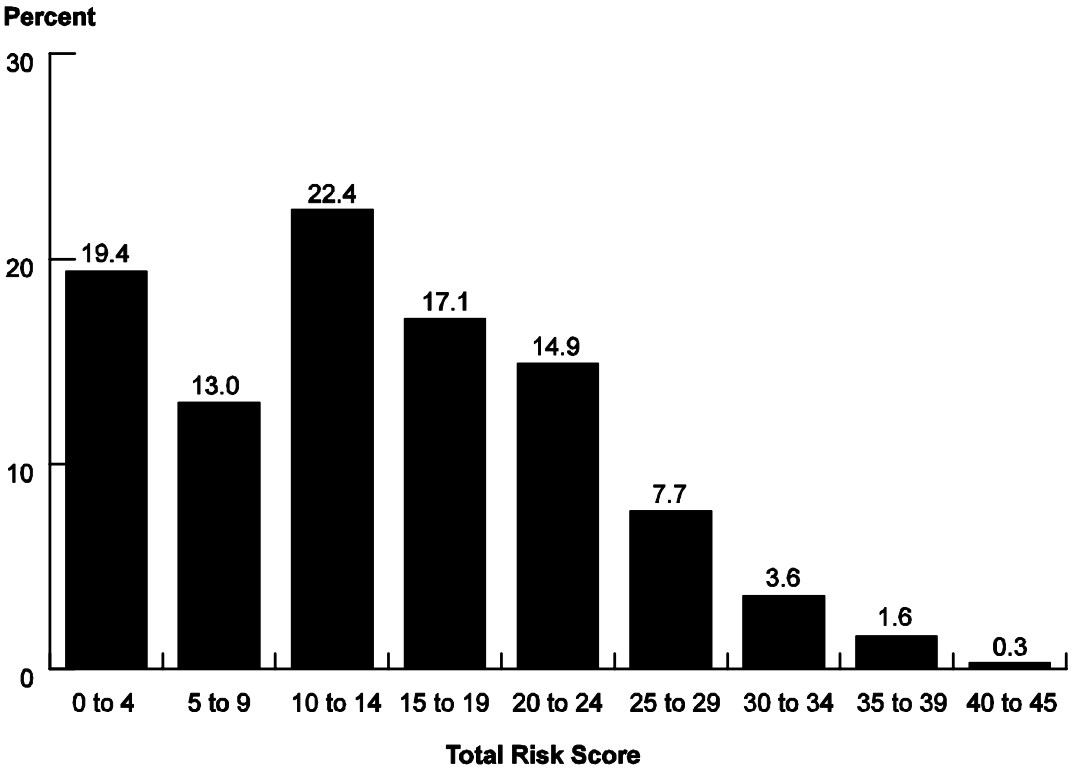
Herd Size (Number of Dairy Cows)							
Small (Less than 100)		Medium (100-499)		Large (500 or More)		All Operations	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
14.6	(0.6)	12.7	(0.6)	16.9	(0.8)	14.3	(0.4)

Average total risk score for operations in the Midwest region (12.9) was lower than scores for operations in the West and Northeast regions (17.8 and 16.0, respectively).

b. Average total risk score for operations housing preweaned heifers, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
17.8	(1.0)	12.9	(0.6)	16.0	(0.8)	14.5	(1.2)

Percentage of Operations by Total Risk Scores for Preweaned Heifers



D. Postweaned Heifer Calves

NOTE: Some tables in this section represent questions or observations where risk levels were not assigned.

1. Postweaned heifers on premises

Overall, 90.9 percent of operations housed postweaned heifers. Seven out of 10 large operations (74.0 percent) housed postweaned heifers compared to 93.3 percent of small operations. Since only 63.9 percent of large operations (see section C.1.a.) retained heifer calves born on the operation, which is less than the 74.0 percent of large operations that housed postweaned heifers, it appears that some large operations brought back postweaned heifers from offsite rearing.

a. Percentage of operations that normally housed postweaned heifers, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Percent	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
93.3	(1.8)	86.4	(2.2)	74.0	(3.8)	90.9	(1.4)

b. Percentage of operations that normally housed postweaned heifers, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Percent	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
88.1	(2.8)	90.9	(2.1)	93.9	(1.7)	81.0	(5.5)

2. Postweaned heifer calf housing

One-fifth of all operations (20.8 percent) always housed postweaned heifers near cows.

a. Percentage of operations that housed postweaned heifers near cows, by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never housed postweaned heifers near cows	47.3	(2.4)
Low	3	Housed near cows only when necessary, only for short periods of time, no runoff possible, and minimal or no direct contact	18.4	(1.8)
Moderate	5	Housed near cows only for short periods of time, where runoff possible, and minimal direct contact	8.0	(1.3)
High	7	Housed next to cows for short periods of time, where runoff possible, and direct contact probable	5.5	(1.3)
Very high	10	Always housed near cows	20.8	(2.1)
Total	NA		100.0	

The majority of large operations (71.7 percent) and medium operations (59.8 percent) never housed postweaned heifers near cows.

b. Percentage of operations that housed postweaned heifers near cows, by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	42.5	(3.0)	59.8	(3.6)	71.7	(5.0)
Low	18.9	(2.3)	18.1	(2.8)	9.4	(3.5)
Moderate	8.4	(1.7)	7.1	(1.8)	4.2	(1.8)
High	6.3	(1.7)	3.0	(1.8)	2.3	(1.4)
Very high	23.9	(2.8)	12.0	(2.3)	12.4	(3.8)
Total	100.0		100.0		100.0	

c. Percentage of operations that housed postweaned heifers near cows, by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	54.0	(5.6)	52.8	(3.4)	33.9	(3.7)	46.5	(9.8)
Low	12.7	(3.5)	20.0	(2.6)	19.6	(3.4)	5.2	(3.1)
Moderate	7.6	(3.0)	8.0	(1.9)	8.0	(2.5)	7.8	(4.2)
High	7.3	(4.7)	3.4	(1.2)	8.8	(3.6)	7.6	(4.1)
Very high	18.4	(4.3)	15.8	(2.6)	29.7	(4.9)	32.9	(8.2)
Total	100.0		100.0		100.0		100.0	

Average risk scores for small operations were twice as high as those for large operations.

d. Average risk score for housing postweaned heifers near cows, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
3.8	(0.2)	2.3	(0.2)	1.9	(0.4)	3.4	(0.2)

Operations in the Northeast region had higher average risk scores than operations in the West and Midwest regions.

e. Average risk score for housing postweaned heifers near cows, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
3.1	(0.4)	2.8	(0.3)	4.6	(0.3)	4.4	(0.9)

NOTE: Because the practices represented in the following tables are perceived to be of lower risk, the risk scale was set at 0 to 5, rather than 0 to 10.

3. Cow-manure contamination of feed, water, or housing areas

The majority of operations (59.8 percent) had no cow-manure contamination of feed, water, or the housing areas of postweaned heifers.

a. Percentage of operations by cow-manure contamination of feed, water, or the housing areas used for postweaned heifers, and by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	No cow-manure contamination	59.8	(2.5)
Low	1	Trace amounts of manure visible, waterers and feeders cleaned more than once a month	20.5	(2.1)
Moderate	2	Some manure visible, waterers and feeders cleaned less than once a month	11.9	(1.6)
High	3	Large amounts of manure visible, waterers and feeders not cleaned regularly	4.9	(1.0)
Very high	5	Extensive manure contamination	2.9	(0.9)
Total	NA		100.0	

b. Percentage of operations by cow-manure contamination of feed, water, or the housing areas used for postweaned heifers, and by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	57.0	(3.2)	67.7	(3.5)	71.1	(5.0)
Low	21.6	(2.6)	17.5	(2.7)	16.1	(4.1)
Moderate	12.2	(2.1)	11.6	(2.5)	5.6	(2.6)
High	5.8	(1.4)	2.3	(1.0)	2.4	(1.4)
Very high	3.4	(1.2)	0.9	(0.6)	4.8	(2.3)
Total	100.0		100.0		100.0	

c. Percentage of operations by cow-manure contamination of feed, water, or the housing areas used for postweaned heifers, and by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	69.0	(5.2)	61.7	(3.4)	50.0	(4.8)	74.5	(8.6)
Low	8.9	(2.6)	18.5	(2.6)	29.6	(4.7)	14.0	(7.1)
Moderate	11.6	(3.8)	9.8	(2.1)	17.7	(3.7)	5.1	(5.2)
High	5.9	(2.6)	6.4	(1.7)	2.7	(1.2)	0.0	(0.0)
Very high	4.6	(2.2)	3.6	(1.5)	0.0	(0.0)	6.4	(3.5)
Total	100.0		100.0		100.0		100.0	

Average risk scores across all herd sizes and regions were similar.

d. Average risk score for cow-manure contamination of feed, water, or housing areas used for postweaned heifers, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
0.8	(0.1)	0.5	(0.1)	0.6	(0.1)	0.7	(0.1)

e. Average risk score for cow-manure contamination of feed, water, or housing areas used for postweaned heifers, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
0.7	(0.1)	0.8	(0.1)	0.7	(0.1)	0.6	(0.2)

4. Shared feed, water, or housing

On a majority of operations (63.1 percent), postweaned heifers never shared feed (including leftover feed—weighbacks), water, or housing with cows, while one in six operations (17.7 percent) always shared these items.

a. Percentage of operations by how often postweaned heifers shared feed (including leftover feed—weighbacks), water, or housing with cows, and by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never shared feed, water, or housing	63.1	(2.4)
Low	1	Shared feed, water, or housing only when necessary or by mistake and less than once a month	7.7	(1.5)
Moderate	2	Shared feed, water, or housing two to five times per month	5.3	(1.1)
High	3	Shared feed, water, or housing more often than not	6.2	(1.3)
Very high	5	Always shared feed, water, or housing	17.7	(2.0)
Total	NA		100.0	

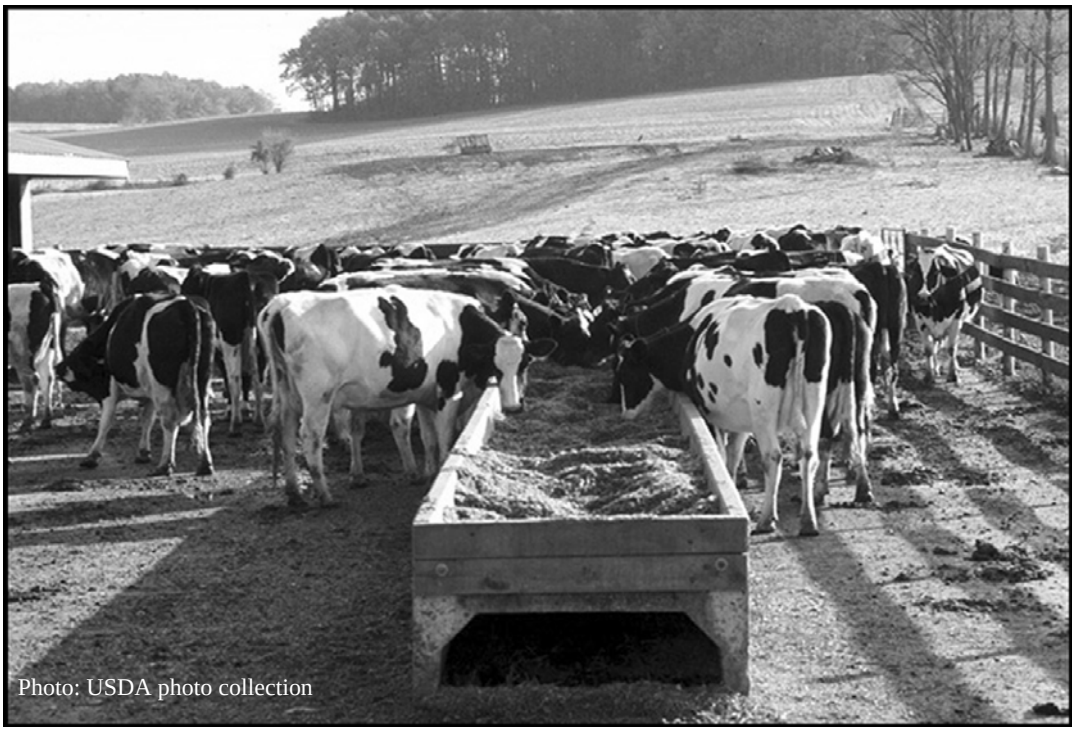


Photo: USDA photo collection

A higher percentage of large and medium operations (75.7 percent and 72.3 percent, respectively) never shared feed, water, or the housing of postweaned heifers with cows than did small operations (59.7 percent).

b. Percentage of operations by how often postweaned heifers shared feed (including leftover feed—weighbacks), water, or housing with cows, and by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	59.7	(3.1)	72.3	(3.2)	75.7	(4.6)
Low	8.1	(1.9)	7.3	(1.7)	2.4	(1.3)
Moderate	5.4	(1.5)	4.4	(1.4)	9.0	(2.8)
High	7.1	(1.7)	4.0	(1.4)	0.0	(--)
Very high	19.7	(2.5)	12.0	(2.5)	12.9	(3.8)
Total	100.0		100.0		100.0	

c. Percentage of operations by how often postweaned heifers shared feed (including leftover feed—weighbacks), water, or housing with cows, and by risk level and region

	Region							
	West		**Midwest**		**Northeast**		**Southeast**	
Risk Level	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
None	79.6	(4.0)	65.3	(3.3)	53.1	(4.8)	63.8	(10.1)
Low	3.0	(1.7)	6.6	(1.8)	10.1	(3.3)	14.7	(9.2)
Moderate	8.4	(2.9)	3.9	(1.4)	8.2	(2.8)	0.3	(0.3)
High	1.7	(1.2)	6.9	(1.9)	7.3	(2.2)	0.0	(0.0)
Very high	7.3	(2.4)	17.3	(2.7)	21.3	(3.9)	21.2	(7.9)
Total	100.0		100.0		100.0		100.0	

d. Average risk score for postweaned heifers sharing feed, water, or housing with cows, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
1.4	(0.1)	0.9	(0.1)	0.8	(0.2)	1.3	(0.1)

The West region had a lower average risk score (0.6) than the Midwest, Northeast, and Southeast regions (1.2, 1.5, and 1.2, respectively).

e. Average risk score for postweaned heifers sharing feed, water, or housing with cows, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
0.6	(0.1)	1.2	(0.1)	1.5	(0.2)	1.2	(0.4)

A higher percentage of small operations (18.8 percent) than large operations (3.6 percent) allowed postweaned heifers and cows to share waterers. Overall, 16.5 percent of operations allowed postweaned heifers and cows to share waterers.

f. Percentage of operations that allowed postweaned heifers to share waterers with cows, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Percent	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
18.8	(2.5)	10.5	(1.9)	3.6	(1.6)	16.5	(1.9)

g. Percentage of operations that allowed postweaned heifers to share waterers with cows, by region

Region							
West		Midwest		Northeast		Southeast	
Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
10.8	(3.3)	19.0	(2.8)	11.4	(2.7)	24.0	(8.5)

Postweaned heifers and cows shared feed-bunk space on only 10.6 percent of operations. A lower percentage of large operations (2.5 percent) than medium or small operations (6.8 percent and 12.1 percent, respectively) allowed postweaned heifers and cows to share feed-bunk space.

h. Percentage of operations that allowed postweaned heifers to share feed-bunk space with cows, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
12.1	(2.1)	6.8	(1.7)	2.5	(1.3)	10.6	(1.6)

i. Percentage of operations that allowed postweaned heifers to share feed-bunk space with cows, by region

Region							
West		Midwest		Northeast		Southeast	
Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
5.7	(2.4)	12.3	(2.4)	8.1	(2.6)	13.1	(6.7)

5. Shared pasture with cows

Postweaned heifers were never allowed to share pasture with cows on 76.7 percent of operations.

a. Percentage of operations by how often postweaned heifers shared pasture with cows, and by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never shared pasture	76.7	(2.3)
Low	1	Shared pasture only when heifers escape	5.9	(1.2)
Moderate	2	Shared pasture less than 25 percent of the time	5.7	(1.3)
High	3	Shared pasture more than 25 percent of the time but less than 100 percent of the time	6.2	(1.4)
Very high	5	Always shared pasture	5.5	(1.2)
Total	NA		100.0	

Only 3.6 percent of large operations allowed postweaned heifers and cows to share pasture.

b. Percentage of operations by how often postweaned heifers shared pasture with cows, and by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	72.5	(3.0)	87.7	(2.0)	96.4	(2.0)
Low	6.3	(1.5)	5.6	(1.3)	0.9	(0.8)
Moderate	6.9	(1.7)	2.3	(0.9)	0.0	(--)
High	7.6	(1.8)	1.9	(0.8)	2.7	(1.8)
Very high	6.7	(1.5)	2.5	(1.0)	0.0	(--)
Total	100.0		100.0		100.0	

The majority of operations in all regions never allowed postweaned heifers to share pasture with cows.

c. Percentage of operations by how often postweaned heifers shared pasture with cows, and by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	93.2	(3.0)	78.2	(3.0)	70.9	(4.8)	63.2	(9.5)
Low	0.3	(0.3)	6.2	(1.6)	5.7	(2.3)	13.1	(5.2)
Moderate	3.3	(2.3)	3.8	(1.3)	9.6	(3.5)	8.6	(6.2)
High	1.7	(1.0)	6.0	(1.9)	8.3	(2.9)	5.0	(3.6)
Very high	1.5	(1.5)	5.8	(1.7)	5.5	(1.9)	10.1	(6.2)
Total	100.0		100.0		100.0		100.0	

Average risk scores were low for all herd sizes but decreased as herd size increased.

d. Average risk score for postweaned heifers sharing pasture with cows, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
0.8	(0.1)	0.3	(0.1)	0.1	(0.1)	0.6	(0.1)

e. Average risk score for postweaned heifers sharing pasture with cows, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
0.2	(0.1)	0.6	(0.1)	0.8	(0.1)	1.0	(0.3)

6. Manure spread on pasture or harvested forage

A majority of operations (58.4 percent) never spread manure on forage ground grazed by or harvested for postweaned heifers.

a. Percentage of operations that spread manure on forage ground grazed by or harvested for postweaned heifers, by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never spread manure on pasture	58.4	(2.4)
Low	1	Manure spread on pasture only when no other option	12.3	(1.6)
Moderate	2	Manure spread on pasture to be grazed or harvested between 0 and 2 months after spreading	19.5	(1.9)
High	3	Manure spread routinely on pasture to be grazed or harvested when forage matures, regardless of time	5.4	(1.0)
Very high	5	Always spread manure on pasture	4.4	(1.0)
Total	NA		100.0	

b. Percentage of operations that spread manure on forage ground grazed by or harvested for postweaned heifers, by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	59.4	(3.1)	54.2	(3.7)	62.4	(5.3)
Low	12.5	(2.0)	12.4	(2.3)	8.1	(3.5)
Moderate	19.8	(2.5)	19.7	(3.0)	10.3	(3.4)
High	3.6	(1.0)	10.9	(2.7)	9.7	(3.0)
Very high	4.7	(1.3)	2.8	(1.0)	9.5	(2.9)
Total	100.0		100.0		100.0	

c. Percentage of operations that spread manure on forage ground grazed by or harvested for postweaned heifers, by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	60.1	(5.5)	60.8	(3.5)	51.7	(4.3)	63.5	(8.9)
Low	4.3	(1.9)	12.6	(2.2)	13.4	(2.8)	16.5	(7.6)
Moderate	7.7	(2.8)	20.1	(2.8)	24.4	(3.8)	6.1	(3.5)
High	21.9	(5.8)	3.5	(1.2)	4.7	(1.5)	4.1	(2.8)
Very high	6.0	(2.1)	3.0	(1.3)	5.8	(2.2)	9.8	(4.3)
Total	100.0		100.0		100.0		100.0	

Average risk was low for all herd sizes and regions.

d. Average risk score for spreading manure on forage ground grazed by or harvested for postweaned heifers, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
0.9	(0.1)	1.0	(0.1)	1.1	(0.2)	0.9	(0.1)

e. Average risk score for spreading manure on forage ground grazed by or harvested for postweaned heifers, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
1.2	(0.2)	0.8	(0.1)	1.1	(0.1)	0.9	(0.2)

7. Manure contamination of equipment used to feed postweaned heifers

More than 6 out of 10 operations (61.3 percent) had no manure contamination of equipment used to feed postweaned heifers. Large or extensive manure contamination of equipment was rare (2.4 percent of operations).

a. Percentage of operations by manure contamination of equipment used to feed postweaned heifers, and by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	No manure contamination	61.3	(2.5)
Low	1	Trace amounts of manure visible, feeding equipment cleaned more than once a month	26.3	(2.3)
Moderate	2	Some manure visible, feeding equipment cleaned less than once a month	10.0	(1.5)
High	3	Large amounts of manure visible, feeding equipment not cleaned regularly	0.9	(0.4)
Very high	5	Extensive manure contamination	1.5	(0.5)
Total	NA		100.0	

b. Percentage of operations by manure contamination of equipment used to feed postweaned heifers, and by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	60.3	(3.2)	66.4	(3.5)	62.2	(5.4)
Low	28.0	(3.0)	20.5	(2.7)	25.2	(4.9)
Moderate	10.7	(1.9)	8.1	(2.1)	8.9	(2.8)
High	0.4	(0.4)	2.4	(1.3)	2.7	(1.9)
Very high	0.6	(0.5)	4.6	(1.6)	1.0	(1.0)
Total	100.0		100.0		100.0	

c. Percentage of operations by manure contamination of equipment used to feed postweaned heifers, and by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	59.9	(5.4)	63.5	(3.4)	56.4	(4.9)	64.8	(9.7)
Low	25.7	(4.9)	24.7	(3.1)	30.6	(4.7)	21.9	(9.3)
Moderate	5.9	(2.4)	10.0	(2.0)	11.7	(3.1)	8.5	(5.8)
High	3.2	(1.7)	0.6	(0.4)	1.0	(1.0)	0.0	(--)
Very high	5.3	(2.4)	1.2	(0.7)	0.3	(0.2)	4.8	(3.2)
Total	100.0		100.0		100.0		100.0	

The average risk score was low across all herd sizes and regions.

d. Average risk score for manure contamination of equipment used to feed postweaned heifers, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
0.5	(0.0)	0.7	(0.1)	0.6	(0.1)	0.6	(0.0)

e. Average risk score for manure contamination of equipment used to feed postweaned heifers, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
0.7	(0.1)	0.5	(0.1)	0.6	(0.1)	0.6	(0.2)

8. Postweaned heifer calves average total risk scores

Six questions from the risk assessment were used to evaluate risk areas. The highest possible risk score was 35. Scores from these areas contributed to the average total risk score. Average total risk scores for postweaned heifers were highest for small operations.

a. Average total risk score for operations housing postweaned heifers, by herd size

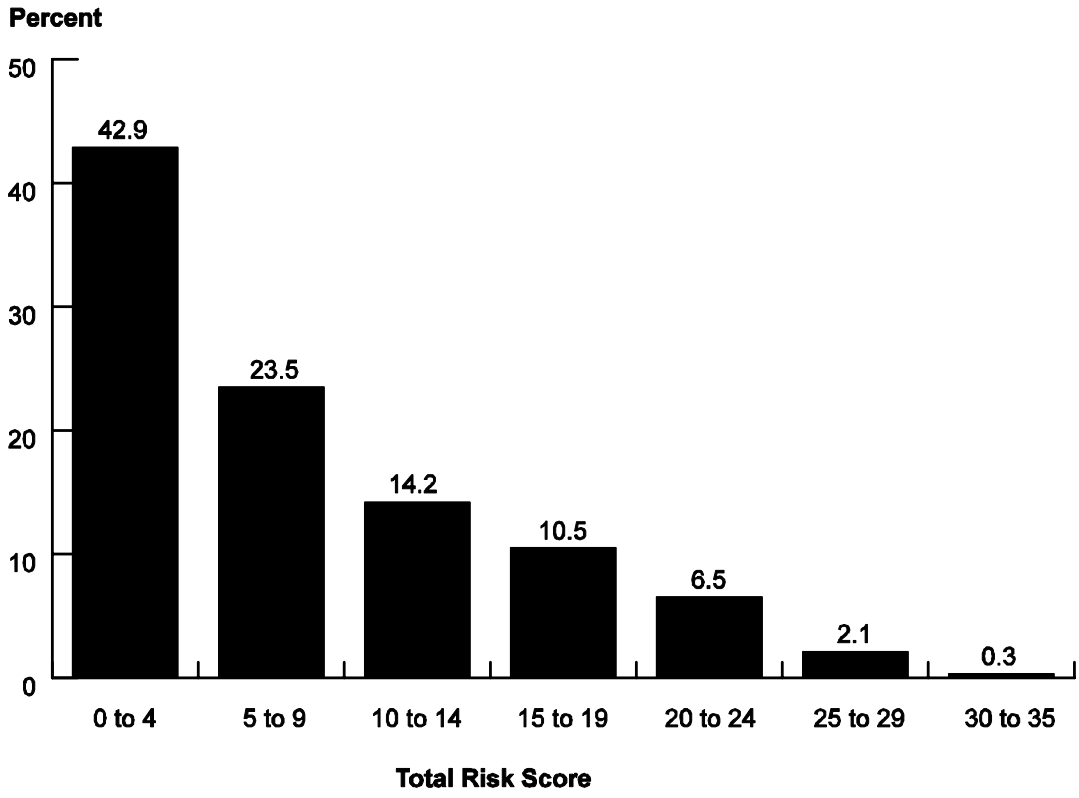
Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
8.2	(0.5)	5.6	(0.4)	5.1	(0.6)	7.5	(0.4)

Average total risk scores for the Midwest region (6.7) were lower than scores for the Northeast region (9.2).

b. Average total risk score for operations housing postweaned heifers, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
6.6	(0.7)	6.7	(0.5)	9.2	(0.6)	8.8	(1.7)

Percentage of Operations by Total Risk Scores for Postweaned Heifers



E. Bred Heifers

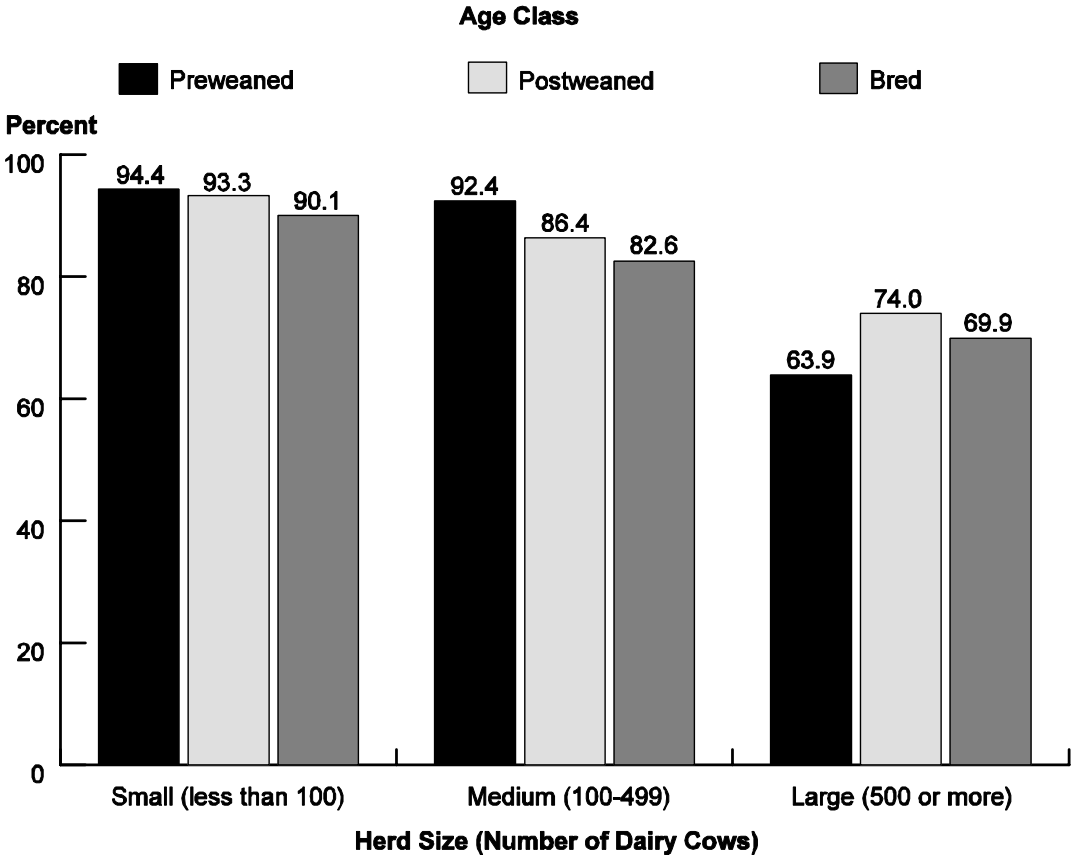
1. Bred heifers on premises

Bred heifers were normally housed from the time they were bred until they calved on 87.5 percent of operations. A higher percentage of small operations (90.1 percent) housed bred heifers than large operations (69.9 percent).

a. Percentage of operations that normally housed bred heifers from the time they were bred until they calved, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Percent	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
90.1	(2.0)	82.6	(2.5)	69.9	(4.0)	87.5	(1.6)

Percentage of Operations that Normally Housed the Following Age Classes of Heifers, by Herd Size



b. Percentage of operations that normally housed bred heifers from the time they were bred until they calved, by region

Region							
West		Midwest		Northeast		Southeast	
Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
83.2	(3.1)	86.6	(2.4)	92.6	(2.1)	79.8	(6.0)

NOTE: The risk scale for practices represented in the following tables is 0 to 4.

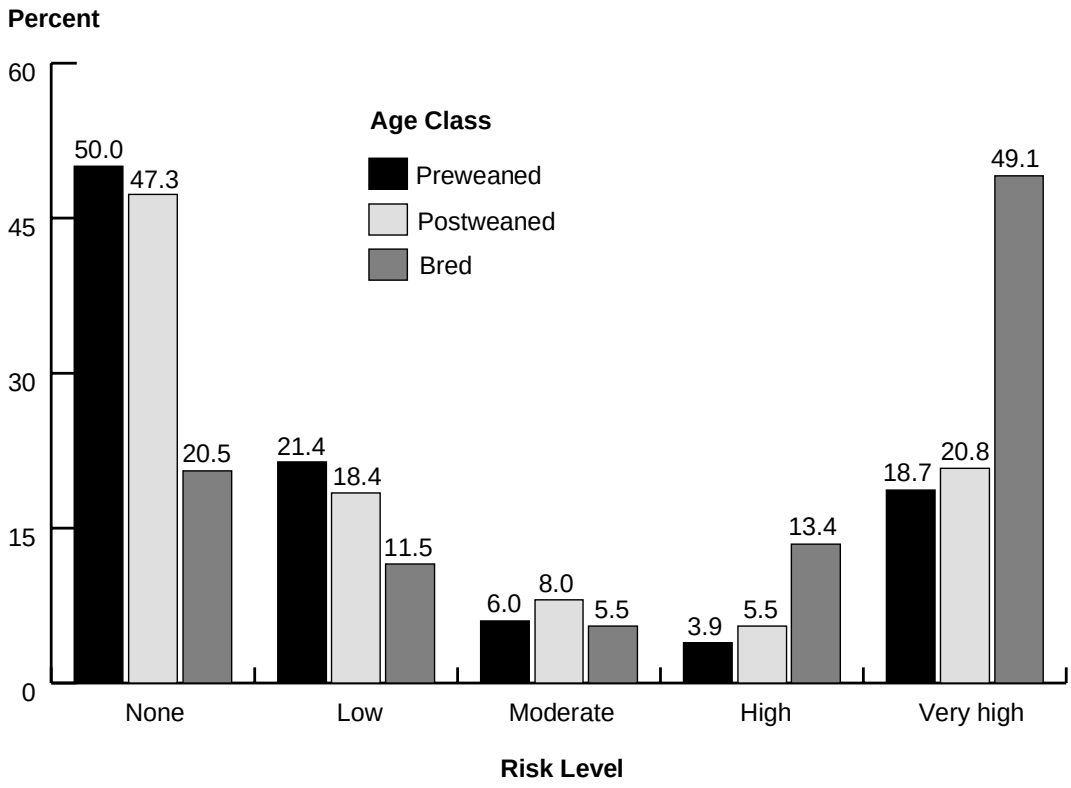
2. Bred-heifer housing

Nearly one out of two operations (49.1 percent) always housed bred heifers near cows.

a. Percentage of operations that housed bred heifers near cows, by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never housed near cattle	20.5	(2.0)
Low	1	Housed near cows only when necessary, only for short periods of time, no run-off possible, and minimal or no direct contact	11.5	(1.5)
Moderate	2	Housed near cows only for short periods of time, where run-off is possible, and minimal direct contact	5.5	(1.3)
High	3	Housed next to cows for short periods of time, where run-off possible, and direct contact probable	13.4	(1.7)
Very high	4	Always housed bred heifers near cows	49.1	(2.6)
Total	NA		100.0	

Percentage of Operations that Housed the Following Age Classes of Heifers Near Cows, by Risk Level



b. Percentage of operations that housed bred heifers near cows, by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	17.7	(2.5)	27.2	(3.5)	36.1	(5.2)
Low	11.4	(1.9)	11.5	(2.2)	12.2	(3.1)
Moderate	6.0	(1.7)	3.5	(1.0)	7.4	(2.6)
High	12.5	(2.1)	17.3	(2.9)	8.8	(2.8)
Very high	52.4	(3.4)	40.5	(3.6)	35.5	(5.4)
Total	100.0		100.0		100.0	

c. Percentage of operations that housed bred heifers near cows, by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	33.5	(6.0)	20.0	(3.1)	17.7	(3.0)	19.9	(5.8)
Low	10.0	(3.2)	11.9	(2.2)	13.2	(2.8)	1.5	(0.8)
Moderate	3.8	(1.7)	2.9	(1.1)	10.9	(3.7)	5.4	(3.7)
High	10.7	(4.4)	13.1	(2.2)	15.4	(3.1)	10.3	(9.3)
Very high	42.0	(6.0)	52.1	(3.7)	42.8	(5.0)	62.9	(8.6)
Total	100.0		100.0		100.0		100.0	

All herd sizes and regions had average risk scores in the moderate- to high-risk range.

d. Average risk score for bred-heifer housing, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
2.7	(0.1)	2.3	(0.1)	2.0	(0.2)	2.6	(0.1)

e. Average risk score bred-heifer housing, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
2.2	(0.2)	2.7	(0.1)	2.5	(0.1)	2.9	(0.2)

3. Cow-manure contamination in feed, water, or housing areas

a. Percentage of operations by cow-manure contamination in feed, water, or bred-heifer housing areas, and by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	No manure contamination	31.2	(2.3)
Low	1	Trace amounts of manure visible, waterers and feeders cleaned more than once a month	30.5	(2.4)
Moderate	2	Some manure visible, waterers and feeders cleaned less than once a month	20.3	(2.1)
High	3	Large amounts of manure visible, waterers and feeders not cleaned regularly	5.0	(1.1)
Very high	4	Extensive manure contamination	13.0	(1.7)
Total	NA		100.0	

Over half of large operations (52.4 percent) had no manure contamination of feed, water, or bred-heifer housing areas.

b. Percentage of operations by cow-manure contamination in feed, water, or bred-heifer housing areas, and by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	28.0	(2.9)	38.3	(3.7)	52.4	(5.4)
Low	31.4	(3.1)	29.9	(3.3)	16.8	(3.9)
Moderate	23.0	(2.7)	12.0	(2.1)	14.4	(3.9)
High	5.1	(1.4)	5.4	(1.7)	2.4	(1.6)
Very high	12.5	(2.2)	14.4	(2.9)	14.0	(3.7)
Total	100.0		100.0		100.0	

The average risk score across all herd sizes for cow-manure contamination in feed, water, or bred-heifer housing areas was 1.4 (low to moderate risk).

c. Average risk score for cow-manure contamination in feed, water, or bred-heifer housing areas, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
1.4	(0.1)	1.3	(0.1)	1.1	(0.2)	1.4	(0.1)

d. Average risk score for cow-manure contamination in feed, water, or bred-heifer housing areas, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
1.4	(0.2)	1.4	(0.1)	1.3	(0.1)	1.4	(0.2)

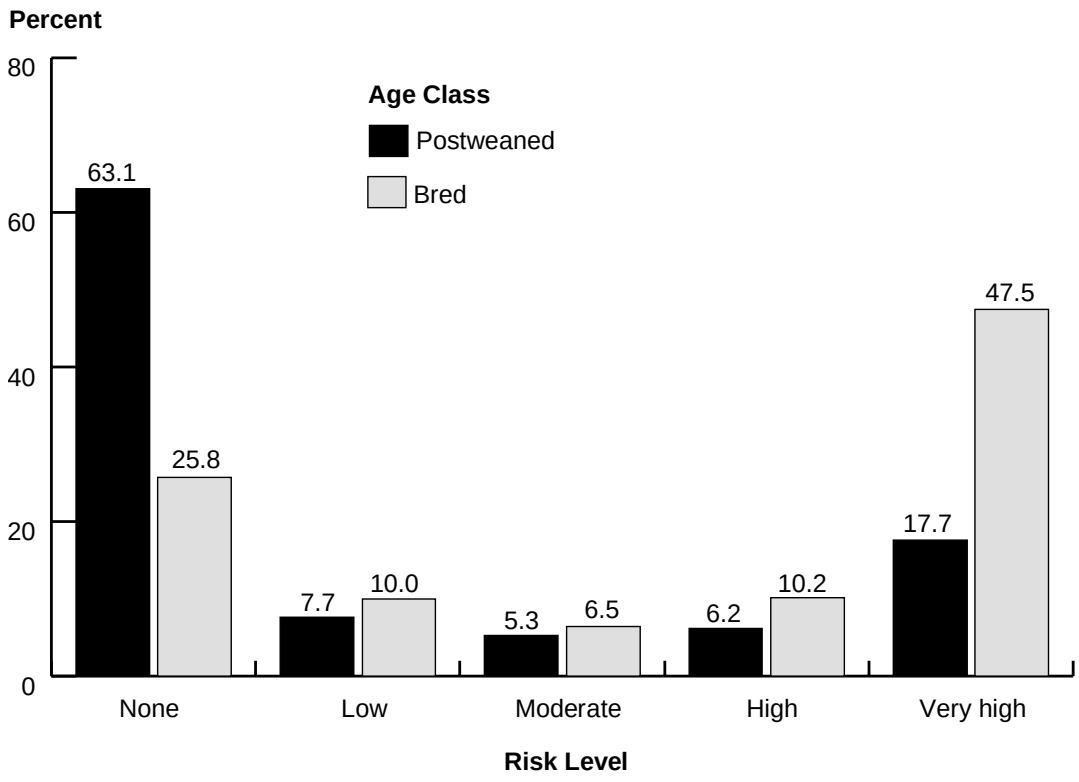
4. Shared feed, water, or housing

On 47.5 percent of operations, bred heifers always shared feed, water, or housing with cows.

a. Percentage of operations by how often bred heifers shared feed (including leftover feed—weighbacks), water, or housing with cows, and by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never shared feed, water, or housing	25.8	(2.2)
Low	1	Shared feed, water, or housing only when necessary or by mistake and less than once a month	10.0	(1.4)
Moderate	2	Shared feed, water, or housing two to five times per month	6.5	(1.1)
High	3	Shared feed, water, or housing more often than not	10.2	(1.7)
Very high	4	Always shared feed, water, or housing	47.5	(2.7)
Total	NA		100.0	

Percentage of Operations by How Often the Following Age Classes of Heifers Shared Feed (Including Leftover Feed--Weighbacks) Water, or Housing with Cows, and by Risk Level



b. Percentage of operations by how often bred heifers shared feed (including leftover feed—weighbacks), water, or housing with cows, and by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	23.8	(2.8)	30.3	(3.3)	36.9	(5.1)
Low	8.9	(1.7)	13.6	(2.8)	10.3	(3.1)
Moderate	5.6	(1.3)	8.7	(2.0)	10.7	(3.2)
High	10.6	(2.2)	9.8	(2.2)	5.7	(1.8)
Very high	51.1	(3.4)	37.6	(3.8)	36.4	(5.4)
Total	100.0		100.0		100.0	

c. Percentage of operations by how often bred heifers shared feed (including leftover feed—weighbacks), water, or housing with cows, and by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	30.1	(5.1)	24.5	(3.3)	26.7	(3.6)	26.6	(6.6)
Low	19.6	(5.6)	9.3	(2.0)	9.0	(2.4)	6.6	(3.9)
Moderate	11.8	(3.6)	5.1	(1.2)	8.4	(2.6)	3.0	(2.7)
High	4.4	(1.8)	9.3	(2.1)	11.7	(3.6)	20.8	(10.2)
Very high	34.1	(5.7)	51.8	(3.7)	44.2	(5.1)	43.0	(9.1)
Total	100.0		100.0		100.0		100.0	

Average risk level for all herd sizes and regions was in the moderate-to-high range.

d. Average risk score for bred heifers sharing feed, water, or housing with cows, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
2.6	(0.1)	2.1	(0.1)	1.9	(0.2)	2.4	(0.1)

e. Average risk score for bred heifers sharing feed, water, or housing with cows, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
1.9	(0.2)	2.5	(0.1)	2.4	(0.1)	2.5	(0.2)

A larger percentage of small operations (65.1 percent) allowed bred heifers to share waterers with cows than did medium and large operations (52.5 percent and 39.7 percent, respectively). Overall, 61.3 percent of operations allowed bred heifers to share waterers with cows.

f. Percentage of operations that allowed bred heifers to share waterers with cows, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Percent	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
65.1	(3.1)	52.5	(3.7)	39.7	(5.5)	61.3	(2.4)

g. Percentage of operations that allowed bred heifers to share waterers with cows, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Percent	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
40.4	(5.6)	63.8	(3.5)	64.1	(4.1)	54.7	(8.9)

A majority of operations (51.6 percent) allowed bred heifers to share feed-bunk space with cows. A higher percentage of small operations (54.1 percent) shared feed-bunk space than large operations (32.7 percent).

h. Percentage of operations that allowed bred heifers to share feed-bunk space with cows, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Percent	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
54.1	(3.3)	46.9	(3.9)	32.7	(5.4)	51.6	(2.6)

Operations in the West region were less likely to allow bred heifers and cows share feed-bunk space than operations in other regions.

i. Percentage of operations that allowed bred heifers to share feed-bunk space with cows, by region

Region							
West		Midwest		Northeast		Southeast	
Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
29.2	(5.3)	54.1	(3.6)	53.6	(5.0)	53.5	(9.4)

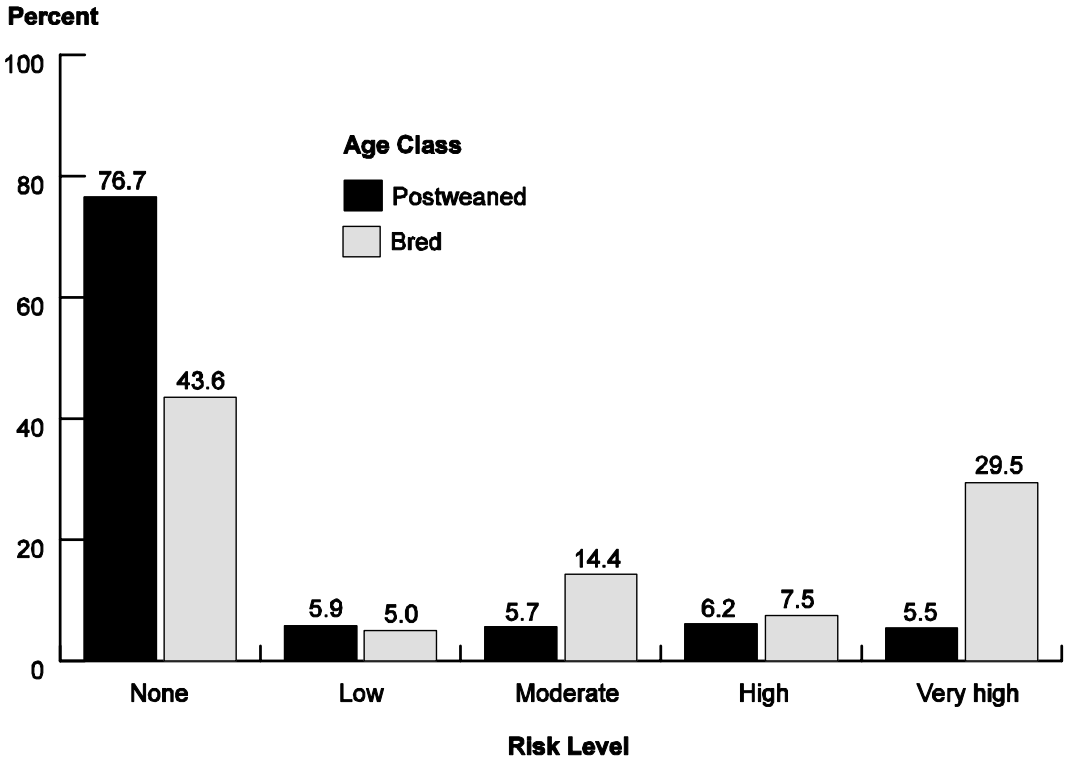
5. Shared pasture with cows

Bred heifers shared pasture with cows on more than half of operations (56.4 percent).

a. Percentage of operations by how often bred heifers shared pasture with cows, and by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never shared pasture	43.6	(2.5)
Low	1	Shared pasture only when heifers escape	5.0	(1.3)
Moderate	2	Shared pasture less than 25 percent of the time	14.4	(1.9)
High	3	Shared pasture more than 25 percent of the time but less than 100 percent of the time	7.5	(1.3)
Very high	4	Always shared pasture	29.5	(2.4)
Total	NA		100.0	

Percentage of Operations by How Often the Following Age Classes of Heifers Shared Pasture with Cows, and by Risk Level



Only 39.0 percent of small operations never allowed bred heifers to share pasture with cows, compared to 51.9 percent of medium operations and 84.5 percent of large operations.

b. Percentage of operations by how often bred heifers shared pasture with cows, and by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	39.0	(3.2)	51.9	(3.5)	84.5	(4.0)
Low	5.6	(1.7)	3.4	(1.2)	1.1	(0.8)
Moderate	15.0	(2.4)	14.3	(2.9)	4.2	(1.9)
High	6.6	(1.5)	10.8	(2.4)	6.1	(2.9)
Very high	33.8	(3.1)	19.6	(3.0)	4.1	(2.3)
Total	100.0		100.0		100.0	

Nearly 7 out of 10 operations in the West region (66.7 percent) never allowed bred heifers to share pasture with cows, compared to 45.6 percent of operations in the Midwest region, 35.6 percent in the Northeast region, and 28.8 percent in the Southeast region. This pattern might reflect that operations in the West region typically house cows in drylot or freestall facilities instead of pasture.

c. Percentage of operations by how often bred heifers shared pasture with cows, and by risk level and region

	Region							
	West		**Midwest**		**Northeast**		**Southeast**	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	66.7	(5.1)	45.6	(3.6)	35.6	(4.7)	28.8	(7.9)
Low	2.1	(1.8)	4.7	(1.8)	2.1	(1.1)	26.5	(9.5)
Moderate	12.8	(5.4)	11.9	(2.2)	21.6	(4.5)	5.4	(2.7)
High	6.8	(3.0)	7.3	(1.8)	8.1	(2.3)	8.2	(4.8)
Very high	11.6	(4.0)	30.5	(3.5)	32.6	(4.1)	31.1	(7.4)
Total	100.0		100.0		100.0		100.0	

Average risk scores were lower for large operations (0.4) than small operations (1.9).

d. Average risk score for bred heifers sharing pasture with cows, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
1.9	(0.1)	1.4	(0.1)	0.4	(0.1)	1.7	(0.1)

e. Average risk score for bred heifers sharing pasture with cows, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
0.9	(0.1)	1.7	(0.1)	2.0	(0.2)	1.9	(0.3)

6. Manure spread on pasture or harvested forage

The majority of operations (54.0 percent) never spread manure on forage ground grazed by or harvested for bred heifers.

a. Percentage of operations that spread manure on forage ground grazed by or harvested for bred heifers, by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never spread manure on pasture	54.0	(2.4)
Low	1	Manure spread on pasture only when no other option	13.3	(1.7)
Moderate	2	Manure spread on pasture to be grazed or harvested 0 to 2 months after spreading	21.6	(2.1)
High	3	Manure spread routinely on pasture to be grazed or harvested when forage matures, regardless of time	5.2	(1.0)
Very high	4	Always spread manure on pasture	5.9	(1.2)
Total	NA		100.0	

b. Percentage of operations that spread manure on forage ground grazed by or harvested for bred heifers, by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	48.4	(4.9)	59.1	(3.5)	47.9	(4.2)	44.0	(8.0)
Low	5.5	(2.4)	12.8	(2.4)	12.2	(2.6)	35.7	(8.9)
Moderate	14.5	(3.5)	20.6	(2.9)	28.3	(3.9)	7.9	(3.8)
High	23.6	(5.3)	2.4	(1.1)	5.7	(2.1)	1.9	(1.2)
Very high	8.0	(2.7)	5.1	(1.7)	5.9	(2.0)	10.5	(4.4)
Total	100.0		100.0		100.0		100.0	

c. Average risk score for spreading manure on forage ground grazed by or harvested for bred heifers, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
0.9	(0.1)	1.1	(0.1)	1.2	(0.1)	0.9	(0.1)

d. Average risk score for spreading manure on forage ground grazed by or harvested for bred heifers, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
1.4	(0.1)	0.8	(0.1)	1.1	(0.1)	1.0	(0.1)

7. Manure contamination of equipment used to feed bred heifers

There was no manure contamination of equipment used to feed bred heifers on 54.0 percent of operations.

a. Percentage of operations by manure contamination of equipment used to feed bred heifers, and by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	No manure contamination	54.0	(2.6)
Low	1	Trace amounts of manure visible, feeding equipment cleaned more than once a month	29.9	(2.4)
Moderate	2	Some manure visible, feeding equipment cleaned less than once a month	12.1	(1.7)
High	3	Large amounts of manure visible, feeding equipment not cleaned regularly	2.7	(0.8)
Very high	4	Extensive manure contamination	1.3	(0.5)
Total	NA		100.0	

Photo: USDA photo collection

Average risk scores were similar across all herd sizes and regions.

b. Average risk score for manure contamination of equipment used to feed bred heifers, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
0.7	(0.1)	0.7	(0.1)	0.6	(0.1)	0.7	(0.0)

c. Average risk score for manure contamination of equipment used to feed bred heifers, by region

Region							
West		**Midwest**		**Northeast**		**Southeast**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
0.7	(0.1)	0.7	(0.1)	0.6	(0.1)	0.9	(0.2)

8. Bred heifer average total risk scores

Six questions from the risk assessment were used to evaluate risk areas. The highest possible risk score was 24. Scores from these areas contributed to the average total risk score.

Average total risk scores were lower for large operations (7.2) than for small operations (10.2). There were no regional differences in average total risk scores for bred heifers.

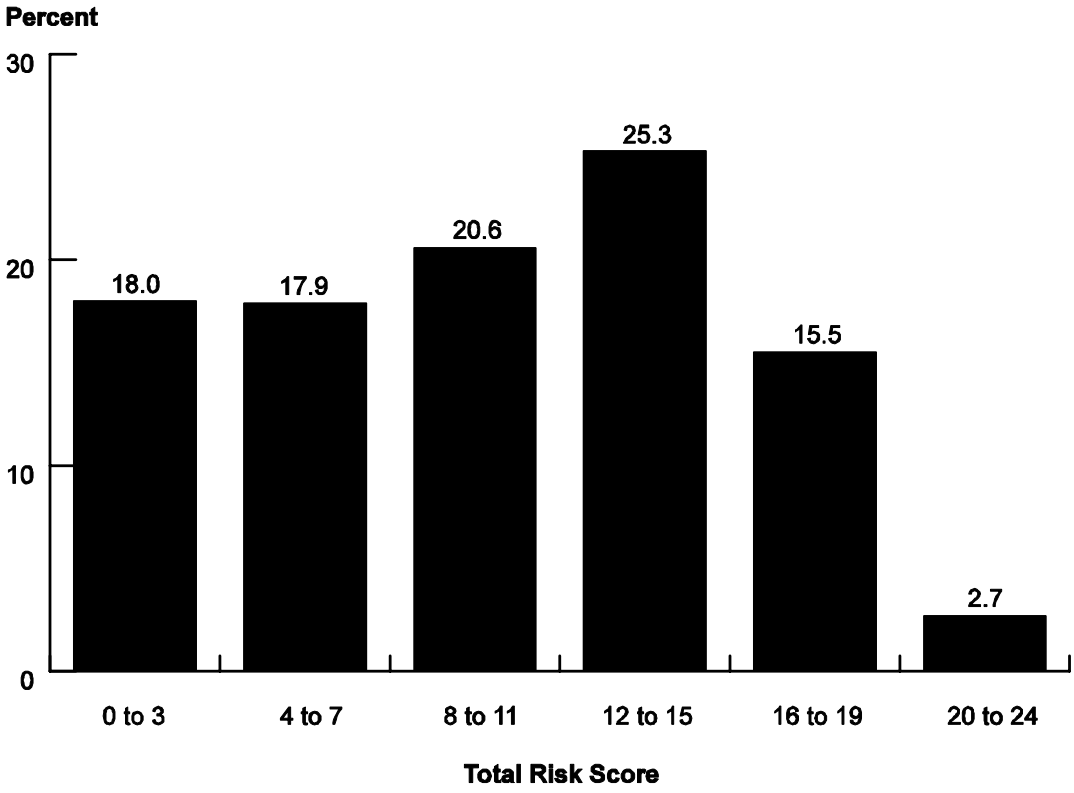
a. Average total risk score for operations housing bred heifers, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
10.2	(0.4)	8.9	(0.5)	7.2	(0.6)	9.8	(0.3)

b. Average total risk score for operations housing bred heifers, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
8.4	(0.7)	9.8	(0.4)	9.9	(0.4)	10.6	(0.8)

Percentage of Operations by Total Risk Scores for Bred Heifers



F. Cows

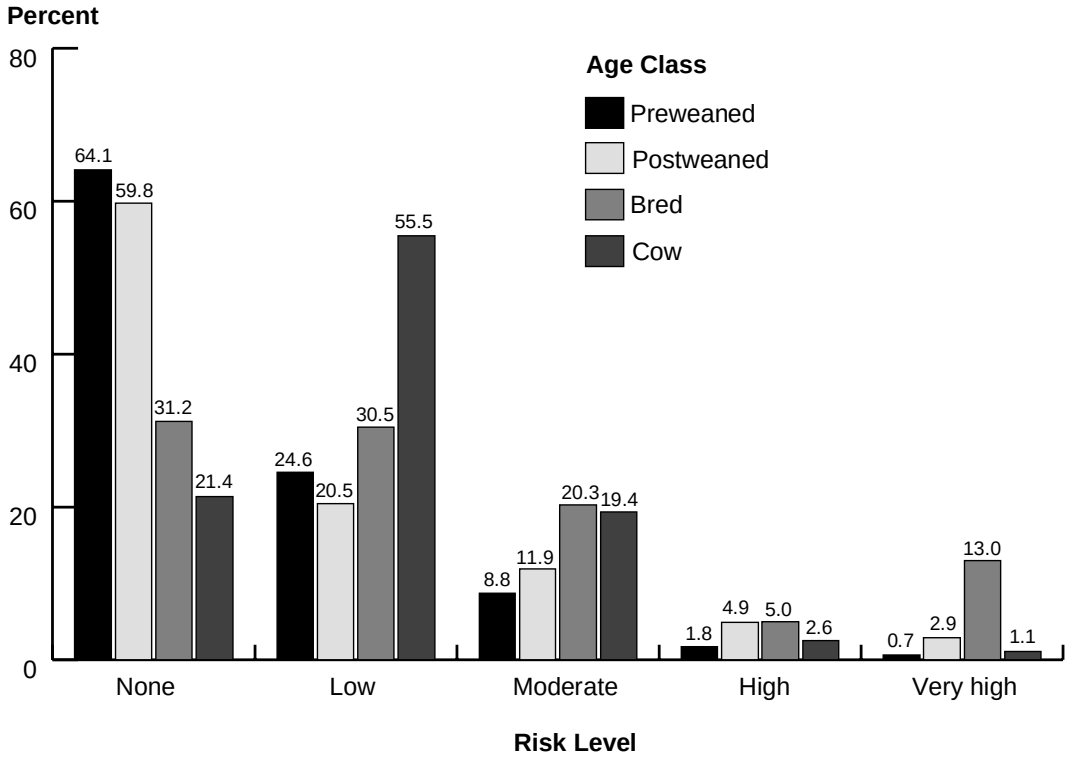
1. Cow-manure contamination of feeders and waterers

More than one out of two operations (55.5 percent) had only trace amounts of manure visible on feeders or waterers and cleaned feeders or waterers more frequently than once a month.

a. Percentage of operations by cow-manure contamination of feeders or waterers, and by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	No manure contamination	21.4	(1.8)
Low	1	Trace amounts of manure visible, waterers and feeders cleaned more than once a month	55.5	(2.3)
Moderate	2	Some manure visible, waterers and feeders cleaned less than once a month	19.4	(1.8)
High	3	Large amounts of manure visible, waterers and feeders not cleaned regularly	2.6	(0.7)
Very high	4	Extensive manure contamination	1.1	(0.5)
Total	NA		100.0	

Percentage of Operations by Cow-Manure Contamination (When Applicable) of Milk, Feed, Water, or Housing Areas Used by the Following Age Classes of Cattle, and by Risk Level



b. Average risk score for cow-manure contamination of feeders or waterers, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
1.1	(0.0)	1.1	(0.1)	1.0	(0.1)	1.1	(0.0)

c. Average risk score for cow-manure contamination of feeders or waterers, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
1.4	(0.1)	1.1	(0.0)	0.9	(0.1)	1.2	(0.1)

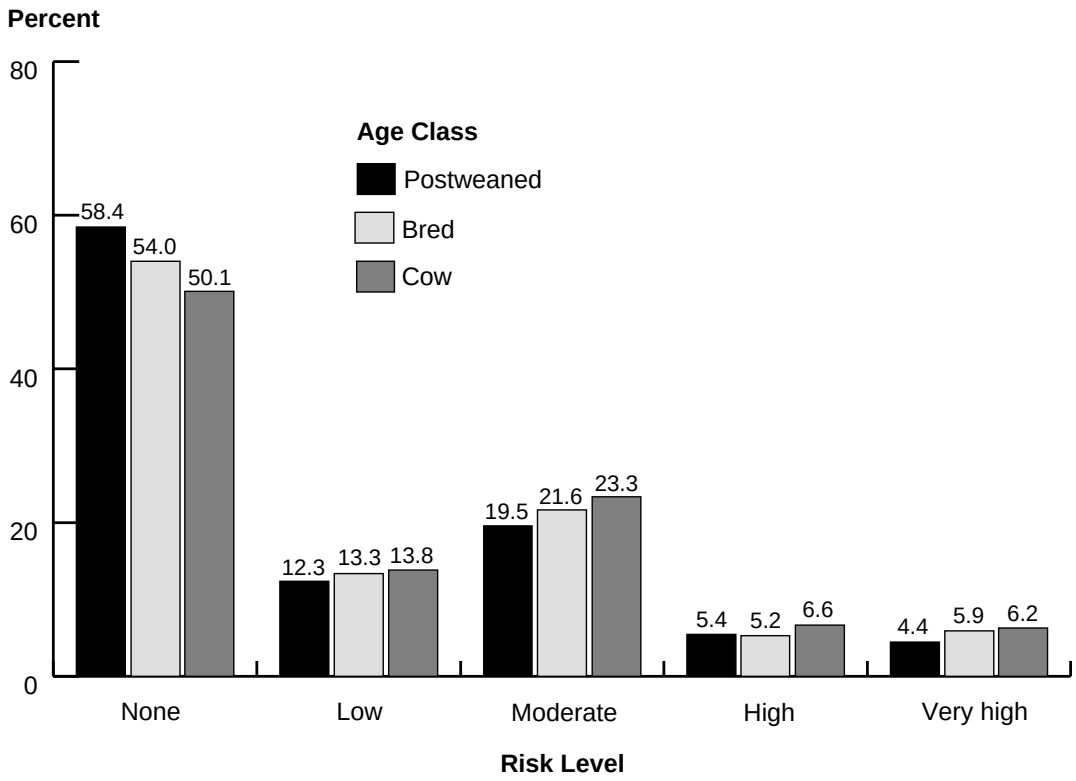
2. Manure spread on pasture or harvested forage

Half of operations (50.1 percent) never spread manure on forage ground grazed by or harvested for cows.

a. Percentage of operations by frequency that manure was spread on forage ground grazed by or harvested for cows, and by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	Never spread manure on pasture	50.1	(2.3)
Low	1	Manure spread on pasture only when no other option	13.8	(1.6)
Moderate	2	Manure spread on pasture to be grazed or harvested between 0 to 2 months after spreading	23.3	(2.0)
High	3	Manure spread routinely on pasture to be grazed or harvested when forage matures, regardless of time	6.6	(1.0)
Very high	4	Always spread manure on pasture	6.2	(1.1)
Total	NA		100.0	

Percentage of Operations that Spread Manure on Forage Ground Grazed by or Harvested for the Following Age Classes of Cattle, by Risk Score



b. Percentage of operations by frequency that manure was spread on forage ground grazed by or harvested for cows, and by risk level and herd size

	Herd Size (Number of Dairy Cows)					
	Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)	
Risk Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**	**Percent**	**Std. Error**
None	53.2	(3.0)	40.1	(3.1)	53.9	(4.6)
Low	14.2	(2.0)	14.0	(2.4)	6.7	(2.2)
Moderate	23.1	(2.5)	25.0	(3.0)	16.8	(3.6)
High	4.3	(1.2)	12.2	(2.2)	13.1	(2.8)
Very high	5.2	(1.3)	8.7	(2.0)	9.5	(2.6)
Total	100.0		100.0		100.0	

c. Percentage of operations by frequency that manure was spread on forage ground grazed by or harvested for cows, and by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	49.3	(4.2)	56.0	(3.3)	42.7	(4.0)	29.9	(6.7)
Low	3.1	(1.9)	12.7	(2.2)	14.6	(2.7)	35.3	(7.7)
Moderate	14.0	(3.0)	23.5	(2.8)	29.2	(3.8)	10.0	(4.5)
High	23.2	(4.7)	3.1	(1.1)	7.4	(2.2)	10.7	(4.3)
Very high	10.4	(2.9)	4.7	(1.5)	6.1	(2.0)	14.1	(4.2)
Total	100.0		100.0		100.0		100.0	

The average risk score for small operations (0.9) was lower than the average risk score for medium operations (1.4)

d. Average risk score for spreading manure on forage ground grazed by or harvested for cows, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
0.9	(0.1)	1.4	(0.1)	1.2	(0.1)	1.0	(0.1)

The average risk score for operations in the Midwest region (0.9) was lower than the average risk score in the West region (1.4).

e. Average risk score for spreading manure on forage ground grazed by or harvested for cows, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
1.4	(0.1)	0.9	(0.1)	1.2	(0.1)	1.4	(0.2)

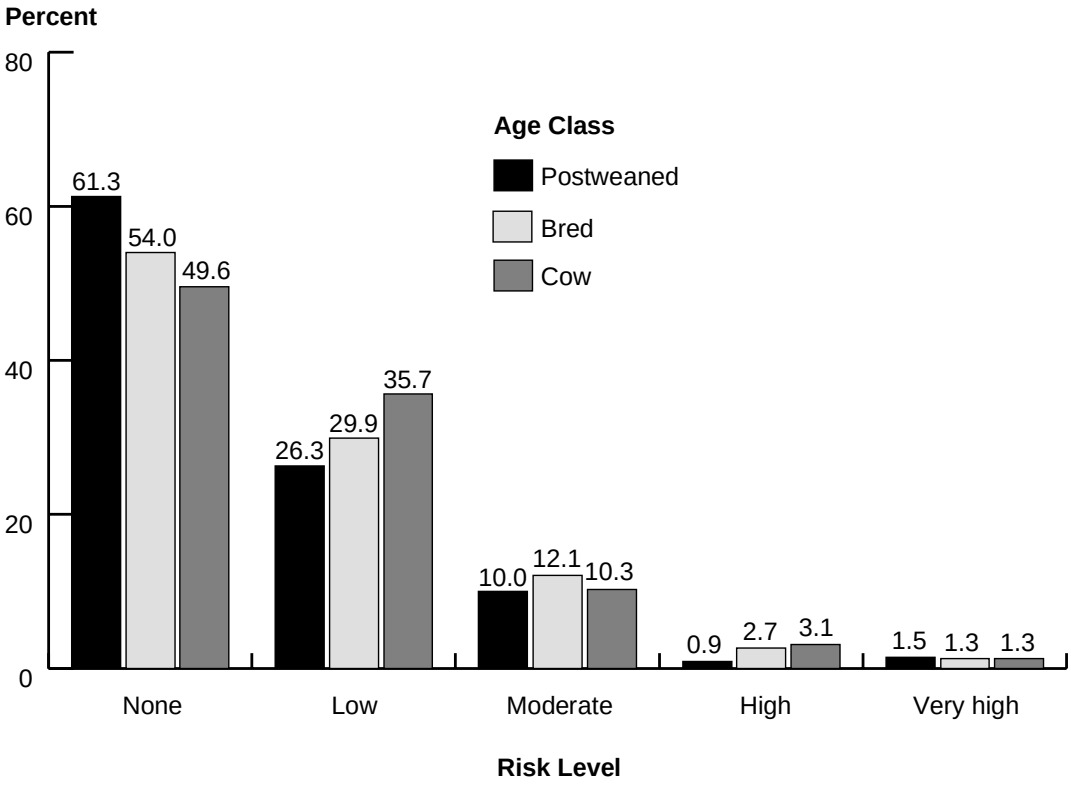
3. Cow-manure contamination of feed storage area and feeding equipment

Almost half of all operations (49.6 percent) had no manure visible in the feed-storage area or on feeding equipment.

a. Percentage of operations by cow-manure contamination of feed storage areas or feeding equipment, and by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	No manure contamination	49.6	(2.3)
Low	1	Trace amounts of manure visible, feeding equipment cleaned more than once a month	35.7	(2.3)
Moderate	2	Some manure visible, feeding equipment cleaned less than once a month	10.3	(1.4)
High	3	Large amounts of manure visible, feeding equipment not cleaned regularly	3.1	(0.9)
Very high	4	Extensive manure contamination	1.3	(0.4)
Total	NA		100.0	

Percentage of Operations by Manure Contamination of Equipment Used to Feed the Following Age Classes of Cattle, and by Risk Level



b. Average risk score for cow-manure contamination of feed storage areas or feeding equipment, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		**Medium** (100-499)		**Large** (500 or More)		**All Operations**	
Score	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**	**Score**	**Std. Error**
0.7	(0.1)	0.7	(0.1)	0.6	(0.1)	0.7	(0.0)

c. Average risk score for cow-manure contamination of feed storage areas or feeding equipment, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
0.9	(0.1)	0.7	(0.1)	0.6	(0.1)	0.9	(0.2)

4. Cow-access to manure storage areas

The majority of operations (68.9 percent) never allowed cows access to manure storage areas. Cows in the West region always had access to manure storage areas on nearly one-quarter (24.1 percent) of operations.

a. Percentage of operations by frequency that cows had access to manure storage areas, by risk level

Risk Level	Risk Score	Risk-Level Description	Percent	Std. Error
None	0	No access to manure storage	68.9	(2.1)
Low	1	Access to manure storage occurs only by mistake, less than once a month	16.6	(1.7)
Moderate	2	Access to manure storage occurs two to five times per month	2.8	(0.6)
High	3	Access to manure storage occurs more often than not	3.2	(0.9)
Very high	4	Always had access to manure storage	8.5	(1.3)
Total	NA		100.0	

b. Percentage of operations by frequency that cows had access to manure storage areas, by risk level and region

	Region							
	West		Midwest		Northeast		Southeast	
Risk Level	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
None	64.9	(4.8)	65.3	(3.1)	74.9	(3.8)	80.9	(5.7)
Low	8.1	(2.6)	20.6	(2.7)	13.3	(2.7)	7.3	(3.8)
Moderate	1.8	(1.3)	2.9	(0.8)	2.9	(1.3)	2.6	(2.5)
High	1.1	(0.6)	3.4	(1.2)	4.0	(2.2)	0.5	(0.5)
Very high	24.1	(4.1)	7.8	(1.8)	4.9	(2.0)	8.7	(4.1)
Total	100.0		100.0		100.0		100.0	

c. Average risk score for cow-access to manure storage areas, by herd size

Herd Size (Number of Dairy Cows)							
Small (Less than 100)		Medium (100-499)		Large (500 or More)		All Operations	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
0.7	(0.1)	0.5	(0.1)	0.9	(0.1)	0.7	(0.1)

d. Average risk score for cow-access to manure storage areas, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
1.1	(0.2)	0.7	(0.1)	0.5	(0.1)	0.5	(0.2)

5. Cows average total risk scores

Four questions from the risk assessment were used to evaluate risk areas. The highest possible risk score was 16. Scores from these areas contributed to the average total risk score. Average total risk scores were similar across all herd sizes.

a. Average total risk score for operations that housed cows, by herd size

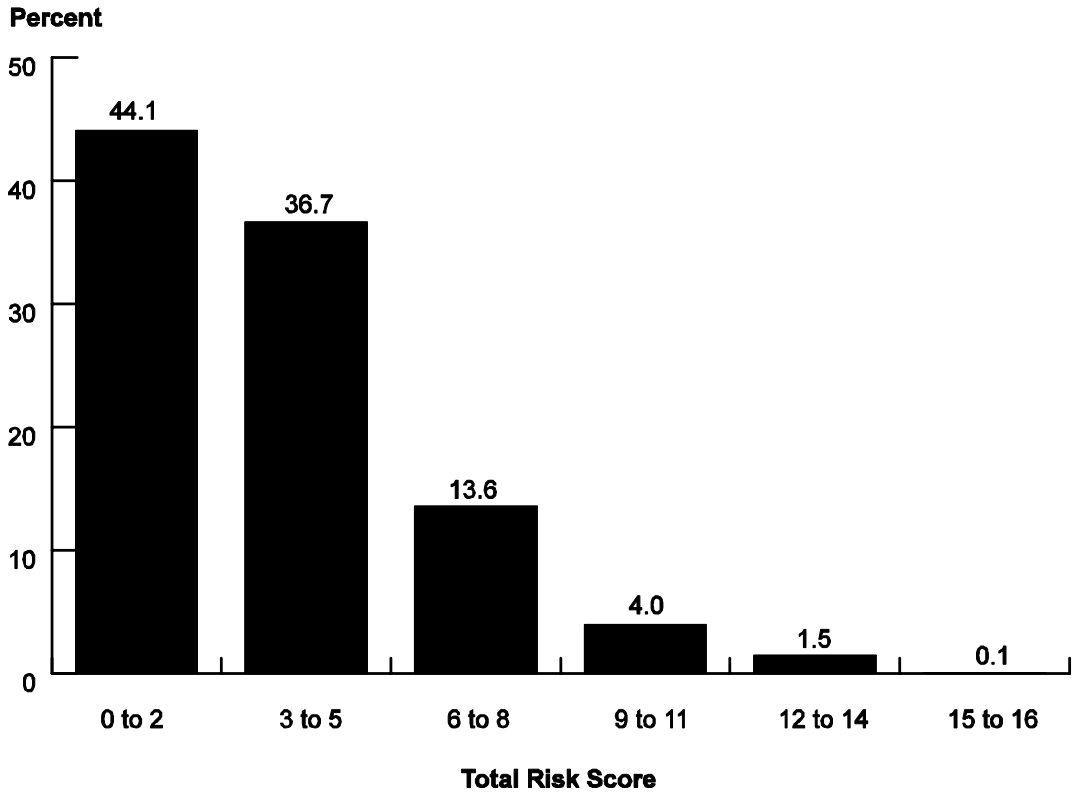
Herd Size (Number of Dairy Cows)							
Small (Less than 100)		Medium (100-499)		Large (500 or More)		All Operations	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
3.4	(0.1)	3.7	(0.2)	3.7	(0.3)	3.5	(0.1)

Average total risk scores for operations in the West region (4.9) were higher than scores for operations in the Midwest region (3.3) and Northeast region (3.2).

b. Average total risk score for operations that housed cows, by region

Region							
West		Midwest		Northeast		Southeast	
Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
4.9	(0.3)	3.3	(0.2)	3.2	(0.2)	4.0	(0.4)

Percentage of Operations by Total Risk Scores for Cows



G. Total Risk Assessment Scores

Scores from all five age-class areas were combined and an overall average total risk score was calculated. The highest possible risk score was 200. Calving area management had the highest average risk score across all herd sizes and regions and accounted for almost 50 percent of the total risk score. This was expected, since this area has the highest possible risk score points based on current knowledge regarding MAP transmission. There were no differences in average total risk scores among operations of different sizes.

a. Summary and overall average total risk scores for operations, by area and herd size

	Herd Size (Number of Dairy Cows)							
	Small (Less than 100)		Medium (100-499)		Large (500 or More)		All Operations	
Area	Score	Std. Error	Score	Std. Error	Score	Std. Error	Score	Std. Error
Calving	31.2	(0.7)	32.2	(0.7)	29.9	(0.8)	31.4	(0.5)
Preweaned calves	14.6	(0.6)	12.7	(0.6)	16.9	(0.8)	14.3	(0.4)
Postweaned calves	8.2	(0.5)	5.6	(0.4)	5.1	(0.6)	7.5	(0.4)
Bred heifers	10.2	(0.4)	8.9	(0.5)	7.2	(0.6)	9.8	(0.3)
Cows	3.4	(0.1)	3.7	(0.2)	3.7	(0.3)	3.5	(0.1)
Overall*	68.7	(1.5)	63.9	(1.9)	65.8	(2.7)	67.6	(1.2)

*Overall scores calculated only for those operations that housed all classes of dairy cattle. For total number of participants, see table 1c. in Appendix I.

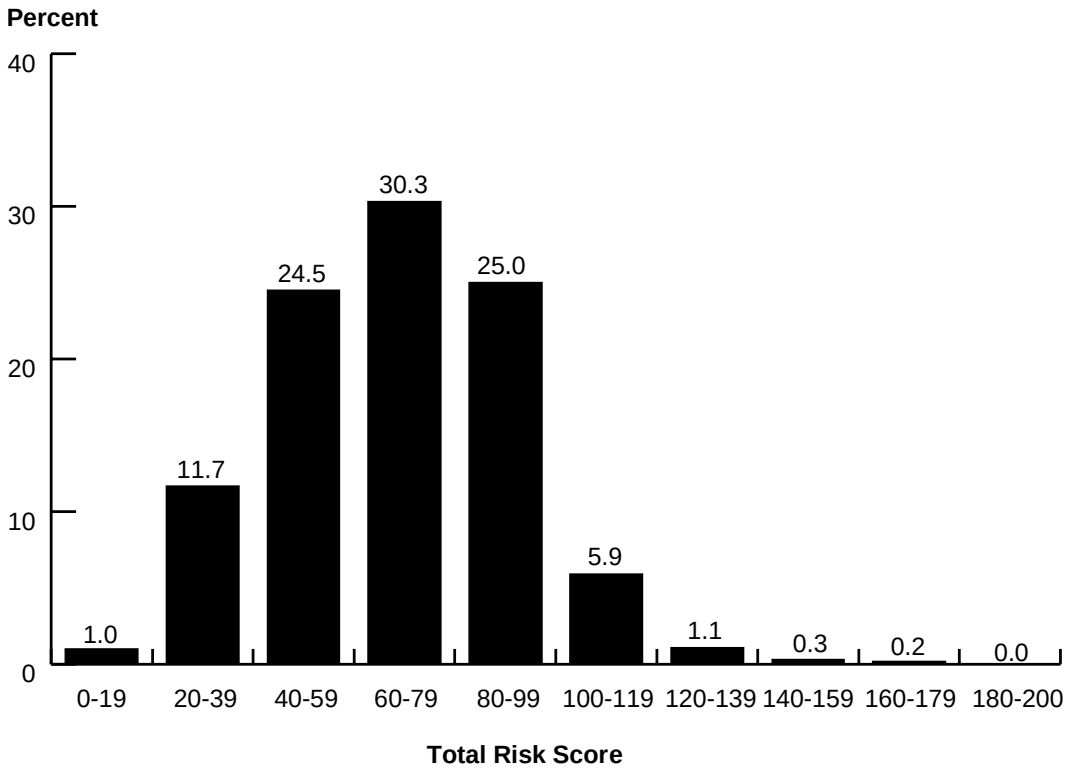
Average total risk scores were lower for the Midwest region (64.4) than the Southeast region (79.7).

b. Summary and overall average total risk scores for operations, by area and region

	Region							
	West		Midwest		Northeast		Southeast	
Area	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error	Percent	Std. Error
Calving	34.8	(1.1)	30.5	(0.8)	30.6	(0.9)	38.0	(1.5)
Preweaned calves	17.8	(1.0)	12.9	(0.6)	16.0	(0.8)	14.5	(1.2)
Postweaned calves	6.6	(0.7)	6.7	(0.5)	9.2	(0.6)	8.8	(1.7)
Bred heifers	8.4	(0.7)	9.8	(0.4)	9.9	(0.4)	10.6	(0.8)
Cows	4.9	(0.3)	3.3	(0.2)	3.2	(0.2)	4.0	(0.4)
Overall*	74.0	(3.2)	64.4	(1.8)	69.5	(2.0)	79.7	(3.8)

*Overall scores only calculated for those operations that housed all classes of dairy cattle

Percentage of Operations by Overall Average Total Risk Scores



Section III: Johne's Disease Testing

A. Testing Methods

1. Background

Due to variable incubation periods and differences in individual immune responses in MAP infected cattle, none of the tests available for Johne's disease diagnosis is perfect. A review of Johne's disease diagnostic tests and their characteristics has been described.[41 42 43] Organism detection and measures of host response are the two main categories of Johne's disease diagnostics. Organism-detection methods are generally more expensive and require more time to obtain results than host-response methods.

Organism-detection methods include identification of MAP through culture (tissues, feces, and milk), histopathological, or polymerase chain reaction (PCR) techniques. MAP is commonly isolated by mycobacteriological culture from feces, ileum, and associated mesenteric lymph nodes during advanced clinical disease. PCR techniques, with results available in 3 to 4 days, have been developed to identify the organism in tissues, feces, and milk. Organism-detection tests for Johne's disease are officially recognized as the definitive test for MAP infection by USDA's Uniform Program Standards for the Voluntary Bovine Johne's Disease Control Program.

Evaluating host responses, including clinical signs of disease, usually targets an animal's immune response to MAP. Several types of tests aimed at measuring immune responses have been developed; delayed type hypersensitivity skin testing and lymphocyte stimulation assays are measures of cell mediated immunity (CMI). Positive tests are usually observed early in the course of disease prior to the down regulation of CMI and increase in humoral immunity. Unfortunately, CMI tests are not specific for MAP infection since other closely related mycobacteria can produce cross-reactions.

Serologic tests are more commonly used for diagnosis or herd screening and include the agar gel immunodiffusion assay, complement fixation, and ELISA. The most extensively used immunological assays for routine diagnosis of Johne's disease are commercial ELISAs.

ELISAs also have been developed that evaluate antibody concentrations in milk, but reported sensitivities of these assays vary. The majority of studies have reported that milk ELISAs are routinely less sensitive than serum ELISAs, using fecal culture as the standard. However, one study reported a significant correlation between serum ELISA and milk ELISA results using a commercially available ELISA.[44] Two recent studies evaluating milk and serum ELISAs compared to fecal culture showed comparable, although low, sensitivities.[45 46] Overall agreement—based on kappa statistics—between the serum and milk ELISAs was between 0.4 and 0.5.

Some animals infected with Johne's disease produce a humoral response prior to fecal shedding, while other animals may shed MAP for long periods before testing positive by

ELISA. There does not appear to be a consistent pattern of individual animals testing positive by fecal culture and ELISA. One study found that 65 percent (26/40) of fecal shedders were positive by an absorbed enzyme immunoassay prior to or on first detection of MAP in feces.[47] A more recent study using a kinetic ELISA (KELA) in dairy cattle, suggests that fecal shedding precedes the humoral response in the majority of animals.[48] Shedding of MAP has also been reported prior to serological response in sheep.[49] When ELISA and fecal culture are applied concurrently to cattle, different populations of subclinically infected animals will be detected.[50]

2. Individual fecal culture

Fecal culture of the organism is one of the definitive diagnostic tests for Johne's disease in cattle. This test is considered 100-percent specific if no contamination of the fecal sample has occurred. Passive shedding, or pass through, is suspected when MAP is cultured from feces and subsequent tissue cultures are negative. Contamination may occur due to passive shedding, manure sampling, and lab error. One report suggests that cows would have to consume 10,000 MAP organisms per day to produce a single colony on culture, due to the quantity of feces produced and the minute amount sampled.[33] However, culture of multiple tissues was unable to detect MAP in 18 percent[42] and 34 percent of fecal-culture positive animals, suggesting passive shedding was occuring.[51] These results may be partially explained by the imperfect sensitivity of fecal culture.

The sensitivity of fecal culture, based on repeated testing of animals or evaluation of samples from known infected cattle, is reported to be between 35 and 50 percent[52 53] but increases as animals progress through the stages of disease.[53 54] Other factors affecting sensitivity include intermittent organism shedding or organism shedding in levels below the threshold of detection, which is close to one colony-forming unit per 1 or 2 grams of feces.[55 56] The level of fecal shedding in individual cattle may vary on a daily basis.

3. Environmental fecal culture

A study in Minnesota collected environmental fecal samples from areas on dairies where large amounts of manure accumulated.[57] Common sources of environmental fecal samples included alleyways, calving pens, holding pens, lagoons, and other manure storage areas. Up to 20 samples per herd were cultured. MAP was detected in the environment of 78 percent of known infected herds.

Results of environmental culture studies also have shown promise in reducing the cost of identifying infected herds. Environmental sampling was recently incorporated into the test-negative component of the USDA Voluntary Bovine Johne's Disease Control Program.

4. Serum ELISA

As mentioned previously, serum ELISA is the most commonly used test to detect evidence of MAP infection. The ELISA measures an animal's antibody response to MAP and has an advantage over all fecal culture techniques in terms of time to results and cost. The sensitivity of the serum ELISA depends on the stage of disease in the animal tested and ranges from 15 percent to 87 percent when compared to concurrent fecal culture. When the serum ELISA was evaluated using tissues cultured for MAP from culled dairy cattle, sensitivity ranged from 6.9 percent to 16.9 percent, depending on the manufacturer of the ELISA test.[58]

Although serum is incubated with *Mycobacterium phlei* to remove some cross-reacting antibodies, it is possible for other *Mycobacterium* species to cause false-positive results. It is unclear why some fecal-culture positive animals are ELISA negative. Possible explanations include localized, walled-off infections isolated from the immune system, inadequate immune response, and the possibility that the animal has ingested MAP and passed it in the feces without becoming infected. Using fecal culture as the standard, ELISA is a highly specific test.

Repeated testing of individual animals has revealed that a proportion of animals may revert to test-negative status after testing positive by ELISA. It has been reported that animals with higher S/P ratios were less likely to revert to test negative at subsequent testing.[59] Almost 40 percent of animals with an IDEXX S/P ratio greater than 0.25 on initial testing reverted to seronegative status, while only 10 percent of animals with an initial S/P above 0.7 tested negative on the repeat test. Although antibody levels do change in individual animals, a portion of this variation on optical density (OD) values may be due to the variation in manufacturer kit lots of the assay. Results of repeated serological testing of fecal-culture negative animals indicate that OD readings are lowest in the periparturient period and increase until 60 days in milk and then remain stable throughout the remainder of the lactation and subsequent lactations. Positive-fecal-culture cows had significantly lower KELA values in first lactation compared to subsequent lactations. Cows that remained fecal-culture negative throughout the study had similar KELA values for all lactations.[48]

5. Milk ELISA

Milk ELISA is performed on milk samples collected during routine Dairy Herd Improvement Association (DHIA) sampling, decreasing the amount of time and labor required to sample animals for Johne's disease. Results of studies evaluating individual-animal milk-ELISA results with serum ELISA have varied. One report, using a LAM ELISA (LAM - lipoarabinomannan is a component of the cell wall used as the bound antigen in the wells) showed a slight improvement in test accuracy using the milk LAM ELISA when compared to serum LAM ELISA.[60] Another report found that a milk ELISA for detecting exposure to MAP lacked correlation with serum ELISA.[61] Milk ELISA sampling also has the potential to provide a measure of herd prevalence.[60]

B. NAHMS Dairy 2002 Johne's Disease Individual Animal Test Results

1. Background

Operations that participated in this portion of the study were not randomly selected from the population included in Phase II. Since the goal was to evaluate management factors associated with within-herd-level prevalence of MAP infection, operations were selected based on their responses from Phase I. Operations were then ranked from low to high risk based on perceived risk factors and assigned to above or below median herd size for their respective State. The following practices were evaluated to determine risk:

- Number of dairy cows on the operation
- How soon calves were separated from their dam
- Whether pooled colostrum was fed
- The percentage of dairy cows that had diarrhea for more than 48 hours
- Whether maternity housing was separate from lactating cow housing
- How many replacements were brought onto the operation during 2001
- Whether the operation required Johne's disease testing for purchased cattle

Perceived low- and high-risk herds were identified from each State, with herds stratified into below and above median herd size for the State. From this list, producers were contacted and asked to participate in biological sampling. Approximately 5 operations in each of the 21 States elected to participate in herd testing. Animals in their second or greater lactation were targeted for testing.

High- and low-risk operations were not selected randomly from their respective groups. Operations from the high-risk group with the highest risk values were selected. Similarly, operations with the lowest risk values in the low-risk group were selected for testing. This sampling design was chosen in order to maximize the potential for identifying risk factors. The nonrandom sample of operations creates the potential for bias if the information from these operations is used to make inferences to either the risk groups or the general dairy population. Since there does not appear to be a mechanism to adjust for potential bias, animal- and herd-level estimates for the United States were not produced from the testing data.

All selected herds were eligible and participated in serum ELISA testing. Approximately half way through testing, it was realized that the estimated number of fecal samples to be tested was much larger than anticipated. At this point, only relatively small herds were allowed to participate in fecal culturing, thus only 62 operations had fecal culture results, while 106 were tested using serum ELISA (Appendix I).

After initiation of the study, the manufacturer of the milk-ELISA test proposed testing individual milk samples collected during DHIA testing using their milk ELISA. Of the 106 herds participating in serum ELISA testing, all that were currently collecting milk for DHIA testing were eligible. Thirty-six operations agreed to have the additional testing performed. All lactating cows, including first lactation animals, were eligible for milk ELISA testing.

2. MAP fecal culture

A total of 7,272 fecal samples were collected from 62 operations in 20 States (Illinois did not participate in fecal-culture testing). Samples were collected from individual cows between March 25 and August 5, 2002. The number of individual fecal samples collected from an operation was determined using table a, p146. Fecal samples were shipped on ice to the National Veterinary Services Laboratories (NVSL) in Ames, IA, where they were stored at –70°C prior to culture. All samples were tested by traditional Herrold's Egg Yolk agar, ESP (TREK) Culture System, and BACTEC 460 methods. A sample that tested positive by any of the three methods was tested using PCR techniques to confirm presence of MAP DNA (see Appendix III). Results were reported as negative or positive, with a level of shedding assigned for positive samples (see table a, p153). Of the 7,272 fecal samples tested, 8.6 percent cultured positive for MAP.

a. MAP fecal-culture results (number and percentage)

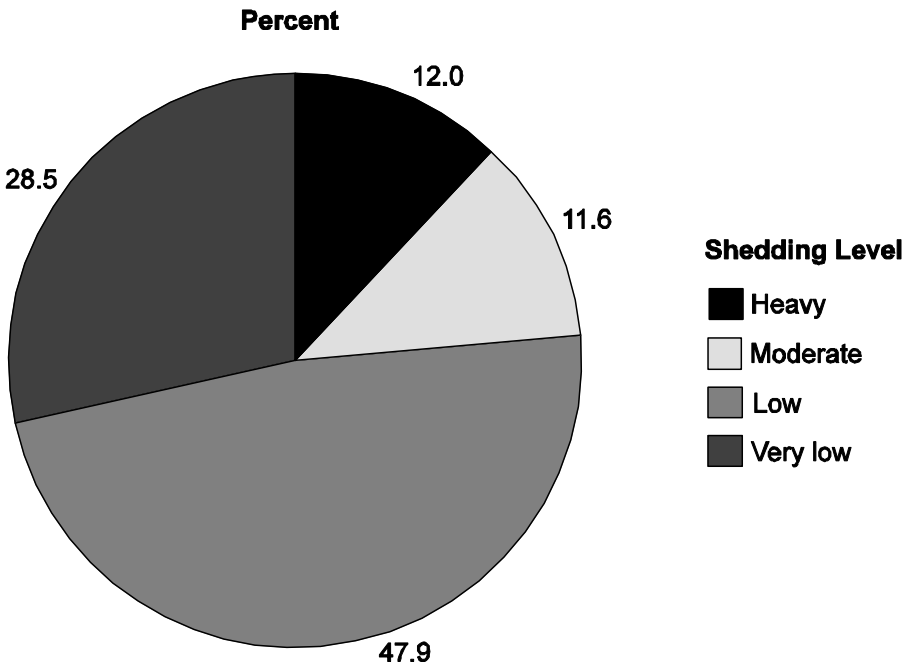
Result	Number	Percent
Positive	624	8.6
Negative	6,648	91.4
Total	7,272	100.0

The highest percentage of positive cultures (47.9 percent) were reported as low shedders. These results do not agree with other published studies which report that 20 to 30 percent of positive cultures are defined as heavy shedders. Since three different fecal culture methods were used, it is possible that the distribution is different from other studies where only one fecal culture method was evaluated. It also is possible that previous diagnosis of MAP infection in the herd, and subsequent testing and removal prior to the 2002 study, redistributed the percentage of animals within shedding levels.

b. Number and percentage of positive MAP fecal-culture results by shedding level

Shedding Level	Number	Percent
Heavy	75	12.0
Moderate	72	11.6
Low	299	47.9
Very low	178	28.5
Total	624	100.0

Percentage of Postive MAP Fecal-Culture Results by Shedding Level



3. MAP serum ELISA

A total of 19,378 serum samples were collected from 106 operations in 21 States and tested at NVSL. Samples were collected from March 25 to September 25, 2002. Testing was performed using a commercially available serum ELISA,* as recommended by the manufacturer, with the exception that samples were only tested in a single well. The ELISA was used to measure antibody response to MAP. Results from the serum testing were reported in OD units, which when subtracted from the negative control and multiplied by 10 provided an ELISA score. ELISA scores were converted to categorical results based on published recommendations (see table b. Appendix IV). Of the 19,378 serum samples tested, 5.5 percent were either positive or strong positive.

*Paracheck™ Biocor Animal Health

a. MAP serum-ELISA results (number and percentage)

Result	Number	Percent
Strong positive	343	1.8
Positive	710	3.7
Inconclusive	587	3.0
Negative	17,738	91.5
Total	19,378	100.0

4. MAP milk ELISA

A total of 15,167 milk samples were tested from 36 operations in 17 States (operations in Illinois, Idaho, Iowa, and Kentucky did not participate in milk-ELISA testing). DHIA personnel collected milk samples from all lactating cows in each operation during routine milk sampling between June 1, 2002, and January 9, 2003. It is important to note that samples for milk-ELISA testing were obtained from all lactating animals, while sampling for serum ELISA and fecal culture targeted second lactation and higher animals. Milk samples were treated with bronopol to preserve the samples during testing and shipment. Milk samples were shipped from several DHIA testing laboratories for testing to Antel BioSystems, Inc., in Lansing, MI. The majority of samples were frozen, and testing was completed in a week.

Individual milk samples were initially screened with an indirect ELISA using a crude MAP protoplasmic antigen preparation as the solid phase. Samples reacting in the screening test were retested in duplicate wells with a preabsorbed (*M. phlei*) indirect ELISA using a purified MAP protoplasmic antigen preparation as the solid phase.

A sample score was obtained from milk ELISA testing by subtracting the negative control OD from the sample OD measurement and multiplying by 10. A sample score 0.7 units greater than the negative control was considered positive. Although only positive and negative test results were reported by Antel BioSystems Inc., for portions of this analysis, samples with absorbance values (450 nm) greater than negative controls by 3.5 units were considered strong positive. Less than 3 percent of all milk samples (2.6 percent) tested with ELISA were positive or strong positive.

a. MAP milk-ELISA results (number and percentage)

Milk ELISA	Number	Percent
Strong positive	157	1.0
Positive	238	1.6
Negative	14,772	97.4
Total	15,167	100.0

5. MAP environmental fecal culture

Environmental samples were collected from 98 of the 106 dairy operations participating in Johne's disease biological sampling. Ideally, five environmental samples were taken from areas where manure accumulated from a majority of adult animals. A single sample was collected from each of these sites and cultured using the same procedures used for individual fecal samples. Almost three-quarters of operations (70.4 percent) had at least one environmental-positive sample.

a. MAP environmental-culture results (number and percentage)

Result	Number Operations	Percent
Positive	69	70.4
Negative	29	29.6
Total	98	100.0

More than half of all samples (52.3 percent) collected from the exit-way from parlor were culture positive for MAP.

b. Environmental sample results for all herds, by source

Source	Number Positive	Number Negative	Total	Percent Positive
Exit-way from parlor	34	31	65	52.3
Floor of holding pen	26	27	53	49.1
Common alleyway	61	66	127	48.0
Lagoon	18	20	38	47.4
Manure spreader	11	15	26	42.3
Manure pit	17	24	41	41.5
Other	42	81	123	34.1
Unknown	7	3	10	70.0
Total	216	267	483	44.7

C. NAHMS Dairy 2002 Test Comparisons

NOTE: To estimate the agreement between tests, results of individual animal tests were compared. Since all animals were not tested by all three tests, only animals with results from two or more tests are represented. Individual-animal test-comparison results are summarized in table 4a. The objective of this study was not to establish additional estimates for sensitivity and specificity of diagnostic tests, since multiple studies designed to obtain estimates have already been conducted. Sensitivity and specificity estimates for detection of MAP infection are very difficult to obtain since there is not an antemortem gold standard diagnostic test currently available. Most current diagnostic tests are compared relative to fecal culture, while fecal culture is usually compared to infection status based on necropsy and culture of multiple tissues or repeated herd testing. The sensitivity of culture, both tissues and feces, is not 100 percent, so even necropsy and subsequent culture may misclassify some infected cattle. Thus, the true infection status of fecal-culture negative animals is unknown.

1. Serum and milk ELISA agreement

The milk ELISA detected 45.7 percent of the animals that tested strong positive or positive by serum ELISA. The calculated weighted kappa (0.53) suggests moderate agreement between the tests.

a. Number of results for test agreement between milk ELISA and serum ELISA

	Serum ELISA				
Milk ELISA	Strong Positive	Positive	Inconclusive	Negative	Total
Strong positive	55	18	1	14	88
Positive	18	36	16	55	125
Negative	15	136	148	5,837	6,136
Total	88	190	165	5,906	6,349

Weighted Kappa = 0.53

2. Fecal culture and serum ELISA agreement

The serum ELISA detected 27.4 percent of the animals that were fecal-culture positive.

a. Number of results for test agreement between serum ELISA and fecal-culture shedding level

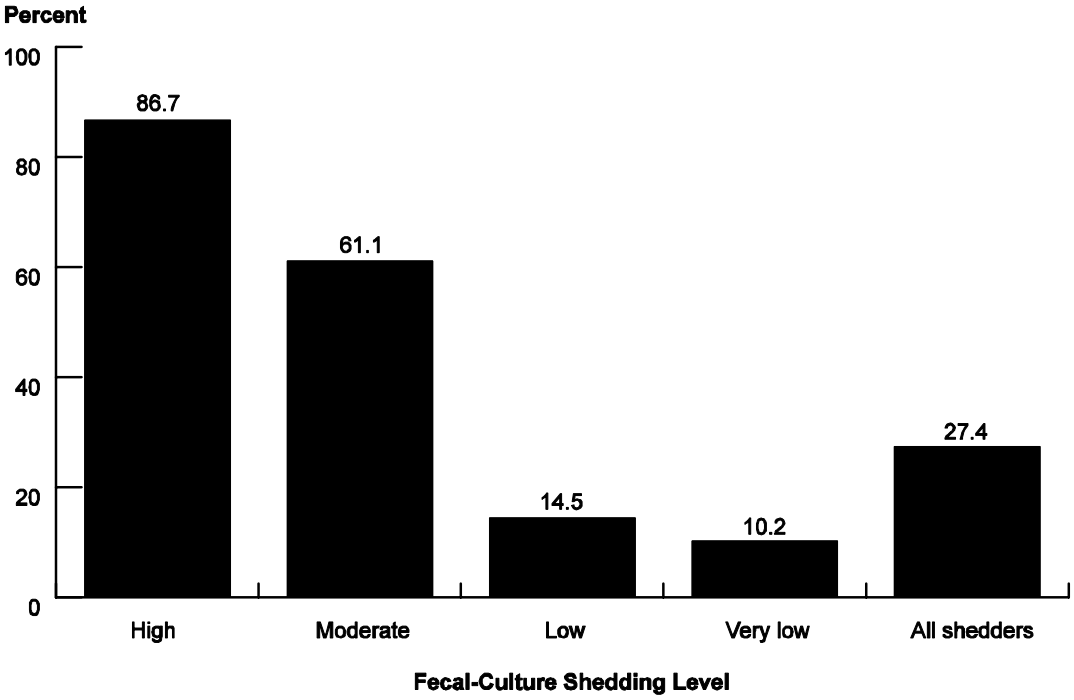
	Fecal Culture						
	Positive (MAP Shedding Level)						
Serum ELISA	**High**	**Moderate**	**Low**	**Very Low**	**Total Number Positive**	**Negative**	**Total**
Strong positive	44	31	24	4	103	40	143
Positive	21	13	19	14	67	168	235
Inconclusive	3	4	14	8	29	146	175
Negative	7	24	240	151	422	6,263	6,685
Total	75	72	297	177	621	6,617	7,238

The majority of animals (86.7 percent) classified as high MAP shedders (based on fecal culture) tested either serum- ELISA positive or strong positive. As shedding level decreased, the ability of the serum ELISA to detect animals shedding MAP decreased.

b. Percentage of cows testing serum-ELISA positive by fecal-culture shedding level

	Fecal-Culture Positive MAP Shedding Level				
Serum ELISA	**High**	**Moderate**	**Low**	**Very Low**	**All**
Positive (includes strong positive)	86.7	61.1	14.5	10.2	27.4
Negative (includes inconclusive)	13.3	38.9	85.5	89.8	72.6
Total	100.0	100.0	100.0	100.0	100.0

Percentage of Cows Testing Serum-ELISA Positive by Fecal-Culture Shedding Level



3. Fecal culture and milk ELISA agreement

The milk ELISA detected 21.1 percent of the animals that were fecal-culture positive.

a. Number of results for test agreement between milk ELISA and fecal-culture shedding level

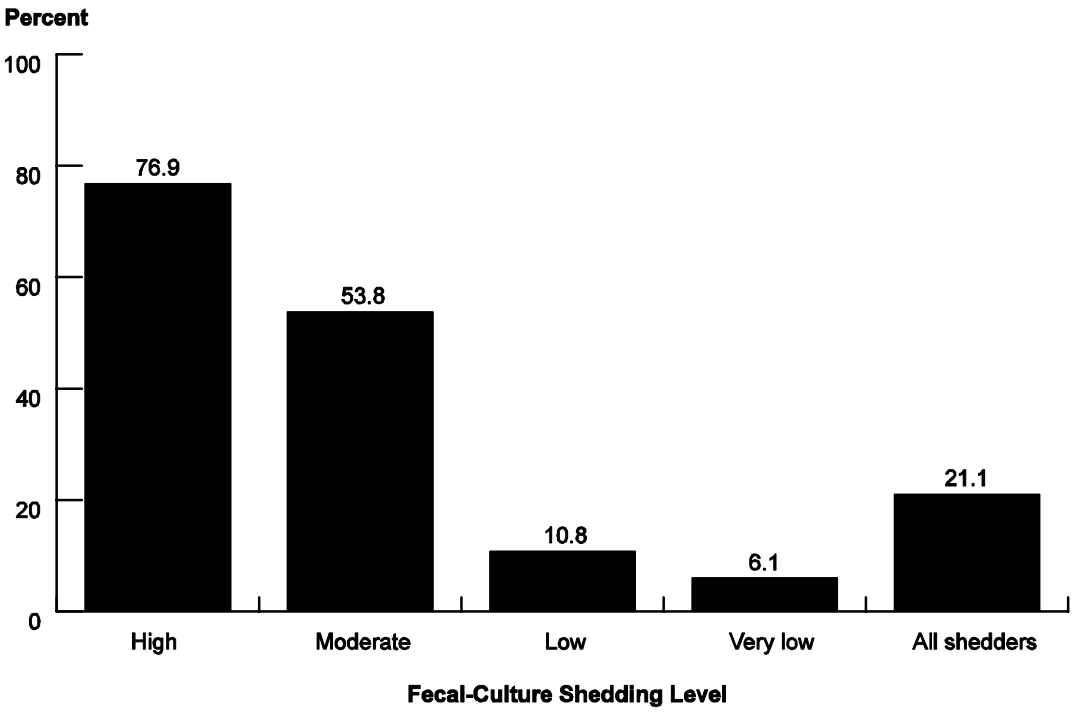
	Fecal Culture						
	Positive (MAP Shedding Level)						
Milk ELISA	**High**	**Moderate**	**Low**	**Very Low**	**Total Number Positive**	**Negative**	**Total**
Strong positive	8	10	6	1	25	6	31
Positive	2	4	3	2	11	22	33
Negative	3	12	74	46	135	1,980	2,115
Total	13	26	83	49	171	2,008	2,179

The majority of animals classified as high MAP shedders (76.9 percent) were detected by milk ELISA. As with serum ELISA, milk ELISA's ability to detect animals decreased as shedding level decreased.

b. Percentage of cows testing milk-ELISA positive by fecal-culture shedding level

	Fecal-Culture Positive MAP Shedding Level				
Milk ELISA	**High**	**Moderate**	**Low**	**Very Low**	**All**
Positive (includes strong positive)	76.9	53.8	10.8	6.1	21.1
Negative	23.1	46.2	89.2	93.9	78.9
Total	100.0	100.0	100.0	100.0	100.0

Percentage of Cows Testing Milk-ELISA Postive, by Fecal-Culture Shedding Level



4. Test comparison summary

Milk ELISA performed comparably to serum ELISA in identifying animals that were fecal-culture positive.

a. Cow-level Johne's disease test-comparison summary

		Reference Population Detected		
Test	**Reference**	**Number**	**Percent**	**95 percent CI***
Milk ELISA	Serum ELISA	6,349	45.7	44.5-46.9
Serum ELISA	Fecal culture	2,173	23.5	21.6-25.4
Milk ELISA	Fecal culture	2,173	21.2	19.5-22.9

*CI = Confidence interval

D. Johne's Disease Prevalence

Note: Although many studies report estimates of Johne's disease prevalence, differences in sampling design and diagnostic strategies make direct comparisons difficult. Calculation of true prevalence requires adjusting for test sensitivity and specificity, which can fluctuate depending on the stage of disease in the population. Animal-level and herd-level prevalence estimates have been reported for a number of States, regions, and countries. Since the Dairy 2002 study was designed to estimate within-herd prevalence, it is not appropriate to estimate U.S. animal- or herd-level prevalence.

1. Animal-level prevalence—historical summary

Although numerous animal-level prevalence studies for Johne's disease have been conducted in the United States, direct comparisons can not be made due to differences in sampling designs. For random-sampling strategies, reported apparent prevalence estimates for dairy cattle ranged from 2.5 percent in the NAHMS Dairy '96 study to 17.1 percent in the Florida study.

Prevalence estimates for dairy market or slaughter cattle were generally higher than estimates based on a random sampling design. With the exception of the Texas study, apparent prevalence estimates for beef cattle, regardless of study design, were lower than dairy cattle when both animal types were included in the same study.

a. Summary of U.S. animal-level prevalence studies for Johne's disease

State/ Country	Year	Sampling Design	Animal Type	Number Herds/ Cattle	Animal-Level Apparent Prevalence (percent)	True Prevalence (percent)	Diagnostic Method
AL[62]	2003	Random	Beef	79/2,073	8.0	8.8	Serum ELISA
CA[63]	2003	Random	Dairy	65/1,950	4.6	9.4	Serum ELISA
CO[64]	2004	Random	Dairy	15/10,280	4.1	Not reported	Serum ELISA
FL[65]	1990	Random	Beef	392/3,874	8.1	Not reported	Serum ELISA
			Dairy	60/617	17.1		
GA[66]	2003	Market	Beef/ Dairy	NA/5,307	4.8	Not reported	Serum ELISA
			Beef	NA/3,950	4.0		
			Dairy	NA/637	10.0		
ME/ Canada[58]	2003	Slaughter	Dairy	NA/984	16.1	Not reported	Tissue culture
MI[67]	1999	Random	Dairy	121/3,866	6.9	Not reported	Serum ELISA
MO[68]	1997	Random	Beef/ Dairy	89/1,954	5.0	Not reported	Serum ELISA
			Beef	68/1,488	5.0		
			Dairy	19/423	8.0		
NY[7]	1997	Random	Dairy	33/5280	5.2	Not reported	Fecal culture
PA[69]	1985	Slaughter	Dairy	NA/1,224	7.2	Not reported	Culture of multiple tissues
TX[70]	1993	Market	Beef/Dairy	NA/2,491	19.1	Not reported	Serum ELISA
			Beef	NA/1,209	25.2		
			Dairy	NA/1,282	13.3		
WI[5]	1994	Random	Dairy	158/4,990	7.3	4.8	Serum ELISA
New England[71]	1985	Slaughter	Primarily Dairy	NA/100	18.0	Not reported	Culture of multiple tissues
United States/ Puerto Rico[72]	1987	Slaughter	Beef/Dairy	NA/7,540	1.6	Not reported	Lymph node culture
			Beef	NA/3,522	0.8		
			Dairy	NA/2,827	2.9		
United States[73 74]	1997	Random	Dairy	967/31,745	2.5	3.4	Serum ELISA
	2001	Random	Beef	380/10,371	0.4	Not reported	Serum ELISA

For Johne's disease, NAHMS Dairy '96 reported a 2.5 percent apparent cow-level prevalence for the United States based on test results from 31,745 cows from 967 herds. This is higher than the apparent prevalence of Belgian dairy cattle (1.2 percent) where 4,497 cows from 98 herds were tested, but very close to Austrian estimates of 3.5 percent in Holstein Friesians. The Netherlands reported an apparent prevalence of 2.5 percent based on test results from 15,822 cows from 378 herds.

b. Summary of non-U.S. animal-level prevalence studies for Johne's disease

State/ Country	Year	Sampling Design	Animal Type	Number Herds/ Cattle	Animal-Level Apparent Prevalence (percent)	True Prevalence (percent)	Diagnostic Method
Austria[75]	1999	Unique	All	2,757/11,028	2.0	Not reported	Serum ELISA
			Dairy*	Unknown	3.5		
Belgium[76]	2000	Random	Dairy	98/4,497	1.2	Not reported	Serum ELISA
			Beef	259/4,010	0.5		
Canada[14 77 78 79 80]	2003	Random	Dairy	50/1,500	7.0	Not reported	Serum ELISA
	1991	Random	Dairy	304/14,932	15.2	6.1	Serum LAM ELISA
	1991	Slaughter	Mixed	NA/400	5.5	Not reported	Tissue Culture
	2001	Random	Dairy	30/900	2.6	Not reported	Serum ELISA
	2002	Random	Dairy	90/2,604	NR	3.4	Serum ELISA
	2002	Unique	Beef	NA/1,799	0.0	0.0	Serum ELISA
Denmark[81]	2000	Random	Dairy	22/1,155	8.8	Not reported	Milk ELISA
England[6]	1996	Slaughter	Mixed	NA/1,553	3.5	Not reported	Tissue PCR
The Netherlands[82]	2000	Random	Dairy	378/15,822	2.5	Not reported	Serum ELISA

*Holstein Friesian cattle only

2. Herd-level prevalence—historical summary

Johne's disease herd-level prevalence can be difficult to determine due to sample size, test characteristics, and within-herd prevalence. NAHMS Dairy '96 reported a 21.6 percent apparent herd prevalence across all herd sizes based upon two or more positive tests or one positive test with at least 5 percent of cull animals with clinical signs. NAHMS Dairy '96 sampling strategy was designed to detect herds with equal to or greater than 10-percent within-herd prevalence. This estimate of herd-level prevalence was conservative since some herds with less than 10-percent within-herd prevalence may not have been detected. Most

of the reported apparent herd-level prevalence for U.S. dairies ranged from 35.0 percent in California to 93.3 percent in Colorado. Herd-level seroprevalence based on 121 herds in Michigan was 55.4 percent (using two or more test-positive animals to designate an infected herd). The sampling scheme was devised to detect a within-herd prevalence level of 10 percent and included sampling either all animals in the herd or 48 animals, whichever was less.

a. Summary of herd-level prevalence studies for Johne's disease

State/ Country	Year	Animal Type	Number Herds/ Cattle	Herd-Level Apparent Prevalence (percent)	True Prevalence (percent)	Diagnostic Method
AL[62]	2003	Beef	79/2,073	63.3[a]	Not reported	Serum ELISA
CA[63]	2003	Dairy	65/1,950	68.0[a]	Not reported	Serum ELISA
				35.0[b]		
CO[64]	2004	Dairy	15/not reported	73.3[c]	Not reported	Fecal culture/ histopathology
				93.3[b]	Not reported	Serum ELISA
MI[67]	1999	Dairy	121/3,866	55.4[b]	Not reported	Serum ELISA
MO[68]	1997	Beef	68/1,488	40.0[a]	Not reported	Serum ELISA
		Dairy	19/423	74.0[a]		
NY[7]	1997	Dairy	33/5,280	57.6[a]	Not reported	Fecal culture
WI[5]	1994	Dairy	158/4,990	50.0[a]	34.0[a]	Serum ELISA
United States[73 74]	1997	Dairy	967/31745	21.6[b]	Not reported	Serum ELISA
	2001	Beef	380/10,371	7.9[a]		
Austria[75]	1999	Dairy/Beef	2,757/11,028	7.0[a]	Not reported	Serum ELISA
Belgium[76]	2000	Dairy	98/4,497	32.0[b]	10.0[b]	Serum ELISA
		Beef	259/4,010	7.0[b]	3.0[b]	
Canada[77 79 80]	2003	Dairy	50/1,500	40.0[b]	26.8[b]	Serum ELISA
	2001	Dairy	30/900	16.7[b]	Not reported	
	2002	Beef	Not reported /1,799	15.0[a]	Not reported	
				3.0[b]	Not reported	
Denmark[83]	2000	Dairy	900/not reported	Not reported	47.0[d]	Bulk-tank milk ELISA
The Netherlands[82]	2000	Dairy	378/15,822	54.7[e]	Not reported	Serum ELISA
Switzerland[84]	2002	Dairy	1,384/not reported	19.7[c]	Not reported	Bulk tank milk PCR
United Kingdom[85]	2002	Dairy	244/not reported	7.8[c]	Not reported	Bulk tank milk PCR

[a]One or more animals testing positive by serology
[b]Two or more animals testing positive by serology or one animal testing positive and clinical signs
[c]Organism identification
[d]Optimized optical density values
[e]Adjusted cut-off level for serology

3. Within-herd prevalence

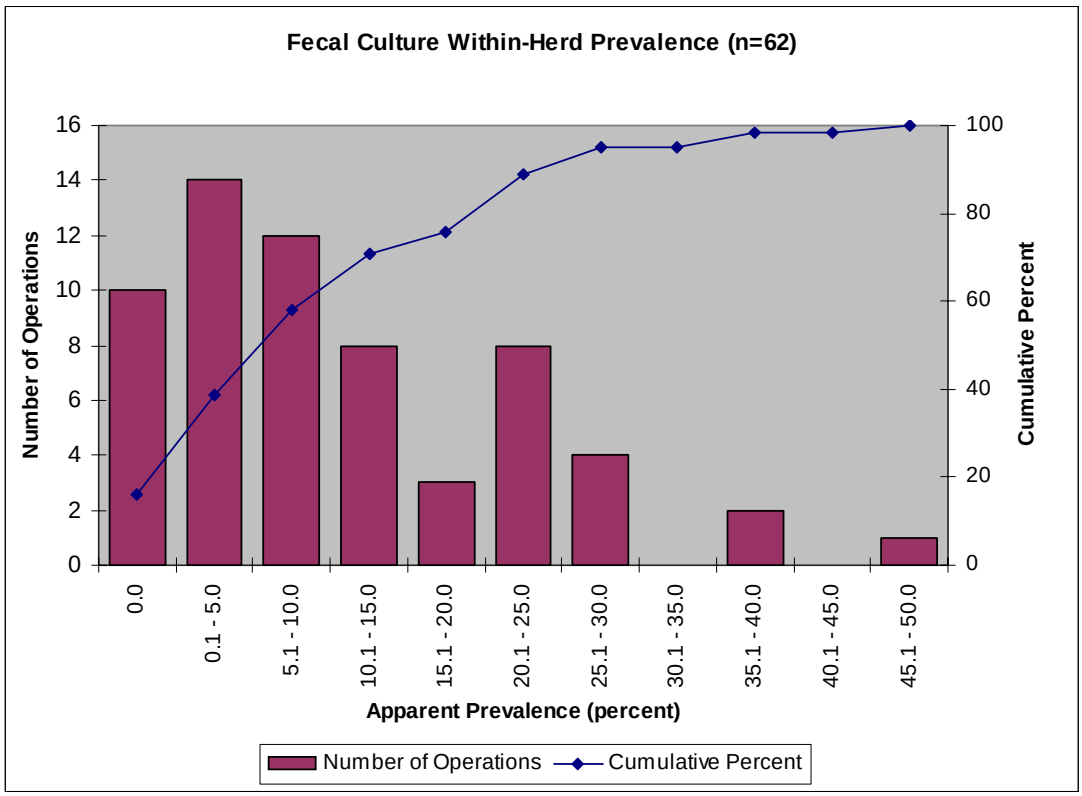
A study in Wisconsin evaluated 158 herds using serum ELISA and reported within-herd prevalence levels ranging from 0.0 to 70.0 percent, with 50.0 percent of herds having 0.0 percent seroprevalence of MAP antibodies.[5] Thirty-three herds in New York were tested using fecal culture; the mean within-herd prevalence level was 5.2 percent with a range of 0.0 to 28.2 percent.[7] In addition, a Colorado study of 15 dairies found a within-herd seroprevalence range from 0.0 to 7.8 percent.[64]

The NAHMS Dairy 2002 study focused on estimating within-herd prevalence of MAP infection using three methods: fecal culture, serum ELISA, and milk ELISA. A subset of operations performed fecal culture and milk ELISA for the study. Sample sizes were calculated to estimate the within-herd prevalence within 2 percent with 95-percent confidence.

A total of 62 operations were tested using fecal culture methods. Of these, 16.1 percent had no animals test fecal culture positive. Approximately 6 out of 10 herds (58.1 percent) had an apparent within-herd prevalence of 10 percent or less.

a. MAP fecal culture within-herd apparent prevalence

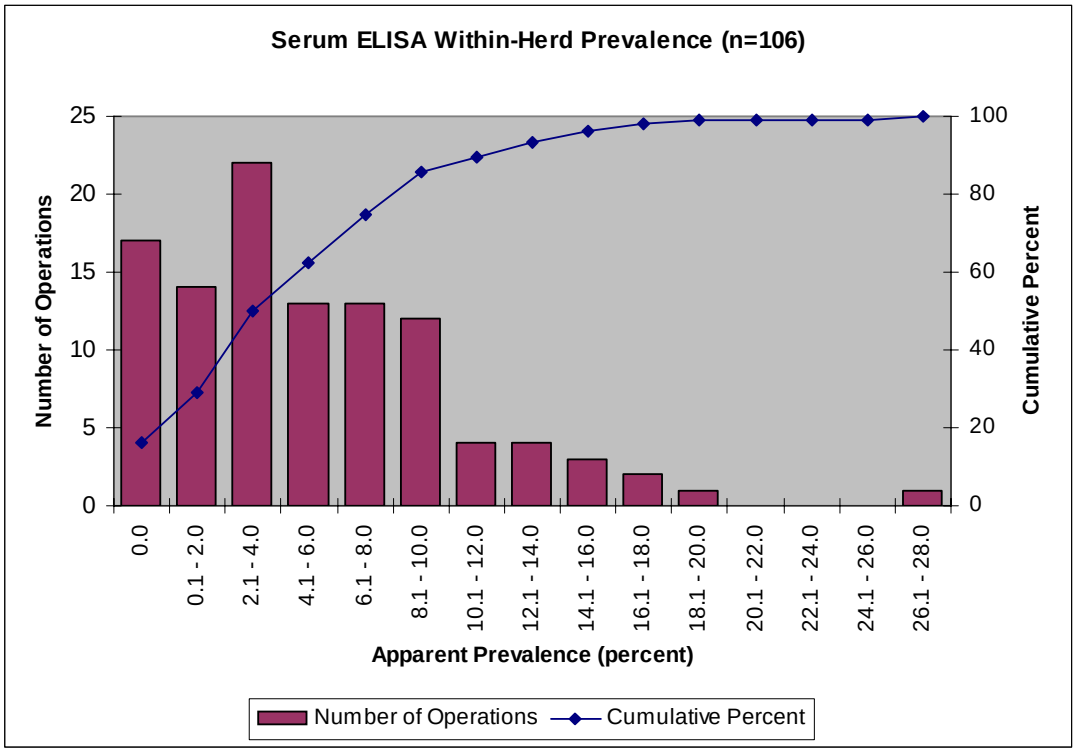
Fecal Prevalence (percent)	**Number Operations**	**Percent Operations**	**Cumulative Percent**
0.0	10	16.1	16.1
0.1-5.0	14	22.6	38.7
5.1-10.0	12	19.4	58.1
10.1-15.0	8	12.9	71.0
15.1-20.0	3	4.8	75.8
20.1-25.0	8	12.9	88.7
25.1-30.0	4	6.5	95.2
30.1-35.0	0	0.0	95.2
35.1-40.0	2	3.2	98.4
40.1-45.0	0	0.0	98.4
45.1-50.0	1	1.6	100.0
Total	62	100.0	


Fecal Culture Within-Herd Prevalence (n=62)
Number of Operations
Cumulative Percent
16
14
12
10
8
6
4
2
0
100
80
60
40
20
0
0.0
0.1 - 5.0
5.1 - 10.0
10.1 - 15.0
15.1 - 20.0
20.1 - 25.0
25.1 - 30.0
30.1 - 35.0
35.1 - 40.0
40.1 - 45.0
45.1 - 50.0
Apparent Prevalence (percent)
Number of Operations
Cumulative Percent

A total of 106 operations participated in serum-ELISA testing. Of these operations, 17 (16.0 percent) had no animals test serum-ELISA positive. Seroprevalence was 10 percent or less on 85.9 percent of operations.

b. MAP serum ELISA within-herd apparent prevalence

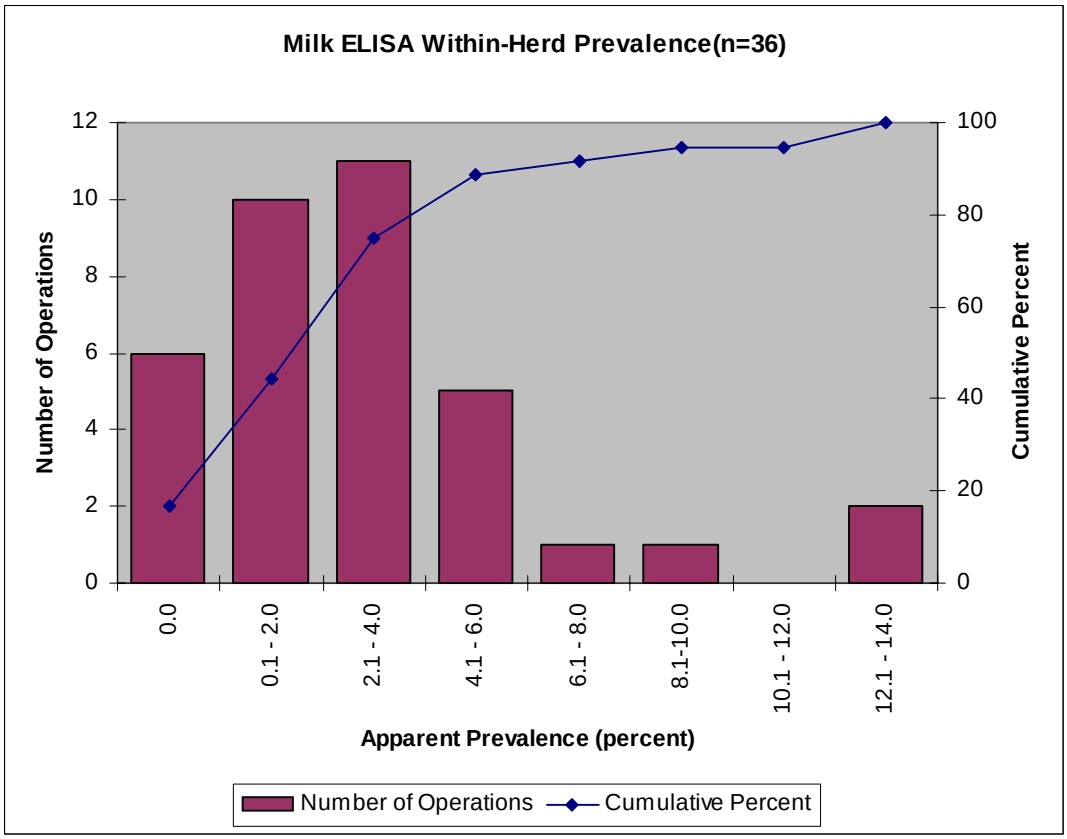
Seroprevalence (percent)	**Number Operations**	**Percent Operations**	**Cumulative Percent**
0.0	17	16.0	16.0
0.1-2.0	14	13.2	29.2
2.1-4.0	22	20.8	50.0
4.1-6.0	13	12.3	62.3
6.1-8.0	13	12.3	74.6
8.1-10.0	12	11.3	85.9
10.1-12.0	4	3.8	89.7
12.1-14.0	4	3.8	93.5
14.1-16.0	3	2.8	96.3
16.1-18.0	2	1.9	98.2
18.1-20.0	1	0.9	99.1
20.1-22.0	0	0.0	99.1
22.1-24.0	0	0.0	99.1
24.1-26.0	0	0.0	99.1
26.1-28.0	1	0.9	100.0
Total	106	100.0	


Serum ELISA Within-Herd Prevalence (n=106)
Number of Operations
Cumulative Percent
25
20
15
10
5
0
100
80
60
40
20
0
0.0
0.1 - 2.0
2.1 - 4.0
4.1 - 6.0
6.1 - 8.0
8.1 - 10.0
10.1 - 12.0
12.1 - 14.0
14.1 - 16.0
16.1 - 18.0
18.1 - 20.0
20.1 - 22.0
22.1 - 24.0
24.1 - 26.0
26.1 - 28.0
Apparent Prevalence (percent)
Number of Operations
Cumulative Percent

A total of 36 operations performed milk-ELISA testing. Compared to fecal culture and serum ELISA results, milk ELISA had a similar percentage of operations (16.7 percent) with no animals that tested positive. More than 9 out of 10 operations (94.5 percent) had milk-ELISA prevalence of 10 percent or less.

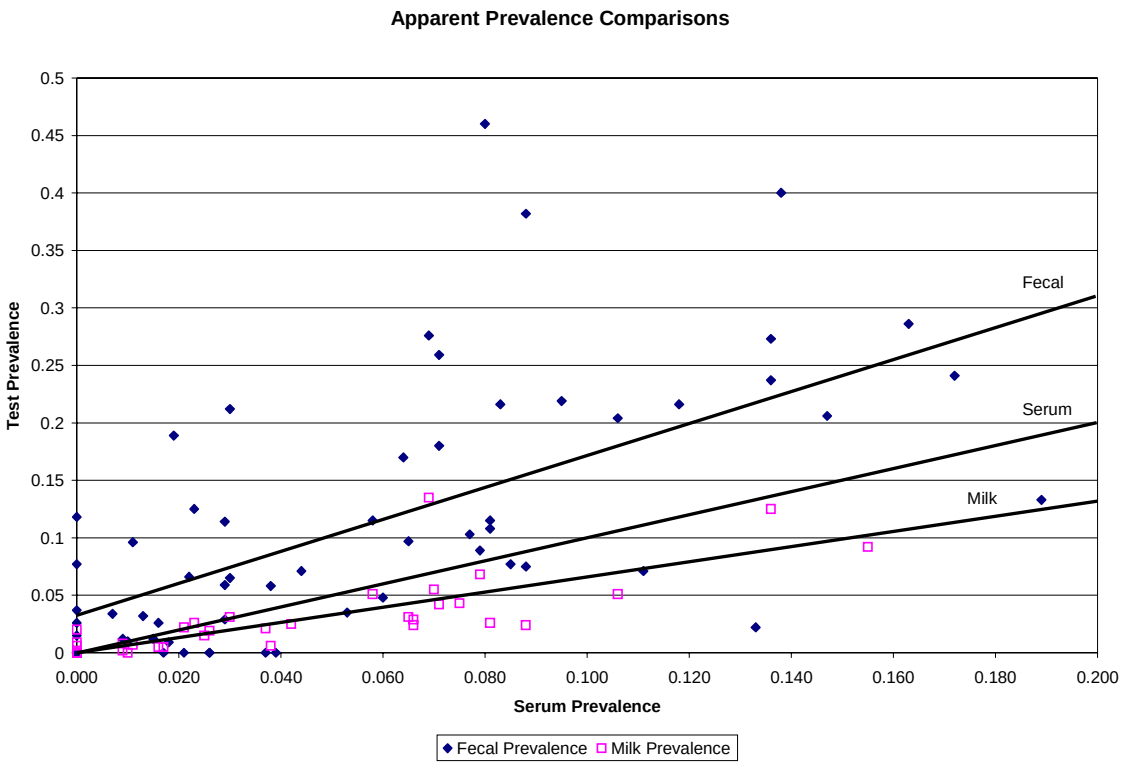
c. MAP milk ELISA within-herd apparent prevalence

Milk Prevalence (percent)	Number Operations	Percent Operations	Cumulative Percent
0.0	6	16.7	16.7
0.1-2.0	10	27.8	44.5
2.1-4.0	11	30.5	75.0
4.1-6.0	5	13.9	88.9
6.1-8.0	1	2.8	91.7
8.1-10.0	1	2.8	94.5
10.1-12.0	0	0.0	94.5
12.1-14.0	2	5.5	100.0
Total	36	100.0	



4. Apparent within-herd prevalence comparison

Within-herd apparent prevalence estimates were highest for fecal culture and lowest for milk ELISA. Since this is a comparison of apparent prevalence estimates, it is expected that fecal culture would have a higher prevalence estimate due to its sensitivity advantage over ELISA methods. Milk ELISA had the lowest estimates of MAP infection, but milk samples were collected from all lactating animals (compared to primarily second lactation and greater animals for fecal culture and serum ELISA).



Section IV: Methods

A. Needs Assessment

NAHMS develops study objectives by exploring existing literature and contacting industry members about their informational needs and priorities during a needs assessment phase. The objective of the needs assessment for the NAHMS Dairy 2002 study was to conduct a national survey to collect information from U.S. dairy producers and other commodity specialists about what they perceived to be the most important dairy health and productivity issues. A driving force of the needs assessment was the desire of NAHMS researchers to receive as much input as possible from a variety of producers, as well as from industry experts and representatives, veterinarians, extension specialists, universities, and dairy organizations.

Focus-group meetings were held at various locations across the United States to help determine the focus of the study:

Birmingham, AL October 21, 2000
United States Animal Health Association (USAHA)

Kansas City, MO October 31, 2000
American Feed Industry Association (AFIA) Dairy Nutrition Committee

Teleconference December 15, 2000
Bovine Association of Management and Nutrition (BAMN)

San Antonio, TX February 4, 2001
American Farm Bureau Federation Dairy Advisory Committee

Riverdale, MD February 16, 2001
Government Perspective Meeting
APHIS, FSIS, FDA, and ARS

In addition, a short survey asking for rankings of major dairy issues was provided via multiple data collection modes. There were 155 surveys completed via the Web, 90 by hard copy, and 1 via telephone.

The focus-group meeting input was merged with survey results to determine Dairy 2002 study objectives.

B. Sampling and Estimation

1. State selection

The preliminary selection of States to be included in the study was done in January 2001 using the NASS, USDA January 28, 2000, Cattle Report. A goal for NAHMS national studies is to include States that account for at least 70 percent of the animal and producer populations in the United States. The initial review of States identified 20 major States with 84 percent of the milk cow inventory and 81 percent of the operations with milk cows (dairy herds). The States were: CA, FL, ID, IL, IN, IA, KY, MI, MN, MO, NM, NY, OH, PA, TN, TX, VT, VA, WA, and WI.

A memo identifying these 20 States was provided in February 2001 to the USDA:APHIS:VS CEAH Director and, in turn, the VS Regional Directors. Regional Directors sought input from their respective States about being included or excluded from the study. By midyear, Colorado was included, based on the State's interest.

2. Operation selection

The list sampling frame was provided by NASS. Within each State a stratified random sample was selected. The size indicator was the number of milk cows for each operation. NASS selected a sample of dairy producers in each State for making the NASS January 1 cattle estimates. The list sample from the January 2001 survey was used as the screening sample. Producers reporting one or more milk cows on January 1, 2001, were included in the sample for contact in January 2002. Due to the predicted large workload, the sample was reduced in 2 States (KY and PA), for a final screening sample of 3,876 operations for Phase I data collection. For Phase II data collection, operations with 30 or more dairy cows on January 1, 2002, that participated in Phase I were invited to continue in the study.

3. Population inferences

Inferences for Phase I cover the population of dairy producers with at least 1 milk cow in the 21 participating States. As of January 1, 2002, these States accounted for 85.7 percent (7,799,000 head) of milk cows in the United States and 83.0 percent (80,910) of operations with milk cows in the United States. (see Appendix II for respective data on individual States.) All respondent data were statistically weighted to reflect the population from which they were selected. The inverse of the probability of selection for each operation was the initial selection weight. This selection weight was adjusted for nonresponse within each State and size group to allow for inferences back to the original population from which the sample was selected.

For operations eligible for Phase II data collection (those with 30 or more dairy cows) weights were adjusted for operations that did not want to continue to the study's second phase. This weight was adjusted again for nonresponse to Phase II data collection. The 21-State target population of operations with 30 or more dairy cows represented 97.3 percent of dairy cows and 74.3 percent of dairy operations in the 21 States (see Appendix II).

For the 815 operations participating in the risk assessment phase, weight adjustments were made to properly represent the 21-State target population of operations with 30 or more dairy cows.

a. Number of animals to test based on herd size to achieve prevalence precision

Number of Cows 2nd Lactation and Higher	Sample Type	
	Fecal	Blood
Less than or equal to 312	All	All
313 to 400	313	All
401 to 500	324	All
501 to 600	332	Up to 531
601 to 700	338	540
701 to 800	342	547
801 to 900	345	552
Greater than 900	360	580

C. Data Collection

1. Phase I

General Dairy Management Report, December 31, 2001, to February 12, 2002. NASS enumerators administered the General Dairy Management Report. The interview took slightly over 1 hour.

2. Phase II

VS Initial Visit, February 25 to April 30, 2002. Federal and State veterinary medical officers or animal health technicians collected the data from producers during an interview lasting approximately 1 hour. Johne's risk assessments were completed from March 15 to October 17, 2002.

Biological samples included individual fecal samples collected from March 25 to August 5, 2002; serologic samples were collected from March 25 to September 25, 2002; milk samples were collected from June 1, 2002 to January 9, 2003; and environmental samples, which include feces from alleyways, lagoons, etc., were collected from March 25 to September 25, 2002.

D. Data Analysis

1. Validation and estimation

a. Phase I: General Dairy Management Report

Initial data entry and validation for the General Dairy Management Report were performed in individual NASS State offices. Data were entered into a SAS data set. NAHMS national staff performed additional data validation on the entire data set after data from all States were combined.

b. Phase II: VS Initial Visit Questionnaire and Risk Assessment

After completing the VS initial-visit questionnaire and risk assessment, data collectors sent them to the State NAHMS coordinators, who manually reviewed them for accuracy and then sent them to CEAH. Data entry and validations were completed using SAS.

2. Response rates

a. Phase I: General Dairy Management Report – Screening Questionnaire

Of the 3,876 operations in the screening sample, 410 operations had no milk cows on January 1, 2002, and were therefore ineligible for the NAHMS Dairy 2002 study. Of these 3,466 dairy operations, 2,461 participated in the initial phase of the study. This phase occurred from December 31, 2001, to February 12, 2002, and included the administration of a questionnaire by NASS enumerators.

a. Phase I: General Dairy Management Report—Screening Questionnaire

Response Category	Number Operations	Percent Operations
No milk cows on Jan. 1, 2002	227	5.9
Out of business	183	4.7
Refusal	821	21.2
Survey complete and VMO consent	1,438	37.1
Survey complete, refused VMO consent	905	23.3
Survey complete, ineligible for VMO	118	3.0
Out of scope (prison, research farm, etc.)	45	1.2
Unknown	2	0.1
Inaccessible	137	3.5
Total	3,876	100.0

b. Phase II: VS Initial Visit Questionnaire

VS initial visit response categories are shown below for all 1,438 operations with 30 or more dairy cows turned over to VS. Of these, 1,013 producers participated.

Phase II: VS Initial Vist Questionnaire		
Response Category	**Number Operations**	**Percent Operations**
Survey completed	1,013	70.4
Producer not contacted	76	5.3
Poor time of year or no time	161	11.2
Did not want anyone on operation	4	0.3
Bad experience with government veterinarians	0	0.0
Did not want to do another survey or divulge information	136	9.5
Told NASS they did not want to be contacted	6	0.4
Ineligible (no dairy cows)	14	1.0
Other reason	28	1.9
Total	1,438	100.0

c. Phase II: Risk Assessment

Of the 1,013 operations that participated in Phase II Initial Visit Questionnaire, 815 participated in the risk assessment.

Appendix I: Sample Profile

A. Responding Sites

1a. Number of responding operations by herd size

	Phase I: General Dairy Management Report	Phase II: VS Initial Visit Questionnaire	Risk Assessment
Herd Size (Dairy Cow Inventory, January 1, 2002)	**Number of Responding Operations**	**Number of Responding Operations**	**Number of Responding Operations**
Less than 100	1,131	400	325
100 to 499	820	392	304
500 or more	510	221	186
Total	2,461	1,013	815

1b. Number of responding operations by region

	Phase I: General Dairy Management Report	Phase II: VS Initial Visit Questionnaire	Risk Assessment
Region	**Number of Responding Operations**	**Number of Responding Operations**	**Number of Responding Operations**
West	525	208	168
Midwest	1,085	448	349
Northeast	596	278	239
Southeast	255	79	29
Total	2,461	1,013	815

1c. Number of operations participating in the risk assessment, by assessment area

Area	Number
Calving	801
Preweaned calves	700
Postweaned calves	685
Bred heifers	672
Cows	810
All five areas	567

1d. Number of samples, herds and States for biological sampling, by testing method

	Testing Method			
Number	**Individual Fecal**	**Serum ELISA**	**Milk ELISA**	**Environmental**
Samples	7,272	19,378	16,167	483
Operations	62	106	36	98
States	20	21	17	21

Appendix II: U.S. Milk Cow Population and Operations

U.S. Milk Cow Population and Operations

		Number of Milk Cows on January 1, 2002[1] (Thousand Head)			Number of Operations 2001		
Region	State	Milk Cows on Operations with 1 or More Head	Milk Cows on Operations with 30 or More Head	30 or More Head Percent	Operations with 1 or More Head	Operations with 30 or More Head	30 or More Head Percent
West	California	1,620	1,618.4	99.9	2,500	2,200	88.0
	Colorado	93	92.0	98.9	800	220	27.5
	Idaho	377	375.5	99.6	1,000	770	77.0
	New Mexico	290	289.4	99.8	500	165	33.0
	Texas	315	311.9	99.0	2,100	1,150	54.8
	Washington	247	246.3	99.7	1,000	665	66.5
	Total	2,942	2,933.5	99.7	7,900	5,170	65.4
Midwest	Illinois	115	111.6	97.0	1,900	1,420	74.7
	Indiana	154	140.1	91.0	2,900	1,400	48.3
	Iowa	205	194.8	95.0	3,500	2,680	76.6
	Michigan	299	284.1	95.0	3,300	2,250	68.2
	Minnesota	500	480.0	96.0	7,800	6,700	85.9
	Missouri	140	133.0	95.0	3,700	2,100	56.8
	Ohio	260	234.0	90.0	5,200	2,800	53.8
	Wisconsin	1,280	1,232.6	96.3	19,100	15,950	83.5
	Total	2,953	2,810.2	95.2	47,400	35,300	74.5
Northeast	New York	675	661.5	98.0	7,300	6,000	82.2
	Pennsylvannia	588	564.5	96.0	10,300	8,500	82.5
	Vermont	154	150.9	98.0	1,600	1,410	88.1
	Total	1,417	1,376.9	97.3	19,200	15,910	82.9
Southeast	Florida	152	151.4	99.6	510	220	43.1
	Kentucky	125	115.0	92.0	2,900	1,600	55.2
	Tennessee	90	87.7	97.5	1,500	870	58.0
	Virginia	120	116.4	97.0	1,500	1,010	67.3
	Total	487	470.5	96.6	6,410	3,700	57.7
Total (21 States)		7,799.0 (85.7% of U.S.)	7,591.1 (85.7% of U.S.)	97.3	80,910 (83.0% of U.S.)	60,080 (86.9% of U.S.)	74.3
Total U.S. (50 States)		9,105.6	8,859.7	97.3	97,460	69,140	70.9

[1] Source: NASS April 2004 Cattle Final Estimates, 1999-2003—(revised January 1, 2002, number of milk cows and number of operations in 2001 with milk cows). An operation is any place having one or more head of milk cows, excluding cows used to nurse calves, on hand at anytime during the year.

Appendix III: Fecal Culture Laboratory Methods

Specimens and culture decontamination

All specimens were processed for decontamination using a previously published method.[86] Briefly, 2 g of specimen were resuspended in 35 ml of distilled water and shaken to disperse visible clumps. After 30 minutes, a 5 ml aliquot was removed and transferred to a solution containing 0.9% (w/v) HPC in ½-strength BHI broth. After overnight incubation, the specimens were centrifuged, the supernatant discarded, and the pellet resuspended in 1 ml of ½-strength BHI containing vancomycin (Sigma) (100 µg/ml), amphotericen B (Sigma) (50 µg/ml) and nalidixic acid (Sigma) (100 µg/ml). Following an additional overnight incubation, appropriately supplemented ESP II and BACTEC 12B liquid-culture bottles were aseptically inoculated with 0.75 ml and 0.1 ml of the treated specimen, respectively. In addition, approximately 50 µl of the same decontaminated inoculum was swabbed onto each of two tubes of HEY agar containing mycobactin J and one tube of HEY without mycobactin.

ESP II media culture supplementation and incubation procedures

Immediately prior to inoculation, ESP II liquid-culture bottles containing 12 ml of broth with mycobactin J were supplemented with 1 ml of *para*-JEM GS Growth Supplement (Trek), 0.5 ml of *para*-JEM AS Antibiotic Supplement (Trek), and 1 ml of *para*-JEM EYS Egg Yolk Supplement (Trek). Cultures were incubated in the ESP II machines for a minimum of 42 days, or until a positive signal was detected. Upon generation of a positive signal, the suspect-positive *para*-JEM culture bottle was removed from the ESP II machine and shaken vigorously on an orbital shaker for a minimum of 1 minute to release adherent bacteria from the sponges prior to acid-fast staining. Aliquots of 100 µl were then prepared for acid-fast staining, using an automated acid-fast slide stainer and an auramine rhodamine fluorescent stain. If no acid-fast organisms resembling *M. paratuberculosis* were seen, the bottle was returned for further incubation until the end of the 42-day period. All bottles, regardless of signal-positive or signal-negative status, were acid-fast stained at the end of 6 weeks. All acid-fast positive cultures were confirmed as *M. paratuberculosis* using a previously published quantitative PCR method.[86]

BACTEC 12B media culture supplementation and incubation procedures

Similarly, BACTEC 12B liquid-culture bottles were supplemented with 100 µl of mycobactin J (Allied Monitor) (50 µg/ml), 200 µl of PANTA antibiotic supplement (Becton Dickinson), 700 µl of sterile water, and 1 ml of 50% egg yolk supplement. Cultures were incubated at 37º C and read weekly on a BACTEC 460 reader for 6 weeks. BACTEC vials exhibiting a GI greater than or equal to 100 were considered suspect positive, and aliquots of 100 µl were prepared for acid-fast staining using an automated acid-fast slide stainer and an auramine rhodamine fluorescent stain. If no acid-fast organisms resembling *M. paratuberculosis* were seen, bottles were re-incubated at 37ºC until the end of the 6-week period. All bottles, regardless of GI reading, were acid-fast stained at the end of 6 weeks. All acid-fast positive cultures were confirmed as *M. paratuberculosis* using a previously published quantitative PCR method .[86]

Solid media culture procedures

All inoculated HEY tubes were incubated at 37°C in a horizontal position for 1 week with the caps loosened to allow absorption/evaporation of residual moisture on the surface of the medium. Caps were then tightened and the tubes returned to an upright position and incubated at 37°C for a total of 16 weeks. Tubes were examined every 4 weeks using a stereomicroscope at 25X magnification, and any resulting colonies with morphology typical of *M. paratuberculosis* were counted and confirmed as *M. paratuberculosis* by quantitative PCR as described below.

DNA preparation and real-time PCR confirmation

DNA from suspect positive cultures was prepared using the DNEasy Tissue Kit (Qiagen), with the following modifications. For bacterial colonies on solid media, a single colony was resuspended in 1.0 ml of sterile PBS and vortexed briefly. Similarly, for liquid cultures 0.5 ml of broth was mixed with 1.0 ml of sterile PBS and vortexed. Samples were then centrifuged at 6000 x *g* for 5 minutes, the supernatant was removed and the sample then treated per the manufacturer's protocols.

Real-time PCR was performed for all suspect positive samples. For this, a fluorescent DNA probe that is specific to an internal region of the PCR product and contains a quencher molecule is bound to the target DNA region. When the probe is intact, the proximity of its reporter dye to the quencher dye does not allow for fluorescent emission. During the extension phase of the PCR reaction, the *Taq* DNA polymerase cleaves this probe, releasing the fluorescent molecule. This fluorescence is measured, and its magnitude is plotted as a direct proportion to the amplification cycle number of the PCR reaction.

To perform the real-time PCR, the IS*900* regions of the *M. paratuberculosis* genome were targeted using the primers 3-F (5'- ccg cta att gag aga tgc gat tgg-3') and 3-R (5'- aat caa ctc cag cag cgc ggc ctc g-3'), and the 5'-FAM labeled fluorescent probe IS900P (5'- tcc acg ccc gcc cag aca gg-3'). Each specimen was tested in duplicate wells on a 96-well plate, using a total of 5 µl of extracted DNA in a 25-µl reaction, prepared with a universal master mix as supplied by the manufacturer (Applied Biosystems). In addition, each plate contained triplicate wells of four serial dilutions of known *M. paratuberculosis* DNA, ranging from 1 ng to 0.001ng. Thermocycling profiles consisted of an initial 10 minute denaturation step at 95ºC, followed by 40 cycles of a 25-second denaturation step plus a 1 minute annealing/extension step. Automatic analysis of the data was then performed at the end of each run for each plate to determine the threshold cycle (C_T) fluorescence values for each sample.

At the completion of each plate run, the C_T positive cutoff value was calculated to determine the positive/negative status of the unknown samples. For this, C_T values of the 0.001 ng standard was used, and the average C_T from its triplicate wells was calculated. Its standard deviation was then determined, and the positive cutoff value was set as the sum of the averaged C_T value plus one standard deviation.

Appendix IV: Categorization of Test Results

a. Fecal culture shedding level criteria by culture method

Culture Method	High	Moderate	Low	Very Low
BACTEC 460	Growth index more than 300 @ 3 wk or less	Growth index = 301-999 @4-5 weeks	Growth index = 101-999 @6 weeks	Growth index less than 100 @ 6 weeks
TREK (ESP) Culture System II	Less than 21 days to positive	Days to positive from 22-28 days	Days to positive from 29-35 days	Days to positive from 36-42 days
Herrold's Egg Yolk Medium (HEYM)	Greater than 50 cfu*/tube	6-50 cfu/tube	1-5 cfu/tube	NA

* Colony Forming Units

b. Paracheck™ ELISA Classification and Interpretation*

Animal Classification	ELISA Score	Explanation and Recommendation
Negative	0.00-0.49	Antibodies to MAP were not detected. Cattle classified as ELISA-negative are either not infected or not producing antibodies.
Inconclusive	0.50-0.99	Cattle with ELISA results in this range are more likely to be infected than ELISA-negative animals.
Positive	1.00-3.49	Cattle with ELISA values in this range are approximately 30-75 times more likely to be infected with MAP than ELISA-negative cattle.
Strong positive	3.50 or more	Cattle with ELISA values in this range are approximately 175-200 times more likely to be infected with MAP than ELISA-negative cattle. Cattle in this category have a higher probability of developing clinical Johne's disease in the next 12 months than lower scored animals.

*Adapted from Wisconsin Veterinary Diagnostic Laboratory Interpretation Chart

Appendix V: Study Objectives and Related Outputs

1. Describe baseline dairy cattle health and management practices and trends in dairy farm health management.
   - Part I: Reference of Dairy Health and Management in the United States, 2002, December 2002
   - Part II: Changes in the United States Dairy Industry, 1991-2002, June 2003
   - Part III: Reference of Dairy Cattle Health and Health Management Practices in the United States, 2002, December 2003
   - Colostrum and bST info sheets, December 2002
   - Mycoplasma and HBS info sheets, June 2003
   - Antibiotic Use on U.S Dairies, 2002, interpretive report, expected summer 2005
   - Milking Procedures info sheet, August 2003

2. Describe strategies to prevent and reduce Johne's disease.
   - **Johne's Disease on United States Dairy Operations, 2002, February 2005**

3. Evaluate management factors associated with the presence of certain food safety pathogens.
   - *Salmonella* and Campylobacter, *Salmonella* and *Listeria*, and *E. coli* info sheets, December 2003

4. Describe the preparedness of producers to respond to foreign animal diseases, such as foot-and-mouth disease.
   - Animal Disease Exclusion Practices on U.S. Dairy Operations, 2002, August 2004

5. Describe waste handling systems
   - Nutrient Management and the U.S. Dairy Industry in 2002, August 2004

Appendix VI: References

1 Collins MT, Morgan IR. Simulation model of paratuberculosis control in a dairy herd. Prev Vet Med 1992 14:21-32.

2 Collins MT, Morgan IR. Economic decision analysis model of a paratuberculosis test and cull program. J Am Vet Med Assoc 1991 Dec;199(12):1724-1729.

3 Groenendaal H, Nielen M, Jalvingh AW, Horst SH, Galligan DT, Hesselink JW. A simulation of Johne's disease control. Prev Vet Med 2002 Jul;54(3):225-245.

4 Groenendaal H, Galligan DT. Economic consequences of control programs for paratuberculosis in midsize dairy farms in the United States. J Am Vet Med Assoc 2003 Dec;223(12):1757-1763.

5 Collins MT, Sockett DC, Goodger WJ, Conrad TA, Thomas CB, Carr DJ. Herd prevalence and geographic distribution of, and risk factors for, bovine paratuberculosis in Wisconsin. J Am Vet Med Assoc 1994 Feb;204(4):636-641.

6 Cetinkaya B, Erdogan HM, Morgan KL. Relationships between the presence of Johne's disease and farm and management factors in dairy cattle in England. Prev Vet Med 1997 Oct;32(3-4):253-266.

7 Obasanjo IO, Grohn YT, Mohammed HO. Farm factors associated with the presence of *Mycobacterium paratuberculosis* infection in dairy herds on the New York State Paratuberculosis Control Program. Prev Vet Med 1997 Oct;32(3-4):243-251.

8 Johnson-Ifearulundu YJ, Kaneene JB. Management-related risk factors for *M. paratuberculosis* infection in Michigan, USA, dairy herds. Prev Vet Med 1998 Dec;37(1-4):41-54.

9 Wells SJ, Wagner BA. Herd-level risk factors for infection with *Mycobacterium paratuberculosis* in US dairies and association between familiarity of the herd manager with the disease or prior diagnosis of the disease in that herd and use of preventive measures. J Am Vet Med Assoc 2000 May;216(9):1450-1457.

10 NAHMS (National Animal Health Monitoring System). Part I: Reference of Dairy Health and Management in the United States. USDA:APHIS:VS; CEAH, National Animal Health Monitoring System. 2002 Fort Collins, CO.

11 Sweeney RW. Transmission of paratuberculosis. Vet Clin North Am Food Anim Pract 1996 Jul;12(2):305-312.

12 Rossiter CA, Burhans WS. Farm-specific approach to paratuberculosis (Johne's disease) control. Vet Clin North Am Food Anim Pract 1996 Jul;12(2):383-415.

13 Sweeney RW, Whitlock RH, Hamir AN, Rosenberger AE, Herr SA. Isolation of *Mycobacterium paratuberculosis* after oral inoculation in uninfected cattle. Am J Vet Res 1992 Aug;53(8):1312-1314.

14 Chi J, VanLeeuwen JA, Weersink A, Keefe GP. Management factors related to seroprevalences to bovine viral-diarrhoea virus, bovine-leukosis virus, *Mycobacterium avium* subspecies *paratuberculosis*, and *Neospora caninum* in dairy herds in the Canadian Maritimes. Prev Vet Med 2002 Sep;55(1):57-68.

15 Thoen CO, Baum KH. Current knowledge on paratuberculosis. J Am Vet Med Assoc 1988 Jun;192(11):1609-1611.

16 Schroen CJ, Kluver PF. Butler KL, McDonald WL, Hope AF, Condron RI. Factors affecting the survival of *Mycobacterium avium* subspecies *paratuberculosis* in soil. 7th Intl Colloq Paratb (2002) Bilboa, Spain

17 Kopecky KE. Distribution of paratuberculosis in Wisconsin, by soil regions. J Am Vet Med Assoc 1977 Feb;170(3):320-324.

18 Johnson-Ifearulundu Y, Kaneene JB. Distribution and environmental risk factors for paratuberculosis in dairy cattle herds in Michigan. Am J Vet Res 1999 May;60(5):589-596.

19 Ward MP, Perez AM. Association between soil type and paratuberculosis in cattle herds. Am J Vet Res 2004 Jan;65(1):10-14.

20 Jorgensen JB. Survival of *Mycobacterium paratuberculosis* in slurry. Nord Vet Med 1977 Jun;29(6):267-270.

21 Larsen AB, Merkal RS, Vardaman TH. Survival time of *Mycobacterium paratuberculosis*. Am J Vet Res 1956 Jul;17(64):549-551.

22 Whan LB, Grant IR, Ball HJ, Scott R, *Rowe MT. Bactericidal effect of chlorine on Mycobacterium* paratuberculosis in drinking water. Lett Appl Microbiol 2001 Sep;33(3):227-231.

23 Wells SJ. Biosecurity on dairy operations: hazards and risks. J Dairy Sci 2000 Oct;83(10):2380-2386.

24 Wells SJ, Dee S, Godden S. Biosecurity for gastrointestinal diseases of adult dairy cattle. Vet Clin North Am Food Anim Pract 2002 Mar;18(1):35-55, v-vi.

25 Wraight MD, McNeil J, Beggs DS, Greenall RK, Humphris TB, Irwin RJ, et al. Compliance of Victorian dairy farmers with current calf rearing recommendations for control of Johne's disease. Vet Microbiol 2000 Dec;77(3-4):429-442.

26 NAHMS (National Animal Health Monitoring System). Part I: Reference of 1996 Dairy Management Practices. USDA:APHIS:VS; CEAH, National Animal Health Monitoring System. 1996, Fort Collins, CO.

27 Moyle AI. Culture and cull procedure for control of paratuberculosis. J Am Vet Med Assoc 1975 Apr;166(7):689-690.

28 Rossiter CA, Hansen D. National Johne's Working Group – Critical management points for prevention and control of Johne's disease in dairy cattle. For the Veterinarian: Johne's Disease Information Series 2000 (2):1-4.

29 Sockett DC. Update on control and management of Johne's disease. Bovine Practitioner 1994 28:136-140.

30 Gay JM, Sherman DM. Factors in the epidemiology and control of ruminant paratuberculosis. Vet Med 1992 87;1133-1139.

31 Chiodini RJ, van Kruiningen HJ, Merkal RS. Ruminant paratuberculosis (Johne's disease): the current status and future prospects. Cornell Vet 1984 Jul;74(3):218-262.

32 Collins MT. Clinical approach to control of bovine paratuberculosis. J Am Vet Med Assoc 1994 Jan;204(2):208-210.

33 Merkal RS. Paratuberculosis: advances in cultural, serologic, and vaccination methods. J Am Vet Med Assoc 1984 Apr;184(8):939-943.

34 van Schaik G, Kalis CH, Benedictus G, Dijkhuizen AA, Huirne RB. Cost-benefit analysis of vaccination against paratuberculosis in dairy cattle. Vet Rec 1996 Dec;139(25):624-627.

35 Wentink GH, Bongers JH, Zeeuwen AA, Jaartsveld FH. Incidence of paratuberculosis after vaccination against *M. paratuberculosis* in two infected dairy herds. Zentralblatt Fuer Veterinaermedizin Reihe B 1994 Oct;41 (7-8):517-522.

36 Larsen AB, Moyle AI, Himes EM. Experimental vaccination of cattle against paratuberculosis (Johne's disease) with killed bacterial vaccines: a controlled field study. Am J Vet Res 1978 Jan;39(1):65-69.

37 Kormendy B. The effect of vaccination on the prevalence of paratuberculosis in large dairy herds. Vet Microbiol 1994 Jul;41(1-2):117-125.

38 Kalis CH, Hesselink JW, Barkema HW, Collins MT. Use of long-term vaccination with a killed vaccine to prevent fecal shedding of *Mycobacterium avium* subsp *paratuberculosis* in dairy herds. Am J Vet Res 2001 Feb;62(2):270-274.

39 Larsen AB, Merkal RS, Kopecky KE, Boothe AD. Hypersensitivity and serologic responses in cattle vaccinated with disrupted *Mycobacterium paratuberculosis* cells and subsequently infected with Mycobacterium bovis. Am J Vet Res 1969 Dec;30(12):2167-2172.

40 Patterson CJ, LaVenture M, Hurley SS, Davis JP. Accidental self-inoculation with *Mycobacterium paratuberculosis* bacterin (Johne's bacterin) by veterinarians in Wisconsin. J Am Vet Med Assoc 1988 May;192(9):1197-1199.

41 Whittington RJ, Sergeant ES. Progress towards understanding the spread, detection and control of *Mycobacterium avium* subsp *paratuberculosis* in animal populations. Aust Vet J 2001 Apr;79(4):267-278.

42 Whitlock RH, Buergelt C. Preclinical and clinical manifestations of paratuberculosis (including pathology). Vet Clin North Am Food Anim Pract 1996 Jul;12(2):345-356.

43 NRC (National Research Council). Diagnosis and Control of Johne's Disease. Washington, DC: National Academies Press 2003.

44 Winterhoff C, Beyerbach M, Homuth M, Strutzberg K, Gerlach GF. Establishment and evaluation of an ELISA for the detection of antibodies in milk against *Mycobacterium avium* subspecies *paratuberculosis*. Dtsch Tierarztl Wochenschr 2002 May;109(5):230-234.

45 Hendrick S, Duffield T, Kelton D, Leslie K, Lissemore K, Archambault M. A relative comparison of diagnostic tests for Johne's disease. Proc Am Assoc Bov Pract Conf 2003 36:182.

46 Lombard JE, Byrem T, McCluskey BJ. Comparison of a milk ELISA test for Johne's disease to traditional modalities in dairy cattle. ISVEE X Proceedings, Vina del Mar, Chile 2003.

47 Cox JC, Drane DP, Jones SL, Ridge S, Milner AR. Development and evaluation of a rapid absorbed enzyme immunoassay test for the diagnosis of Johne's disease in cattle. Aust Vet J 1991 May;68(5):157-160.

48 van Schaik G, Rossiter CR, Stehman SM, Shin SJ, Schukken YH. Longitudinal study to investigate variation in results of repeated ELISA and culture of fecal samples for *Mycobacterium avium* subsp *paratuberculosis* in commercial dairy herds. Am J Vet Res 2003 Apr;64(4):479-484.

49 Whittington RJ, Reddacliff LA, Marsh I, McAllister S, Saunders V. Temporal patterns and quantification of excretion of *Mycobacterium avium* subsp *paratuberculosis* in sheep with Johne's disease. Aust Vet J 2000 Jan;78(1):34-37.

50 Collins MT, Sockett DC, Ridge S, Cox JC. Evaluation of a commercial enzyme-linked immunosorbent assay for Johne's disease. J Clin Microbiol 1991 Feb;29(2):272-276.

51 Pavlik I, Matlova L, Bartl J, Svastova P, Dvorska L, Whitlock R. Parallel faecal and organ *Mycobacterium avium* subsp. *paratuberculosis* culture of different productivity types of cattle. Vet Microbiol 2000 Dec;77(3-4):309-324.

52 Collins MT. Diagnosis of paratuberculosis. Vet Clin North Am Food Anim Pract 1996 Jul;12(2):357-371.

53 Whitlock RH, Wells SJ, Sweeney RW, Van Tiem J. ELISA and fecal culture for paratuberculosis (Johne's disease): sensitivity and specificity of each method. Vet Microbiol 2000 Dec;77(3-4):387-398.

54 Collins MT, Sockett DC. Accuracy and economics of the USDA-licensed enzyme-linked immunosorbent assay for bovine paratuberculosis. J Am Vet Med Assoc 1993 Nov;203(10):1456-1463.

55 Thoen CO, Haagsma J. Molecular techniques in the diagnosis and control of paratuberculosis in cattle. J Am Vet Med Assoc 1996 Aug;209(4):734-737.

56 Stabel JR, Bosworth TL, Kirkbride TA, Forde RL, Whitlock RH. A simple, rapid, and effective method for the extraction of *Mycobacterium paratuberculosis* DNA from fecal samples for polymerase chain reaction. J Vet Diagn Invest 2004 Jan;16(1):22-30.

57 Raizman EA, Wells SJ. The distribution of *Mycobacterium avium* subsp *paratuberculosis* in the environment surrounding Minnesota dairy farms. ISVEE X Proceedings, Vina del Mar, Chile 2003.

58 McKenna SLB, Keefe GP, Sockett DC, VanLeeuwen JA, McClure J, Hanna P, Spangler E, Barkema HW. Evaluation of the sensitivity of three ELISA tests for the detection of *Mycobacterium avium paratuberculosis* infection using tissue culture as a gold standard. Proc Am Assoc Bov Pract Conf 2003 36:181.

59 Hirst HL, Garry FB, Salman MD. Assessment of test results when using a commercial enzyme-linked immunosorbent assay for diagnosis of paratuberculosis in repeated samples collected from adult dairy cattle. J Am Vet Med Assoc 2002 Jun;220(11):1685-1689.

60 Sweeney RW, Whitlock RH, Buckley CL, Spencer P, Rosenberger AE, Hutchinson LJ. Diagnosis of paratuberculosis in dairy cattle, using enzyme-linked immunosorbent assay for detection of antibodies against Mycobacterium paratuberculosis in milk. Am J Vet Res 1994 Jul;55(7):905-909.

61 Hardin LE, Thorne JG. Comparison of milk with serum ELISA for the detection of paratuberculosis in dairy cows. J Am Vet Med Assoc 1996 Jul;209(1):120-122.

62 Hill BB, West M, Brock KV. An estimated prevalence of Johne's disease in a subpopulation of Alabama beef cattle. J Vet Diagn Invest 2003 Jan;15(1):21-25.

63 Adaska JM, Anderson RJ. Seroprevalence of Johne's disease infection in dairy cattle in California, USA. Prev Vet Med 2003 Aug;60(3):255-261.

64 Hirst HL, Garry FB, Morley PS, Salman MD, Dinsmore RP, Wagner BA, McSweeney KD, Goodell GM. Seroprevalence of Mycobacterium avium subsp paratuberculosis infection among dairy cows in Colorado and herd-level risk factors for seropositivity. J Am Vet Med Assoc. 2004 Jul 1;225(1):97-101.

65 Braun RK, Buergelt CD, Littell RC, Linda SB, Simpson JR. Use of an enzyme-linked immunosorbent assay to estimate prevalence of paratuberculosis in cattle of Florida. J Am Vet Med Assoc 1990 Apr;196(8):1251-1254.

66 Pence M, Baldwin C, Black CC 3rd. The seroprevalence of Johne's disease in Georgia beef and dairy cull cattle. J Vet Diagn Invest 2003 Sep;15(5):475-477.

67 Johnson-Ifearulundu Y, Kaneene JB, Lloyd JW. Herd-level economic analysis of the impact of paratuberculosis on dairy herds. J Am Vet Med Assoc 1999 Mar;214(6):822-825.

68 Thorne JG, Hardin LE. Estimated prevalence of paratuberculosis in Missouri, USA cattle. Prev Vet Med 1997 Jul;31(1-2):51-57.

69 Whitlock RH, Hutchinson LJ, Merkal RS, Glickman LT, Rossiter C, Harmon S, Spencer P, Fetrow J, Bruce J, Benson CE, Dick J. Prevalence and economic considerations of Johne's disease in Northeastern U.S. Proceedings, Annual Meeting of the United States Animal Health Association Milwaukee, WI 1985 98:484-490.

70 Alexander JL, Mandy W, Glass R. Results of the ELISA seroprevalence survey for antibodies to paratuberculosis in Texas dairy and beef cattle. Proceedings, Annual Meeting of the United States Animal Health Association, Las Vegas, NV 1993 97:307.

71 Chiodini RJ, van Kruiningen HJ. The prevalence of paratuberculosis in culled New England cattle. Cornell Vet 1986 Jan;76(1):91-104.

72 Merkal RS, Whipple DL, Sacks JM, Snyder GR. Prevalence of *Mycobacterium paratuberculosis* in ileocecal lymph nodes of cattle culled in the United States. J Am Vet Med Assoc 1987 Mar;190(6):676-680.

73 NAHMS (National Animal Health Monitoring System). Johne's Disease on U.S. Dairy Operations. USDA:APHIS:VS; CEAH, National Animal Health Monitoring System. 1997 Fort Collins, CO.

74 Dargatz DA, Byrum BA, Hennager SG, Barber LK, Kopral CA, Wagner BA, et al. Prevalence of antibodies against *Mycobacterium avium* subsp *paratuberculosis* among beef cow-calf herds. J Am Vet Med Assoc 2001 Aug;219(4):497-501.

75 Gasteiner J, Wenzl H, Fuchs K, Jark U, Baumgartner W. Serological cross-sectional study of paratuberculosis in cattle in Austria. Zentralblatt Fuer Veterinaermedizin Reihe B 1999 Sep;46(7):457-466.

76 Boelaert F, Walravens K, Biront P, Vermeersch JP, Berkvens D, Godfroid J. Prevalence of paratuberculosis (Johne's disease) in the Belgian cattle population. Vet Microbiol 2000 Dec;77(3-4):269-281.

77 Sorensen O, Rawluk S, Wu J, Manninen K, Ollis G. *Mycobacterium paratuberculosis* in dairy herds in Alberta. Can Vet J 2003 Mar;44(3):221-226.

78 McNab WB, Meek AH, Duncan JR, Martin SW, Van Dreumel AA. An epidemiological study of paratuberculosis in dairy cattle in Ontario: study desing and prevalence estimates. Can J Vet Res 1991 Jul;55(3):246-251.

79 VanLeeuwen JA, Keefe GP, Tremblay R, Power C, Wichtel JJ. Seroprevalence of infection with *Mycobacterium avium* subspecies *paratuberculosis*, bovine leukemia virus, and bovine viral diarrhea virus in maritime Canada dairy cattle. Can Vet J 2001 Mar;42(3):193-198.

80 Waldner CL, Cunningham GL, Janzen ED, Campbell JR. Survey of *Mycobacterium avium* subspecies *paratuberculosis* serological status in beef herds on community pastures in Saskatchewan. Can Vet J 2002 Jul;43(7):542-546.

81 Jakobsen MB, Alban L, Nielsen SS. A cross-sectional study of paratuberculosis in 1155 Danish dairy cows. Prev Vet Med 2000 Jul;46(1):15-27.

82 Muskens J, Barkema HW, Russchen E, van Maanen K, Schukken YH, Bakker D. Prevalence and regional distribution of paratuberculosis in dairy herds in The Netherlands. Vet Microbiol 2000 Dec;77(3-4):253-261.

83 Nielsen SS, Thamsborg SM, Houe H, Bitsch V. Bulk-tank milk ELISA antibodies for estimating the prevalence of paratuberculosis in Danish dairy herds. Prev Vet Med 2000 Mar;44(1-2):1-7.

84 Corti S, Stephan R. Detection of *Mycobacterium avium* subspecies *paratuberculosis* specific IS900 insertion sequences in bulk-tank milk samples obtained from different regions throughout Switzerland. BMC Microbiology 2002 Jun;2(1):15.

85 Grant IR, Ball HJ, Rowe MT. Incidence of *Mycobacterium paratuberculosis* in bulk raw and commercially pasteurized cows' milk from approved dairy processing establishments in the United Kingdom. Applied & Environmental Microbiology 2002 May;68(5):2428-2435.

86 Kim SG, Shin SJ, Jacobson RH, Miller LJ, Harpending PR, Stehman SM, et al. Development and application of quantitative polymerase chain reaction assay based on the ABI 7700 system (TaqMan) for detection and quantification of *Mycobacterium avium* subsp. *paratuberculosis*. J Vet Diagn Invest 2002 Mar;14(2):126-131.

Appendix VII: Additional Resource Information on Johne's Disease

Abbas AK, Murphy KM, Sher A. Functional diversity of helper T lymphocytes. Nature 1996 Oct;383(6603):787-793.

Abbas B, Riemann HP. IgG, IgM and IgA in the serum of cattle naturally infected with *Mycobacterium paratuberculosis*. Comparative Immunology, Microbiology & Infectious Diseases 1988;11(3-4):171-175.

Abbas B, Riemann HP, Hird DW. Diagnosis of Johne's disease (paratuberculosis) in Northern California cattle and a note on its economic significance. California Vet 1983;8:20-24.

Anargyros P, Astill DS, Lim IS. Comparison of improved BACTEC and Lowenstein-Jensen media for culture of mycobacteria from clinical specimens. J Clin Microbiol 1990 Jun;28(6):1288-1291.

Barrington GM, Gay JM, Eriks IS, Davis WC, Evermann JF, Emerson C, et al. Temporal patterns of diagnostic results in serial samples from cattle with advanced paratuberculosis infections. J Vet Diagn Invest 2003 Mar;15(2):195-200.

Barrington GM, Gay JM, Evermann JF. Biosecurity for neonatal gastrointestinal diseases. Vet Clin North Am Food Anim Pract 2002 Mar;18(1):7-34.

Benedictus G, Dijkhuizen AA, Stelwagen J. Economic losses due to paratuberculosis in dairy cattle. Vet Rec 1987 Aug;121(7):142-146.

Buergelt CD, Duncan JR. Age and milk production data of cattle culled from a dairy herd with paratuberculosis. J Am Vet Med Assoc 1978 Sep;173(5 Pt 1):478-480.

Bull TJ, McMinn EJ, Sidi-Boumedine K, Skull A, Durkin D, Neild P, et al. Detection and verification of *Mycobacterium avium* subsp. *paratuberculosis* in fresh ileocolonic mucosal biopsy specimens from individuals with and without Crohn's disease. J Clin Microbiol 2003 Jul;41(7):2915-2923.

Cetinkaya B, Egan K, Harbour DA, Morgan KL. An abattoir-based study of the prevalence of subclinical Johne's disease in adult cattle in south west England. Epidemiology & Infection 1996 Jun;116(3):373-379.

Chiodini RJ. Immunology: resistance to paratuberculosis. Vet Clin North Am Food Anim Pract 1996 Jul;12(2):313-343.

Chiodini RJ, Davis WC. The cellular immunology of bovine paratuberculosis: the predominant response is mediated by cytotoxic gamma/delta T lymphocytes which prevent CD4+ activity. Microb Pathog 1992 Dec;13(6):447-463.

Chiodini RJ, Rossiter CA. Paratuberculosis: a potential zoonosis? Vet Clin North Am Food Anim Pract 1996 Jul;12(2):457-467.

Clarke CJ. The pathology and pathogenesis of paratuberculosis in ruminants and other species. J Comp Pathol 1997 Apr;116(3):217-261.
Collins MT. Paratuberculosis and Crohn's disease: a relationship? Proceedings, Annual Meeting of the United States Animal Health Association Grand Rapids, MI 1994 98:293-298.

Collins MT, Kenefick KB, Sockett DC, Lambrecht RS, McDonald J, Jorgensen JB. Enhanced radiometric detection of *Mycobacterium paratuberculosis* by using filter-concentrated bovine fecal specimens. J Clin Microbiol 1990 Nov;28(11):2514-2519.

Corner LA, Pfeiffer DU, Abbott KA. Unanswered questions about the transmission of *Mycobacterium avium* subspecies *paratuberculosis*. Vet J 2003 May;165(3):182-183.

Coussens PM. *Mycobacterium paratuberculosis* and the bovine immune system. Anim Health Res Rev 2001 Dec;2(2):141-161.

Crohn BB, Ginzburg L, Oppenheimer GD. Regional ileitis: a pathologic and clinical entity. 1932. Mt Sinai J Med 2000 May;67(3):263-268.

Damato JJ, Collins MT. Growth of *Mycobacterium paratuberculosis* in radiometric, Middlebrook and egg-based media. Vet Microbiol 1990 Mar;22(1):31-42.

Dargatz DA, Garry FB, Traub-Dargatz JL. An introduction to biosecurity of cattle operations. Vet Clin North Am Food Anim Pract 2002 Mar;18(1):1-5, v.

Eamens GJ, Whittington RJ, Marsh IB, Turner MJ, Saunders V, Kemsley PD, et al. Comparative sensitivity of various faecal culture methods and ELISA in dairy cattle herds with endemic Johne's disease. Vet Microbiol 2000 Dec;77(3-4):357-367.

Eppleston J, Whittington RJ. Isolation of *Mycobacterium avium* subsp *paratuberculosis* from the semen of rams with clinical Johne's disease. Aust Vet J 2001 Nov;79(11):776-767.

Garland CF, Lilienfeld AM, Mendeloff AI, Markowitz JA, Terrell KB, Garland FC. Incidence rates of ulcerative colitis and Crohn's disease in fifteen areas of the United States. Gastroenterology 1981 Dec;81(6):1115-1124.

Giese SB, Ahrens P. Detection of *Mycobacterium avium* subsp. *paratuberculosis* in milk from clinically affected cows by PCR and culture. Vet Microbiol 2000 Dec;77(3-4):291-297.

Goodell GM, Hirst HL, Garry FB, Dinsmore RP. Comparison of cull rates and milk production of clinically normal dairy cows grouped by ELISA *Mycobacterium avium paratuberculosis* serum antibody results. ISVEE IX Proceedings, Breckenridge, CO, USA 2000.

Goodger WJ, Collins MT, Nordlund KV, Eisele C, Pelletier J, Thomas CB, et al. Epidemiologic study of on-farm management practices associated with prevalence of *Mycobacterium paratuberculosis* infections in dairy cattle. J Am Vet Med Assoc 1996 Jun;208(11):1877-1881.

Grant IR, Kirk RB, Hitchings E, Rowe MT. Comparative evaluation of the MGIT and BACTEC culture systems for the recovery of *Mycobacterium avium* subsp. *paratuberculosis* from milk. J Appl Microbiol 2003;95(1):196-201.

Greenstein RJ. Is Crohn's disease caused by a mycobacterium? Comparisons with leprosy, tuberculosis, and Johne's disease. Lancet Infect Dis 2003 Aug;3(8):507-514.

Hagan WA. Age as a factor in susceptibility to Johne's disease. Cornell Vet 1938 28:34-40.

Hanna BA, Ebrahimzadeh A, Elliott LB, Morgan MA, Novak SM, Rusch-Gerdes S, et al. Multicenter evaluation of the BACTEC MGIT 960 system for recovery of mycobacteria. J Clin Microbiol 1999 Mar;37(3):748-752.

Harris NB, Barletta RG. *Mycobacterium avium* subsp. *paratuberculosis* in Veterinary Medicine. Clin Microbiol Rev 2001 Jul;14(3):489-512.

Hartmann P, Plum G. Immunological defense mechanisms in tuberculosis and MAC-infection. Diagn Microbiol Infect Dis 1999 Jun;34(2):147-152.

Hietala SK. The options in diagnosing ruminant paratuberculosis. Vet Med 1992 87;1133-1139.

Huda A, Jensen HE. Comparison of histopathology, cultivation of tissues and rectal contents, and interferon-gamma and serum antibody responses for the diagnosis of bovine paratuberculosis. J Comp Pathol 2003 Nov;129(4):259-267.

Johnson-Ifearulundu Y, Kaneene JB. Relationship between soil type and *Mycobacterium paratuberculosis*. J Am Vet Med Assoc 1997 Jun;210(12):1735-1740.

Johnson YJ, Kaneene JB, Gardiner JC, Lloyd JW, Sprecher DJ, Coe PH. The effect of subclinical *Mycobacterium paratuberculosis* infection on milk production in Michigan dairy cows. J Dairy Sci 2001 Oct;84(10):2188-2194.

Johnson-Ifearulundu YJ, Kaneene JB, Sprecher DJ, Gardiner JC, Lloyd JW. The effect of subclinical *Mycobacterium paratuberculosis* infection on days open in Michigan, USA, dairy cows. Prev Vet Med 2000 Aug;46(3):171-181.

Kalis CH, Hesselink JW, Russchen EW, Barkema HW, Collins MT, Visser IJ. Factors influencing the isolation of *Mycobacterium avium* subsp. *paratuberculosis* from bovine fecal samples. J Vet Diagn Invest 1999 Jul;11(4):345-351.

Klausen J, Huda A, Ekeroth L, Ahrens P. Evaluation of serum and milk ELISAs for paratuberculosis in Danish dairy cattle. Prev Vet Med 2003 May;58(3-4):171-178.

Kruip TA, Muskens J, van Roermund HJ, Bakker D, Stockhofe-Zurwieden N. Lack of association of *Mycobacterium avium* subsp. *paratuberculosis* with oocytes and embryos from moderate shedders of the pathogen. Theriogenology 2003 Apr;59(7):1651-1660.

Lambrecht RS, Collins MT. Inability to detect mycobactin in mycobacteria-infected tissues suggests an alternative iron acquisition mechanism by mycobacteria in vivo. Microb Pathog 1993 Mar;14(3):229-238.

Larsen AB. Paratuberculosis: the status of our knowledge. J Am Vet Med Assoc 1972 Dec;161(11):1539-1541.

Larsen AB, Merkal RS, Cutlip RC. Age of cattle as related to resistance to infection with *Mycobacterium paratuberculosis*. Am J Vet Res 1975 Mar;36(3):255-257.

Larsen AB, Stalheim OH, Hughes DE, Appell LH, Richards WD, Himes EM. *Mycobacterium paratuberculosis* in the semen and genital organs of a semen-donor bull. J Am Vet Med Assoc 1981 Jul;179(2):169-171.

Lepper AW, Wilks CR, Kotiw M, Whitehead JT, Swart KS. Sequential bacteriological observations in relation to cell-mediated and humoral antibody responses of cattle infected with *Mycobacterium paratuberculosis* and maintained on normal or high iron intake. Aust Vet J 1989 Feb;66(2):50-55.

Lombard JE, Hirst HL, Antognoli MC, Salman MD, Garry FB. Evaluation of diagnostic tests for Johne's disease using detection of *Mycobacterium avium* ss. *paratuberculosis* in tissues to classify infection status of dairy cows. Proc. Am. Assoc. Bov. Pract. 37:205, 2004

Lowenthal JW, Cerottini JC, MacDonald HR. Interleukin 1-dependent induction of both interleukin 2 secretion and interleukin 2 receptor expression by thymoma cells. J Immunol 1986 Aug;137(4):1226-1231.

McNab WB, Meek AH, Martin SW, Duncan JR. Associations between dairy production indices and lipoarabinomannan enzyme-immunoassay results for paratuberculosis. Can J Vet Res 1991 Oct;55(4):356-361.

Merkal RS, Kopecky KE, Larsen AB. Immunologic mechanisms in bovine paratuberculosis. Am J Vet Res 1970 Mar;31(3):475-485.

Momotani E, Whipple DL, Thiermann AB, Cheville NF. Role of M cells and macrophages in the entrance of *Mycobacterium paratuberculosis* into domes of ileal Peyer's patches in calves. Vet Pathol 1988 Mar;25(2):131-137.

Naser SA, Schwartz D, Shafran I. Isolation of *Mycobacterium avium* subsp *paratuberculosis* from breast milk of Crohn's disease patients. Am J Gastroenterol 2000 Apr;95(4):1094-1095.

Nielsen SS, Enevoldsen C, Grohn YT. The *Mycobacterium avium* subsp. *paratuberculosis* ELISA response by parity and stage of lactation. Prev Vet Med 2002 May;54(1):1-10.

Nielsen SS, Grohn YT, Enevoldsen C. Variation of the milk antibody response to paratuberculosis in naturally infected dairy cows. J Dairy Sci 2002 Nov;85(11):2795-2802.

Nordlund KV, Goodger WJ, Pelletier J, Collins MT. Associations between subclinical paratuberculosis and milk production, milk components, and somatic cell counts in dairy herds. J Am Vet Med Assoc 1996 Jun;208(11):1872-1876.

Olsen I, Storset AK. Innate IFN-gamma production in cattle in response to MPP14, a secreted protein from *Mycobacterium avium* subsp. *paratuberculosis*. Scand J Immunol 2001 Sep;54(3):306-313.

Ott SL, Wells SJ, Wagner BA. Herd-level economic losses associated with Johne's disease on US dairy operations. Prev Vet Med 1999 Jun;40(3-4):179-192.

Patterson DSP, Berrett S. Malabsorption in Johne's disease of cattle: depressed in vitro amino-acid uptake by isolated intestinal tissue preparations. Vet Rec. 1968 83:55-56.

Pearson L. A note on the occurrence in America of chronic bacterial dysentery of cattle. Am. Vet. Rev. 1908 32:602-605.

Pemberton DH. Diagnosis of Johne's disease in cattle using mesenteric lymph node biopsy: accuracy in clinical suspects. Aust Vet J 1979 May;55(5):217-219.

Pillai SR, Jayarao BM. Application of IS900 PCR for detection of *Mycobacterium avium* subsp. *paratuberculosis* directly from raw milk. J Dairy Sci 2002 May;85(5):1052-1057.

Rohde RF, Shulaw WP. Isolation of *Mycobacterium paratuberculosis* from the uterine flush fluids of cows with clinical paratuberculosis. J Am Vet Med Assoc 1990 Dec;197(11):1482-1483.

Rossiter CA, Henning WR. Isolation of *Mycobacterium paratuberculosis* (*M. ptb*) from thin market cows at slaughter. J Dairy Sci 2001 84(Suppl):113-114.

Seitz SE, Heider LE, Heuston WD, Bech-Nielsen S, Rings DM, Spangler L. Bovine fetal infection with *Mycobacterium paratuberculosis*. J Am Vet Med Assoc 1989 May;194(10):1423-1426.

Shin SJ. Report of the committee on Johne's disease. Proceedings, Annual Meeting of the United States Animal Health Association Las Vegas, NV 1989 93:380-381.

Shin SJ, Kim SG, Miller LJ, Harpending PR, Patten VH, Lein DH. A new liquid culture method, the TREK ESP Culture System II, for rapid detection of *Mycobacterium avium* subsp. *paratuberculosis* in bovine fecal samples. Proceedings Am Assoc Vet Lab Diag Birmingham, AL 2000 43:29.

Shin SJ, Kim SG, Miller LJ, Harpending PR, Cornell JL, Patten VH, Stehman SM, Rossiter CA, McDonough PL, Lein DH. Further evaluation of ESP Culture System II for detection of *Mycobacterium avium* subsp. p*aratuberculosis* in bovine fecal samples. Proceedings Am Assoc Vet Lab Diag Hershey, PA 2001 44:39.

Sockett DC, Carr DJ, Collins MT. Evaluation of conventional and radiometric fecal culture and a commercial DNA probe for diagnosis of *Mycobacterium paratuberculosis* infections in cattle. Can J Vet Res 1992 Apr;56(2):148-153.

Spangler E, Bech-Nielsen S, Heider LE. Diagnostic performance of two serologic tests and fecal culture for subclinical paratuberculosis, and associations with production. Prev Vet Med 1992 13:185-195.

Spangler E, Heider LE, Bech-Nielsen S, Dorn CR. Serologic enzyme-linked immunosorbent assay responses of calves vaccinated with a killed *Mycobacterium paratuberculosis* vaccine. Am J Vet Res 1991 Aug;52(8):1197-1200.

Stabel JR. An improved method for cultivation of *Mycobacterium paratuberculosis* from bovine fecal samples and comparison to three other methods. J Vet Diagn Invest 1997 Oct;9(4):375-380.

Stehman SM. Paratuberculosis in small ruminants, deer, and South American camelids. Vet Clin North Am Food Anim Pract 1996 Jul;12(2):441-455.

Stephan R, Buhler K, Corti S. Incidence of *Mycobacterium avium* subspecies *paratuberculosis* in bulk-tank milk samples from different regions in Switzerland. Vet Rec 2002 Feb;150(7):214-215.

Streeter RN, Hoffsis GF, Bech-Nielsen S, Shulaw WP, Rings DM. Isolation of *Mycobacterium paratuberculosis* from colostrum and milk of subclinically infected cows. Am J Vet Res 1995 Oct;56(10):1322-1324.

Sweeney RW, Hutchinson LJ, Whitlock RH, Spencer PA, Galligan DT. Effect of *Mycobacterium paratuberculosis* on milk production in dairy cattle. Proceedings, Fourth Intl Colloq Paratb Cambridge, UK (1994) 1995a:133-135.

Sweeney RW, Hutchinson LJ, Whitlock RH, Spencer PA, Galligan DT. Effect of *Mycobacterium paratuberculosis* on milk production in dairy cattle. Proceedings, Fourth Intl Colloq Paratb Cambridge, UK (1994) 1995:133-135.

Sweeney RW, Whitlock RH, Buckley CL, Spencer PA. Evaluation of a commercial enzyme-linked immunosorbent assay for the diagnosis of paratuberculosis in dairy cattle. J Vet Diagn Invest 1995 Oct;7(4):488-493.

Sweeney RW, Whitlock RH, Rosenberger AE. *Mycobacterium paratuberculosis* cultured from milk and supramammary lymph nodes of infected asymptomatic cows. J Clin Microbiol 1992 Jan;30(1):166-171.

Sweeney RW, Whitlock RH, Rosenberger AE. *Mycobacterium paratuberculosis* isolated from fetuses of infected cows not manifesting signs of the disease. Am J Vet Res 1992 Apr;53(4):477-480.

Taylor TK, Wilks CR, McQueen DS. Isolation of *Mycobacterium paratuberculosis* from the milk of a cow with Johne's disease. Vet Rec 1981 Dec;109(24):532-533.

Thorel MF, Krichevsky M, Levy-Frebault VV. Numerical taxonomy of mycobactin-dependent mycobacteria, emended description of *Mycobacterium avium*, and description of *Mycobacterium avium* subsp. *avium* subsp. *nov*., *Mycobacterium avium* subsp. *paratuberculosis* subsp. *nov*., and *Mycobacterium avium* subsp. *silvaticum* subsp. *nov*. Int J Syst Bacteriol 1990 Jul;40(3):254-260.

Tobin MV, Logan RF, Langman MJ, McConnell RB, Gilmore IT. Cigarette smoking and inflammatory bowel disease. Gastroenterology 1987 Aug;93(2):316-321.

USAHA (United States Animal Health Association). Uniform Program Standards for the Voluntary Bovine Johne's Disease Control Program. 2002. Available online at http://www.aphis.usda.gov/vs/nahps/johnes/johnes-umr.pdf.

van Kruiningen HJ, Chiodini RJ, Thayer WR, Coutu JA, Merkal RS, Runnels PL. Experimental disease in infant goats induced by a Mycobacterium isolated from a patient with Crohn's disease. A preliminary report. Dig Dis Sci 1986 Dec;31(12):1351-1360.

Van Roermund HJW, Stegeman JA, de Jong MCM. Dynamics of paratuberculosis infections in dairy herds. ISVEE IX Proceedings, Breckenridge, CO, USA 2000.

Vary PH, Andersen PR, Green E, Hermon-Taylor J, McFadden JJ. Use of highly specific DNA probes and the polymerase chain reaction to detect *Mycobacterium paratuberculosis* in Johne's disease. J Clin Microbiol 1990 May;28(5):933-937.

Wall S, Kunze ZM, Saboor S, Soufleri I, Seechurn P, Chiodini R, et al. Identification of spheroplast-like agents isolated from tissues of patients with Crohn's disease and control tissues by polymerase chain reaction. J Clin Microbiol 1993 May;31(5):1241-1245.

Wells SJ. Control of Johne's disease on dairy operations – the Minnesota model. Proceedings, Annual Meeting of the United States Animal Health Association Hershey, PA 2001 105:261-263.

Wells SJ, Whitlock RH, Wagner BA, Collins J, Garry F, Hirst H, et al. Sensitivity of test strategies used in the Voluntary Johne's Disease Herd Status Program for detection of *Mycobacterium paratuberculosis* infection in dairy cattle herds. J Am Vet Med Assoc 2002 Apr;220(7):1053-1057.

Whipple DL, Callihan DR, Jarnagin JL. Cultivation of *Mycobacterium paratuberculosis* from bovine fecal specimens and a suggested standardized procedure. J Vet Diagn Invest 1991 Oct;3(4):368-373.

Whipple DL, Kapke PA, Andersen PR. Comparison of a commercial DNA probe test and three cultivation procedures for detection of *Mycobacterium paratuberculosis* in bovine feces. J Vet Diagn Invest 1992 Jan;4(1):23-27.

Whitlock RH, Rosenberger AE. Fecal culture protocol for *Mycobacterium paratuberculosis* A recommended procedure. Proceedings, Annual Meeting of the United States Animal Health Association. Denver, CO 1990 94:280-285.

Whitlock RH, Rosenberger AE, Spencer PA. Laboratory culture technique for Johne's disease: A critical evaluation of contamination and incubation times. Proceedings, Annual Meeting of the United States Animal Health Association. Las Vegas, NV 1989 93:382-386.

Whittington RJ, Marsh I, McAllister S, Turner MJ, Marshall DJ, Fraser CA. Evaluation of modified BACTEC 12B radiometric medium and solid media for culture of *Mycobacterium avium* subsp. *paratuberculosis* from sheep. J Clin Microbiol 1999 Apr;37(4):1077-1083.

Whittington RJ, Marsh I, Turner MJ, McAllister S, Choy E, Eamens GJ, et al. Rapid detection of *Mycobacterium paratuberculosis* in clinical samples from ruminants and in spiked environmental samples by modified BACTEC 12B radiometric culture and direct confirmation by IS900 PCR. J Clin Microbiol 1998 Mar;36(3):701-707.

Williams-Bouyer N, Yorke R, Lee HI, Woods GL. Comparison of the BACTEC MGIT 960 and ESP culture system II for growth and detection of mycobacteria. J Clin Microbiol 2000 Nov;38(11):4167-4170.

Williams MR, Millar P. Changes in serum immunoglobulin levels in Jerseys and Friesians near calving. Res Vet Sci. 1979 Jan;26(1):81-84.

Wilson DJ, Rossiter C, Han HR, Sears PM. Association of *Mycobacterium paratuberculosis* infection with reduced mastitis, but with decreased milk production and increased cull rate in clinically normal dairy cows. Am J Vet Res 1993 Nov;54(11):1851-1857.

Zurbrick BG, Czuprynski CJ. Ingestion and intracellular growth of *Mycobacterium paratuberculosis* within bovine blood monocytes and monocyte-derived macrophages. Infection & Immunity 1987 Jul;55(7):1588-1593.