United States
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of Agriculture

Animal and
Plant Health
Inspection
Service

**Veterinary
Services**

Papillomatous Digital Dermatitis

on U.S. Dairy Operations

Footwarts
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Footwarts

NAHMS Dairy '96

May 1997

Study Collaborators:

- Centers for Epidemiology and Animal Health (CEAH)
- USDA:APHIS:VS Veterinary Medical Officers and Animal Health Technicians in Dairy ‘96 states
- State Veterinary Medical Officers in Dairy ‘96 states
- National Agricultural Statistics Service (NASS)
- Dairy ‘96 participating producers

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Abstract

Objective (as part of the NAHMS Dairy '96 study): Describe the incidence of papillomatous digital dermatitis in the U.S. including regional and seasonal patterns relative to that of clinical lameness, describe use of hoof care practices on U.S. dairy operations, and evaluate specific herd-level management factors associated with digital dermatitis occurrence in U.S. dairy operations.

Design: Population-based cross-sectional survey.

Sample population: U.S. dairy operations with at least 30 cows in 20 states, representing 79.4 percent of U.S. dairy cows.

Procedure: Questionnaire administered by veterinary medical officer or animal health technicians on-farm to dairy managers.

Results: Papillomatous digital dermatitis was reported from 47 percent of dairy herds across the U.S. Seventy-eight percent of affected herds reported their first cases occurred in 1993 or later. Regions of the U.S. with the highest percent of herds affected included the Southwest, Northeast, and Northwest. The disease occurred throughout the year and the effect of season varied by region. Overall, 17.2 percent of cows and 6.8 percent of bred heifers were reported with clinical signs of lameness during the 12 months prior to the Dairy '96 interviews that took place from February 20 through May 24, 1996. Factors associated with high papillomatous digital dermatitis incidence included region, herd size, type of land lactating cows accessed on a daily basis, flooring type where lactating cows walked, percent of cows born off the operation, use of a primary hoof-trimmer who trimmed cows' hooves on other operations, and lack of washing hoof trimming equipment between cows.

Implications: Papillomatous digital dermatitis occurs in U.S. dairy herds across the country. Management strategies to potentially prevent or reduce incidence of papillomatous digital dermatitis on dairy operations include those related to biosecurity and cow hoof environmental conditions.

A. Introduction

Papillomatous digital dermatitis (digital dermatitis or footwarts) has been recognized as an emerging disease condition in dairy cows. It was first reported in Italy in 1974 (Cheli and Mortellaro, 1974), and since that time has been reported from countries around the world (Blowey, 1988). In the U.S., it was first reported as lameness outbreaks in New York dairy herds (Rebhun and others, 1980) and, since the late 1980's, as an important cause of bovine lameness (Read and others, 1992).

Clinically, digital dermatitis typically appears as a lameness outbreak of variable severity within dairy herds. It is a superficial skin disease of the bovine digit with variable presentation, depending on the stage of the lesion, from painful, moist, strawberry-like lesions to raised, hairy, wart-like lesions (Read and others, in press). These lesions, usually located on the rear of the foot between the bulbs of the heel, have been referred to by several names, including hairy footwarts, strawberry (or raspberry) heelwarts, and digital dermatitis. Early lesions usually respond to topical antibiotic treatment, although they may recur later.

The economic impact of digital dermatitis within dairy herds has not been well-defined to date. From reports, high morbidity seen in some herds and resulting severe lameness in affected cows, with associated losses in milk production, reproductive efficiency, body weight and treatment costs create significant losses for affected dairy producers (Rebhun and others, 1980; Nutter and Moffitt, 1990). A study from a Mexican herd with 33 percent of cows affected during lactation reported a 20-day increase in calving to conception interval (Argaez-Rodriguez and others, 1996).

The cause of digital dermatitis is not fully understood at this time, but aspects of the host-agent-environment complex have been studied. California researchers have isolated two separate spirochete bacteria from footwart lesions and have concluded that these spirochetes are most similar to Treponema (Walker and others, 1995). While they have not been able to reproduce the disease from the isolated organisms, their work is ongoing. These researchers suggest that digital dermatitis is a contagious disease, based on spread of disease regionally, high levels of disease within affected herds, within-herd spread after introduction of affected cattle, and higher prevalence in younger cows (Read and others, in press). Research in the area of environmental predispositions of digital dermatitis has suggested that certain herd-level or management practices predispose dairy herds to infection. These factors include large herd size, moisture of corrals where cows walk, and introduction of dairy replacement heifers to the operation (Rodriguez-Lainz and others, 1996a; Rodriguez-Lainz and others, 1996b). Increased understanding of causal factors for this disease would facilitate development of management strategies to prevent or minimize disease and resulting economic losses.

Objectives of this study were to (1) describe the incidence of digital dermatitis in the U.S. including regional and seasonal distributions as well as that of clinical lameness and the prevalence of use of hoof care practices on U.S. dairy operations and (2) evaluate specific herd-level management factors associated with digital dermatitis occurrence in U.S. dairy operations.

Dairy ‘96 reports are accessable on the Internet at these locations:

- World Wide Web at **http://www.aphis.usda.gov/vs/ceah/cahm**. Menu choices:
  - National Animal Health Monitoring System
  - Dairy Cattle
- APHIS Gopher at **gopher.aphis.usda.gov**. Menu choices:
  - APHIS Information
  - Animal Health Information
  - Animal Health Monitoring, Risk Assessments, and Emerging Issues

For questions about this report or additional Dairy ‘96 and NAHMS results, please contact:

Centers for Epidemiology and Animal Health
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Fort Collins, CO 80521
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Internet: NAHMS_INFO@aphis.usda.gov
Web site: http://www.aphis.usda.gov/vs/ceah/cahm

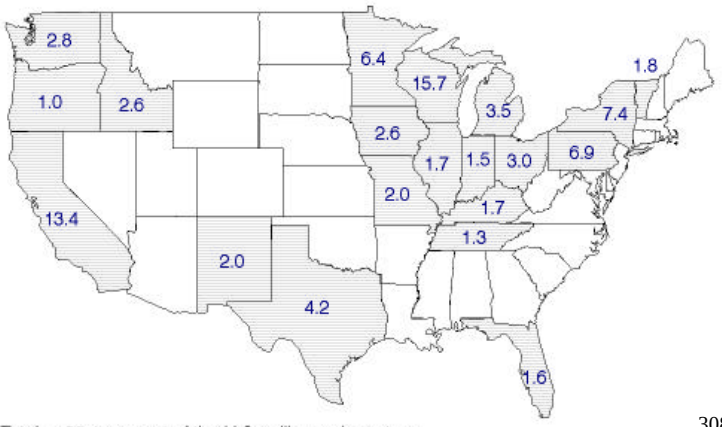
Further information about papillomatous digital dermatitis in cattle is available on the World Wide Web at: http://sphinx.ucdavis.edu/research/footwarts/pdd.html.

B. Methods

The National Animal Health Monitoring System (NAHMS) Dairy '96 Study, conducted by the USDA:APHIS:Veterinary Services, was designed to provide information on the national dairy herd for research and educational purposes. Study objectives were defined using a needs assessment process involving focus groups that represented U.S. dairy producers, veterinarians, dairy scientists, allied industries, as well as the USDA:APHIS. One area prioritized during this process was to gather information to support farm-level preventive strategies for digital dermatitis.

The first phase of the Dairy '96 Study was designed in collaboration with USDA:National Agricultural Statistics Service (NASS). A stratified random sample of 4,516 dairy producers in 20 states (see map) was selected from the NASS list frame. These 20 states represented 83.1 percent of U.S. dairy cows in January 1995. During the first phase, NASS enumerators contacted dairy producers in January 1996 and administered a questionnaire assessing dairy health and management. Study participation was voluntary for producers and individual producer information remained confidential. Each producer with at least 30 dairy cows that completed the questionnaire was asked to participate in the second phase of the NAHMS Dairy '96 Study. Operations with 30 or more cows represented 79.4 percent of U.S. dairy cows.

Percent of U.S. Milk Cow Inventory, January 1, 1996, for States Participating in the NAHMS Dairy '96 Study



Total = 83.1 percent of the U.S. milk cow inventory.

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Names of those producers willing to participate in the second phase of the study were released by NASS to USDA:APHIS. At this phase, each producer was contacted by APHIS or State veterinary medical officers or animal health technicians for a second herd visit that was held during the period from February 20 through May 24, 1996. During this herd visit, dairy producers completed a second questionnaire which included questions regarding digital dermatitis. To assess incidence of digital dermatitis (as reported by dairy managers retrospectively), data collectors provided a brief, standardized description of the disease and showed several photographs of footwart lesions from a bulletin provided by University of California-Davis researchers (Read and Walker).

After data collection, questionnaires were checked by interviewers who provided an assessment of data quality. Study coordinators in each state and the Centers for Epidemiology and Animal Health performed additional data quality assessments, data checks, and edits. Interviewer and state study coordinator assessment of producer and field data quality showed that overall data quality was satisfactory (Table 1 on the next page). Data from 99.2 percent of operations were considered high or adequate quality (scores 1-3) based on interviewer assessment of producer responses. Data from 99.7

* Identification numbers are assigned to each graph in this report for public reference.

percent of operations were considered high or adequate quality (scores 1-3) based on questionnaire completeness and number of errors.

Table B1. Producer and field data quality scores for responses from dairy operations participating in digital dermatitis questionnaire.

Score	Percent Responses	Definition
Producer Data Quality Scores (Assessed by Interviewer)		
1	27.3	Producer has a thorough knowledge of the operation and complete information on record. There is no question about the validity of the overall data this producer provided.
2	47.1	Producer has a good knowledge of the operation and has records for most of the needed information. There is little question about the overall data quality this producer provided.
3	24.8	Producer has a fair knowledge of the operation and the information provided seems consistent, although it may not be recorded. Data are based on the producer's best and earnest recollection and knowledge. Records were not consulted.
4	0.8	Producer has little understanding of the operation and the industry in general. Information is inconsistent and often fabricated or based on "wild" guesses.
Total	100.0	
Field Data Quality Scores (Assessed by State Study Coordinator)		
1	64.0	Questionnaire is complete. Legible, free of errors, and the totals reconcile. Explanations for missing or questionable responses are written on the form. Data can be edited without difficulty.
2	30.2	Questionnaire is complete, legible, contains few errors, and the totals reconcile. Explanations for missing or questionable responses are written but may not be complete. Data can be edited with little difficulty.
3	5.5	Questionnaire contains non-legible responses, incomplete sections, or many obvious errors. A few of the totals do not reconcile, and explanations for missing or questionable responses are missing or not legible. Data are difficult to edit.
4	0.3	Questionnaire is not complete, not legible, contains obvious errors, and totals do not reconcile. Explanations for missing or questionable responses are missing or not legible. Data are difficult to edit and may be discarded.
Total	100.0	

Descriptive Analysis

For computation of point estimates of lameness incidence, lameness management practices, and digital dermatitis incidence, weights representing the inverse of the sampling fraction for each dairy operation adjusted for producer nonresponse were utilized. Statistical software that incorporated the study design stratification in variance estimates was used to estimate variances associated with the point estimates. Incidence was calculated as the weighted sum of the number of cows (or bred heifers) affected with digital dermatitis during the previous 12 months divided by the weighted sum of the cow (or bred heifer) inventory on the day of the interview.

Differences in response rates from the first phase of the study to the digital dermatitis phase were noted among regions, herd sizes, Dairy Herd Improvement Association (DHIA) participation, and rolling herd average milk production, but not among several other variables including culling rate and cow deaths. Analysis weights were adjusted for nonresponse within each region-herd size-DHIA stratum to account for these differences.

Inferential Analysis

The goal of the inferential analysis was to identify herd-level factors associated with digital dermatitis incidence. The outcome variable for inferential analysis was dairy herds with greater than 5 percent of cow inventory affected with digital dermatitis reported by herd managers in the previous 12 months compared to those dairy herds with less than or equal to 5 percent of cow inventory affected. A screening procedure was used to select herd-level factors for consideration in a multivariable model. A chi-square test for independence, adjusting for weights and study design, was used as the screening test and variables with $p < 0.1$ were considered eligible for multivariable modeling.

The second step was to evaluate associations using a logistic regression model. Variables from the initial screening procedure were removed sequentially from the full model using the Wald statistic, as weighted and design-adjusted log-likelihood estimates are not available in this survey analysis procedure. From coefficients of the final logistic regression model, odds ratios (as estimates of relative risks) with 95 percent confidence limits were generated.

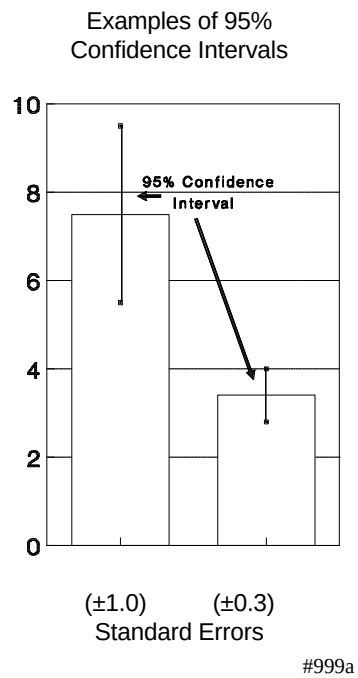
Terms Used in This Report

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

Heifer: female dairy bovine that has not yet calved.

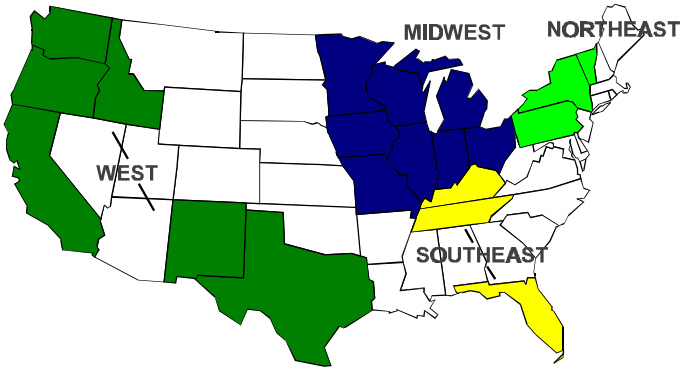
Odds ratio: estimate of relative risk, or increased risk, compared to reference level (where odds ratio = 1).

Operation average: a single value for each operation is summed over all operations reporting divided by the number of operations reporting. For instance, the operation average percent of cows showing clinical signs of lameness on page 7 is the weighted mean percent of cows that were lame for each operation. In contrast, the weighted percent of cows is the weighted sum of the number of cows that were lame across all herds divided by the weighted sum of cow inventory.



Population estimates: averages and proportions weighted to represent the population. Most of the estimates in this report are provided with a measure of variability called the standard error and denoted by (±). Chances are 95 out of 100 that the interval created by the estimate plus or minus two standard errors will contain the true population value. In the example at right, an estimate of 7.5 with a standard error of ±1.0 results in a range 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 results in a range of 2.8 to 4.0.

Regions Used for NAHMS Dairy '96
Digital Dermatitis Inferential Analysis



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Regions: The four regions shown below were further divided for digital dermatitis descriptive analyses.
- **Northeast:** New York, Pennsylvania, and Vermont.
- **Southeast:** Florida, Kentucky, and Tennessee.
- **Midwest:**
  * North Midwest: Michigan, Minnesota, and Wisconsin.
  * South Midwest: Illinois, Indiana, Iowa, Missouri, and Ohio.
- **West:**
  * Northwest: Idaho, Oregon, and Washington.
  * Southwest: California, New Mexico, and Texas.

Sample profile: information that describes characteristics of the reporting operations from which Dairy '96 data were collected.

Signs (of digital dermatitis): Lesions, usually found on the bulb of the heel, start out as dime size round or oval moist, strawberry-like surface which is often painful and prone to bleeding. Later, lesions can be observed as golf-ball size, sometimes with long, hair-like projections on the surface. There is little or no digital swelling (in contrast to foot rot). Digital dermatitis may lead to severe lameness, walking on toes, clubbed hooves, loss of body weight, and decreased milk yield and fertility.

Standard error: see population estimates.

C. Descriptive Analysis: Population Estimates

In herds with at least 30 dairy cows, 17.2 percent of cow inventory and 6.8 percent of bred heifer inventory were reported lame in the previous 12 months. These should be viewed as conservative estimates since many lameness cases are unrecognized by herd managers (Wells and others, 1993). Results from the Dairy ‘96 Study demonstrate the incidence of lameness was higher in larger herds than smaller herds.

1. Clinical lameness in dairy cattle

a. Cows

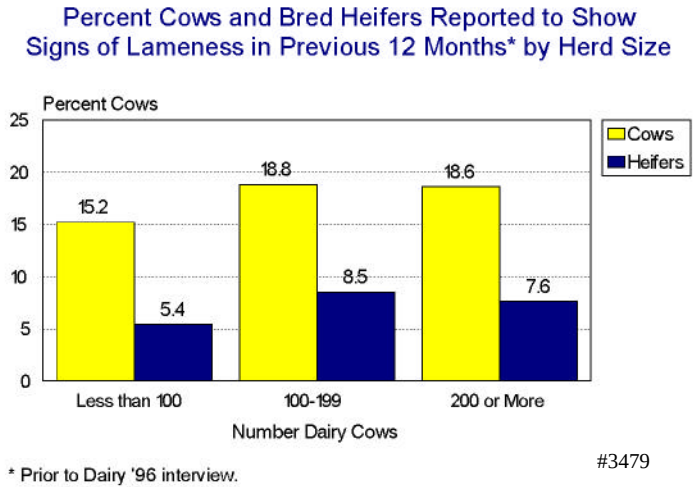
i. Percent of cows showing clinical signs of lameness during the 12 months prior to the Dairy ‘96 interview (as a percent of cow inventory at the time of the interview) by herd size:

Number Dairy Cows	Operation Average Percent	Standard Error	Percent Cows	Standard Error
Less than 100	15.0	(± 0.7)	15.2	(± 0.7)
100-199	18.8	(± 1.2)	18.8	(± 1.1)
200 or more	19.9	(± 1.3)	18.6	(± 1.4)
All herds	16.0	(± 0.6)	17.2	(± 0.6)

In addition, regional differences were noted, with the highest incidence in the Northeast (21.2 percent of cows) and lowest incidence in the Southeast (8.6 percent of cows). This same trend was shown in bred heifers.

ii. Percent of cows showing clinical signs of lameness during the 12 months prior to the Dairy ‘96 interview (as a percent of cow inventory at the time of the interview) by region:

Region	Operation Average Percent	Standard Error	Percent Cows	Standard Error
West	14.1	(± 0.9)	15.0	(± 1.5)
Midwest	15.7	(± 0.9)	17.8	(± 0.9)
Northeast	18.9	(± 1.1)	21.2	(± 1.3)
Southeast	6.7	(± 1.0)	8.6	(± 1.1)
All regions	16.0	(± 0.6)	17.2	(± 0.6)



b. Bred heifers

i. Percent of bred heifers showing clinical signs of lameness during the 12 months prior to the Dairy ‘96 interview (as a percent of bred heifer inventory at the time of the interview) by herd size:

Number Dairy Cows	Operation Average Percent	Standard Error	Percent Bred Heifers	Standard Error
Less than 100	6.3	(± 0.8)	5.4	(± 0.5)
100-199	10.3	(± 1.5)	8.5	(± 1.1)
200 or more	10.7	(± 2.1)	7.6	(± 1.2)
All herds	7.3	(± 0.7)	6.8	(± 0.5)

ii. Percent of bred heifers showing clinical signs of lameness during the 12 months prior to the Dairy ‘96 interview (as a percent of bred heifer inventory at the time of the interview) by region:

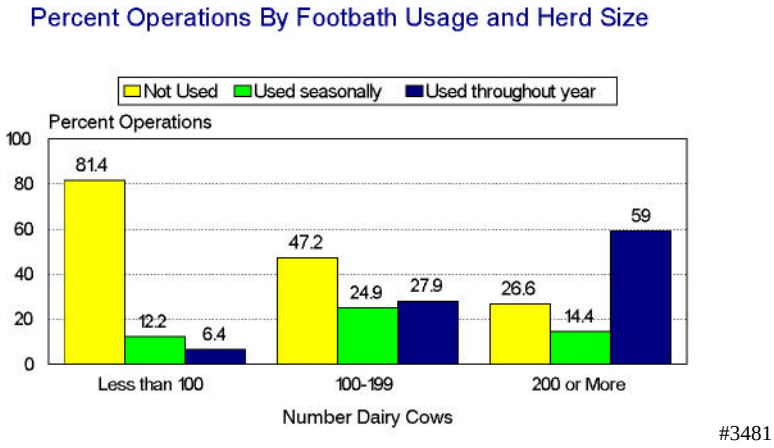
Region	Operation Average Percent	Standard Error	Percent Bred Heifers	Standard Error
West	8.2	(± 1.9)	4.2	(± 0.6)
Midwest	7.2	(± 1.0)	7.9	(± 1.0)
Northeast	7.7	(± 1.2)	9.1	(± 1.0)
Southeast	3.9	(± 2.5)	2.8	(± 0.8)
All regions	7.3	(± 0.7)	6.8	(± 0.5)

Related to lameness preventive practices, footbath use and hoof trimming varied markedly by herd size with increased use as herd size increased. Only 6.4 percent of operations with fewer than 100 dairy cows used footbaths throughout the year. In comparison, 27.9 percent of herds with 100 to 199 cows and 59 percent of herds with 200 or more cows used footbaths throughout the year.

2. Use of foot care/treatment practices

a. Percent of operations by footbath usage and herd size:

	Percent Operations Number Dairy Cows							
Use	Less than 100	Standard Error	100-199	Standard Error	200 or More	Standard Error	Total	Standard Error
No footbath used	81.4	(± 1.7)	47.2	(± 3.4)	26.6	(± 2.9)	72.1	(± 1.5)
Footbath used only seasonally	12.2	(± 1.4)	24.9	(± 3.1)	14.4	(± 2.1)	14.3	(± 1.2)
Footbath used throughout year	6.4	(± 1.0)	27.9	(± 3.3)	59.0	(± 3.2)	13.6	(± 1.0)
Total	100.0		100.0		100.0		100.0	

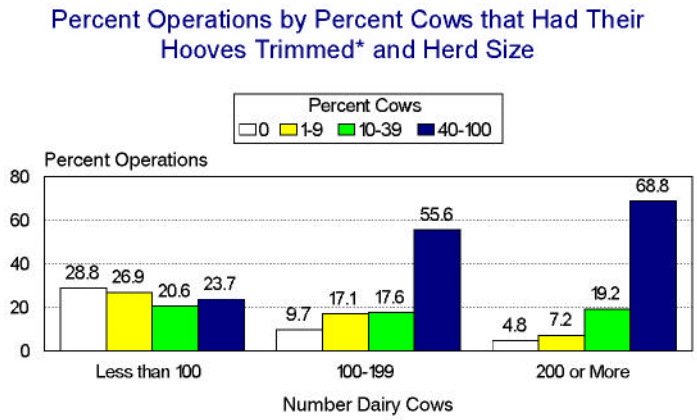


While 23.7 percent of herds with fewer than 100 cows reported 40 percent or more of the cows had hooves trimmed in the previous 12 months, 55.6 percent of herds with 100 to 199 cows and 68.8 percent of those with 200 or more cows reported at least 40 percent of cows had hooves trimmed.

b. Hoof trimming

i. Percent of operations by percent of cows that had their hooves trimmed at least once in the 12 months prior to the Dairy '96 interview by herd size:

	Percent Operations							
	Number Dairy Cows							
Percent of Cows	Less than 100	Standard Error	100-199	Standard Error	200 or More	Standard Error	Total	Standard Error
0	28.8	(± 2.0)	9.7	(± 1.8)	4.8	(± 1.3)	24.1	(± 1.6)
1-9	26.9	(± 2.0)	17.1	(± 2.8)	7.2	(± 1.4)	24.0	(± 1.6)
10-39	20.6	(± 1.8)	17.6	(± 2.6)	19.2	(± 2.3)	20.0	(± 1.5)
40-59	7.6	(± 1.2)	12.5	(± 2.5)	14.4	(± 2.8)	8.8	(± 1.0)
60-89	6.9	(± 1.0)	19.1	(± 2.7)	24.8	(± 3.1)	10.1	(± 0.9)
90-100	9.2	(± 1.1)	24.0	(± 3.0)	29.6	(± 2.8)	13.0	(± 1.0)
Total	100.0		100.0		100.0		100.0	



* At least once in the 12 months prior to Dairy '96 interview.

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Hoof trimming equipment, a potential means to transmit disease, was not routinely washed or chemically disinfected between cows on 69.8 percent of operations that trimmed hooves. Only one-fourth (24.9 percent) of operations routinely washed hoof trimming equipment between cows with water, and less than one-fifth (18.2 percent) of operations routinely chemically disinfected this equipment between cows.

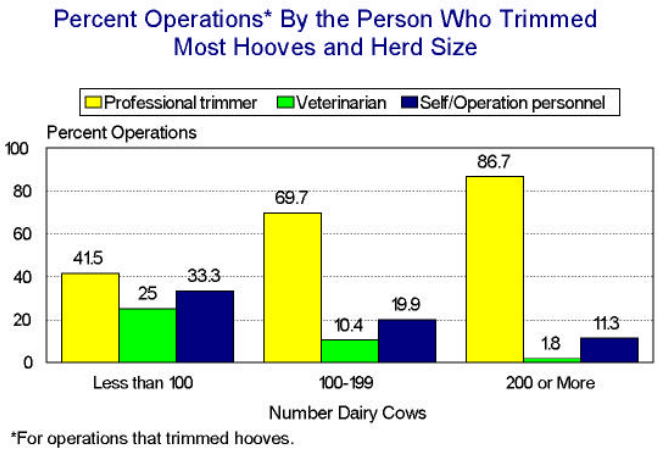
ii. For operations that trimmed hooves in the 12 months prior to the Dairy '96 interview, percent of operations by routine method of cleaning hoof trimming equipment between cows:

Method Between Cows	Percent Operations	Standard Error
Wash with water	24.9	(± 1.9)
Chemically disinfect	18.2	(± 1.7)
Neither wash nor disinfect	69.8	(± 2.0)

As herd size increased, fewer operations used their own personnel or a veterinarian to trim hooves. The person who trimmed the most cow hooves varied by operation size. On 86.7 percent of operations with 200 or more cows, a professional hoof trimmer trimmed the most hooves on the operation, compared to 41.5 percent of dairy operations with less than 100 cows. The veterinarian was the primary hoof trimmer on only 1.8 percent of operations with 200 or more cows compared to 25.0 percent of operations with fewer than 100 cows.

iii. For operations that trimmed hooves, percent of operations by the person who trimmed most hooves and herd size:

	Percent Operations							
	Number Dairy Cows							
Trimmer	Less than 100	Standard Error	100-199	Standard Error	200 or More	Standard Error	Total	Standard Error
Professional hoof trimmer (not this operation's personnel)	41.5	(± 2.5)	69.7	(± 3.6)	86.7	(± 1.9)	50.8	(± 2.0)
Veterinarian (not this operation's personnel)	25.0	(± 2.3)	10.4	(± 2.2)	1.8	(± 1.0)	20.2	(± 1.8)
Self or this operation's personnel	33.3	(± 2.5)	19.9	(± 3.3)	11.3	(± 1.6)	28.9	(± 1.9)
Other	0.2	(± 0.2)	0.0	(± 0.0)	0.2	(± 0.2)	0.1	(± 0.1)
Total	100.0		100.0		100.0		100.0	



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c. For operations that trimmed hooves in the 12 months prior to the Dairy '96 interview, percent of operations where the main hoof trimmer also trimmed cattle hooves on other operations:

Percent Operations	Standard Error
70.6	(± 1.9)

d. For operations that trimmed hooves, percent of operations by number of visits a *professional hoof trimmer* made to the operation and herd size:

	Percent Operations							
	Number Dairy Cows							
Number Visits	Less than 100	Standard Error	100-199	Standard Error	200 or More	Standard Error	Total	Standard Error
0	56.5	(± 2.5)	28.1	(± 3.6)	12.8	(± 1.8)	47.2	(± 2.0)
1	22.9	(± 2.2)	16.9	(± 2.7)	4.3	(± 1.1)	20.1	(± 1.7)
2	12.1	(± 1.5)	16.6	(± 2.4)	11.4	(± 2.2)	12.8	(± 1.2)
3-4	6.9	(± 1.2)	17.8	(± 3.1)	16.3	(± 2.8)	9.8	(± 1.1)
5-9	1.3	(± 0.5)	15.4	(± 2.6)	16.5	(± 2.8)	5.3	(± 0.7)
10 or more	0.3	(± 0.3)	5.2	(± 1.7)	38.7	(± 3.2)	4.8	(± 0.5)
Total	100.0		100.0		100.0		100.0	

e. For operations that trimmed hooves, percent of operations by number of visits a *veterinarian* made to the operation for the purpose of trimming hooves and herd size:

	Percent Operations							
	Number Dairy Cows							
Number Visits	Less than 100	Standard Error	100-199	Standard Error	200 or More	Standard Error	Total	Standard Error
0	58.0	(± 2.6)	68.0	(± 3.7)	85.8	(± 2.5)	62.4	(± 2.0)
1	10.1	(± 1.7)	7.5	(± 2.4)	2.8	(± 1.2)	9.0	(± 1.3)
2	10.1	(± 1.6)	4.9	(± 1.3)	2.8	(± 1.0)	8.5	(± 1.2)
3-4	12.1	(± 1.7)	3.8	(± 1.3)	2.2	(± 0.8)	9.7	(± 1.3)
5-9	6.0	(± 1.2)	7.0	(± 2.2)	3.8	(± 1.8)	5.9	(± 1.0)
10 or more	3.7	(± 1.2)	8.8	(± 2.3)	2.6	(± 0.9)	4.5	(± 0.9)
Total	100.0		100.0		100.0		100.0	

3. Papillomatous digital dermatitis (digital dermatitis or footwarts)

Forty-seven percent of U.S. dairy herds reported cows or bred heifers had ever shown signs of digital dermatitis. This percentage varied by herd size, as 81.9 percent of herds with 200 or more cows reported having had cases compared to 40.5 percent of herds with fewer than 100 cows.

a. Historical distribution of digital dermatitis

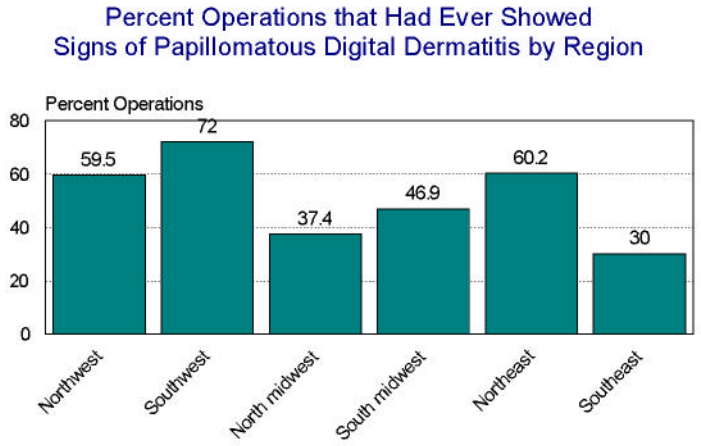
i. Percent of operations where cows or bred heifers had ever shown clinical signs of digital dermatitis by herd size:

Number Dairy Cows	Percent Operations	Standard Error
Less than 100	40.5	(± 2.1)
100-199	63.6	(± 3.5)
200 or more	81.9	(± 2.8)
All herds	47.0	(± 1.8)

While digital dermatitis was reported across the country, differences were noted by region, with the highest percentage of herds affected in the Southwest (72 percent), Northeast (60.2 percent), and Northwest (59.5 percent).

ii. Percent of operations where cows or bred heifers had ever shown clinical signs of digital dermatitis by region:

Region	Percent Operations	Standard Error
Northwest	59.5	(± 4.6)
Southwest	72.0	(± 3.6)
North midwest	37.4	(± 2.9)
South midwest	46.9	(± 4.1)
Northeast	60.2	(± 3.5)
Southeast	30.0	(± 6.5)



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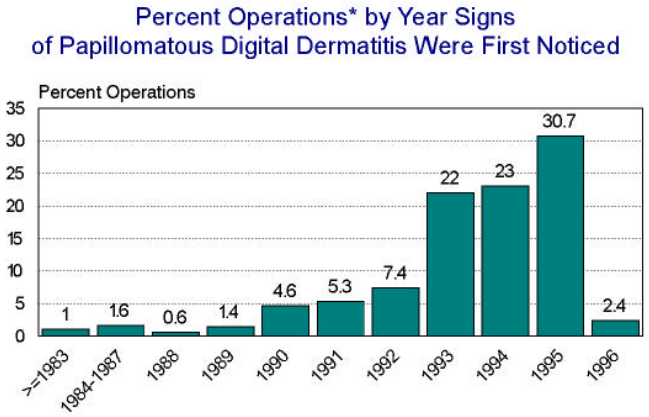
The recent emergence (or at least recent recognition) of digital dermatitis as a disease problem was evident as 78.1 percent of herds reporting digital dermatitis first noted the problem in 1993 or later.

iii. For operations that reported digital dermatitis, percent of operations by year first noticed:

Time Period	Percent Operations	Standard Error
1983 or before	1.0	(± 0.5)
1984-1987	1.6	(± 0.6)
1988	0.6	(± 0.3)
1989	1.4	(± 0.5)
1990	4.6	(± 1.1)
1991	5.3	(± 1.1)
1992	7.4	(± 1.3)
1993	22.0	(± 2.3)
1994	23.0	(± 2.2)
1995	30.7	(± 2.6)
1996 (to date of interview)	2.4	(± 0.7)
Total	100.0	



* For operations that reported papillomatous digital dermatitis.

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In the previous 12 months, affected cows were reported on 43.5 percent of dairy operations and affected bred heifers were reported on 10.7 percent of operations.

b. Incidence of digital dermatitis signs in previous year.

i. Percent of operations where cows had shown clinical signs of digital dermatitis in the 12 months prior to the Dairy '96 interview by herd size:

Number Dairy Cows	Percent Operations	Standard Error
Less than 100	36.4	(± 2.1)
100-199	61.9	(± 3.5)
200 or more	80.3	(± 2.8)
All herds	43.5	(± 1.7)

ii. Percent of operations where cows had shown clinical signs of digital dermatitis in the 12 months prior to the Dairy '96 interview by region:

Region	Percent Operations	Standard Error
Northwest	56.1	(± 4.6)
Southwest	70.3	(± 3.6)
North midwest	35.4	(± 2.8)
South midwest	45.5	(± 4.1)
Northeast	53.1	(± 3.5)
Southeast	20.8	(± 5.0)

iii. Percent of operations by percent of cows[1] (and percent of bred heifers) that showed signs of digital dermatitis in the 12 months prior to the Dairy '96 interview:

	Percent Operations Reporting Signs of Digital Dermatitis			
Percent Dairy Cows (Bred Heifers)	In Dairy Cows	Standard Error	In Bred Heifers	Standard Error
0	56.5	(± 1.7)	89.3	(± 0.9)
0.1-5.0	9.9	(± 1.1)	1.7	(± 0.3)
5.1-10.0	6.7	(± 0.8)	1.9	(± 0.4)
10.1-20.0	9.6	(± 1.0)	3.2	(± 0.5)
20.1-30.0	6.8	(± 0.9)	1.3	(± 0.4)
More than 30.0	10.5	(± 1.1)	2.6	(± 0.5)
Total	100.0		100.0	

1 Percent of cows (and percent of bred heifers) was calculated as the number of cows (bred heifers) showing signs of digital dermatitis divided by cow (bred heifer) inventory at the time of the interview.

Overall, 11.9 percent of cows and 4.2 percent of bred heifers were reported affected in the previous 12 months. These percentages were interpreted in this report as incidences during the 12-month period, since the clinical course of digital dermatitis in affected cows is usually fairly short (within 21 days) after treatment (Read and others, in press).

iv. Percent of all cows (and bred heifers) that had shown clinical signs of digital dermatitis in the 12 months prior to the Dairy ‘96 interview as a percent of cow (and bred heifer) inventory by herd size:

Number Dairy Cows	Percent Cows	Standard Error	Percent Bred Heifers	Standard Error
Less than 100	7.8	(± 0.6)	1.6	(± 0.3)
100-199	14.1	(± 1.3)	5.9	(± 1.3)
200 or more	15.3	(± 1.5)	6.4	(± 1.2)
All herds	11.9	(± 0.7)	4.2	(± 0.5)

Although a greater percentage of *herds* were affected in the Southwest region (70.3 percent, page 15), a greater percentage of *cows* were affected in the Northeast region (15.3 percent).

v. Percent of all cows (and bred heifers) that had shown clinical signs of digital dermatitis in the 12 months prior to the Dairy ‘96 interview as a percent of cow (and bred heifer) inventory by region:

Region	Percent Cows	Standard Error	Percent Bred Heifers	Standard Error
Northwest	12.0	(± 1.8)	3.1	(± 1.0)
Southwest	12.7	(± 2.0)	2.0	(± 0.5)
North midwest	11.2	(± 1.3)	5.6	(± 1.3)
South midwest	9.9	(± 1.0)	2.0	(± 0.4)
Northeast	15.3	(± 1.3)	7.2	(± 1.3)
Southeast	4.7	(± 1.4)	0.6	(± 0.3)

Within positive herds, approximately one in five cows (18.9 percent) were affected. The average percent of cows affected differed only marginally across herd sizes whereas, larger differences in percentage of bred heifers affected occurred across herd sizes.

vi. For herds that had ever had signs of digital dermatitis, operation average percent of cows[1] (and bred heifers) that showed signs of digital dermatitis in the 12 months prior to the Dairy '96 interview by herd size:

	Cows		Bred Heifers	
Number Dairy Cows	Operation Average Percent	Standard Error	Operation Average Percent	Standard Error
Less than 100	17.7	(± 1.2)	3.5	(± 0.8)
100-199	22.1	(± 1.7)	10.6	(± 2.1)
200 or more	19.9	(± 1.6)	13.8	(± 3.9)
All herds	18.9	(± 0.9)	6.2	(± 0.9)

vii. For herds that had ever had signs of digital dermatitis, operation average percent of cows[1] (and bred heifers) that showed signs of digital dermatitis in the 12 months prior to the Dairy '96 interview by region:

	Cows		Bred Heifers	
Region	Operation Average Percent	Standard Error	Operation Average Percent	Standard Error
Northwest	13.5	(± 1.6)	6.4	(± 2.6)
Southwest	15.2	(± 1.3)	3.4	(± 0.9)
North midwest	21.4	(± 1.9)	9.7	(± 2.1)
South midwest	16.5	(± 1.4)	2.5	(± 0.6)
Northeast	19.7	(± 1.6)	5.4	(± 1.1)
Southeast	10.6	(± 3.1)	0.2	(± 0.1)

1 Percent of cows (and percent of bred heifers) was calculated as the number of cows (bred heifers) showing signs of digital dermatitis divided by cow (bred heifer) inventory at the time of the interview.

A high percentage of digital dermatitis-affected cattle were also reported lame (81.9 percent of cows affected and 85.9 percent of bred heifers). Yet, not all affected cattle were lame, and it must be acknowledged that additional affected cattle were probably missed, especially if not lame. A recent study from Chile (Rodriguez-Lainz and others, 1996) indicated that digital dermatitis prevalence in cows detected at the parlor by examination of feet was, on average, twice as high as that reported by herd managers.

An estimated 11.9 percent of cows were reported to have had clinical signs of digital dermatitis in the Dairy '96 study (page 16), with 81.9 percent of these affected cows experiencing lameness. Therefore, 9.7 percent of the U.S. cow population represented experienced digital dermatitis with lameness. This estimate represented 57 percent of the cows reported as clinically lame (17.2 percent, page 7).

c. Of animals with signs of digital dermatitis in the 12 months prior to the Dairy '96 interview, percent that were lame:

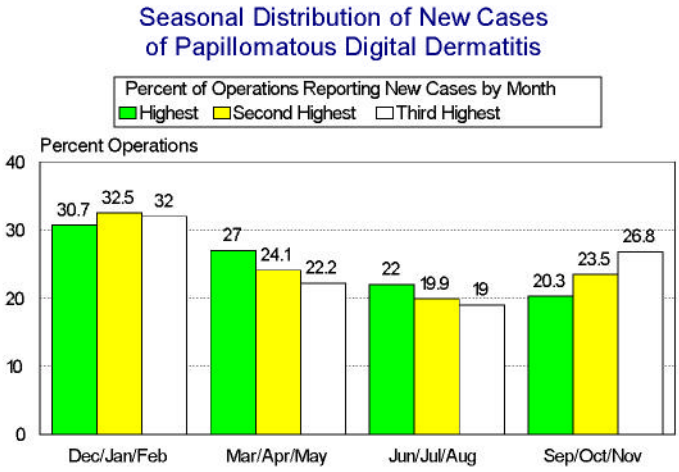
Group	Percent Animals	Standard Error
Cows	81.9	(± 5.6)
Bred heifers	85.9	(± 7.7)
Both cows and bred heifers	82.1	(± 5.4)

An evaluation of the seasonality of digital dermatitis incidence showed that new cases occurred throughout the year within each region. Overall, December through February were the months reported most frequently with the highest, second highest, and third highest number of new cases.

d. Month of onset

i. For operations that had signs of digital dermatitis in cows or bred heifers, percent of operations by the month with the *highest* number of new cases of digital dermatitis based on the previous 12 months by region:

	Percent Operations								
Region	December, January, or February	Stand. Error	March, April, or May	Stand. Error	June, July, or August	Stand. Error	September, October, or November	Stand. Error	Total
Northwest	35.2	(± 7.4)	28.0	(± 6.1)	21.3	(± 5.9)	15.5	(± 4.7)	100.0
Southwest	34.1	(± 5.1)	20.7	(± 4.5)	26.5	(± 4.8)	18.7	(± 3.7)	100.0
North midwest	31.3	(± 4.8)	34.8	(± 5.3)	17.2	(± 3.8)	16.7	(± 3.7)	100.0
South midwest	29.1	(± 5.2)	15.3	(± 3.6)	27.0	(± 4.8)	28.6	(± 6.3)	100.0
Northeast	29.2	(± 4.4)	26.1	(± 4.2)	23.4	(± 4.1)	21.3	(± 3.7)	100.0
Southeast	37.8	(± 15.4)	25.6	(± 14.8)	27.4	(± 12.0)	9.2	(± 5.5)	100.0
All regions	**30.7**	**(± 2.5)**	**27.0**	**(± 2.6)**	**22.0**	**(± 2.1)**	**20.3**	**(± 2.2)**	**100.0**



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ii. For operations that had signs of digital dermatitis in cows or bred heifers, percent of operations by month with the *second highest* number of new cases of digital dermatitis based on the previous 12 months by region:

	Percent Operations								
Region	December, January, or February	Stand. Error	March, April, or May	Stand. Error	June, July, or August	Stand. Error	September, October, or November	Stand. Error	Total
Northwest	21.9	(± 7.1)	29.6	(± 6.6)	15.6	(± 4.2)	32.9	(± 7.4)	100.0
Southwest	37.7	(± 5.4)	16.6	(± 4.3)	21.9	(± 4.3)	23.8	(± 4.6)	100.0
North midwest	24.0	(± 4.9)	33.3	(± 6.1)	18.2	(± 4.1)	24.5	(± 5.0)	100.0
South midwest	35.5	(± 6.3)	15.0	(± 4.0)	27.5	(± 5.2)	22.0	(± 7.2)	100.0
Northeast	40.7	(± 5.2)	20.7	(± 4.2)	17.0	(± 3.9)	21.6	(± 4.0)	100.0
Southeast	17.5	(± 12.4)	27.9	(± 15.5)	25.3	(± 12.0)	29.3	(± 13.8)	100.0
All regions	**32.5**	**(± 2.8)**	**24.1**	**(± 2.8)**	**19.9**	**(± 2.2)**	**23.5**	**(± 2.6)**	**100.0**

iii. For operations that had signs of digital dermatitis in cows or bred heifers, percent of operations by month with the *third highest* number of new cases of digital dermatitis based on the previous 12 months by region:

	Percent Operations								
Region	December, January, or February	Stand. Error	March, April, or May	Stand. Error	June, July, or August	Stand. Error	September, October, or November	Stand. Error	Total
Northwest	34.1	(± 8.2)	16.4	(± 5.0)	13.8	(± 4.3)	35.7	(± 7.9)	100.0
Southwest	28.0	(± 5.0)	17.5	(± 4.8)	26.9	(± 4.7)	27.6	(± 5.1)	100.0
North midwest	28.3	(± 5.8)	19.3	(± 5.5)	24.7	(± 5.1)	27.7	(± 5.3)	100.0
South midwest	34.8	(± 6.3)	20.6	(± 4.6)	9.3	(± 2.4)	35.3	(± 7.0)	100.0
Northeast	36.5	(± 5.2)	26.1	(± 4.8)	18.1	(± 3.9)	19.3	(± 4.1)	100.0
Southeast	13.6	(± 7.3)	52.5	(± 15.3)	4.7	(± 2.7)	29.2	(± 12.3)	100.0
All regions	**32.0**	**(± 2.9)**	**22.2**	**(± 2.7)**	**19.0**	**(± 2.3)**	**26.8**	**(± 2.7)**	**100.0**

4. Sample profile for reporting operations

a. Operations reporting by herd size on January 1, 1996

i. Total cattle and calves on hand:

Size Group	Number Operations Reporting
Less than 50	11
50-99	197
100-399	732
400 or more	271
Unknown	8
Total	1,219

ii. Total dairy cows, dry or milked:

Size Group	Number Operations Reporting
Less than 50	196
50-99	433
100-299	412
300 or more	177
Unknown	1
Total	1,219

iii. Total number of dairy heifers:

Size Group	Number Operations Reporting
Less than 10	34
10-29	152
30-49	251
50-99	365
100 or more	400
Unknown	17
Total	1,219

Note: Data from the above sampled operations were weighted to represent all dairy operations with at least 30 milk cows in the 20 states participating in the study.

D. Inferential Analysis: Herd Factors Associated with Digital Dermatitis Incidence

Distribution of within-herd digital dermatitis incidence in dairy cows and bred heifers in the previous year is shown in the Population Estimates on page 15. A 5 percent incidence of digital dermatitis was used as the cut-off level for this analysis. Dairy operations with a known low incidence of digital dermatitis (less than or equal to 5 percent) were grouped with herds not reporting cases of digital dermatitis to reduce potential misclassification of herds with unrecognized digital dermatitis. Since higher digital dermatitis incidence (i.e., greater than 5 percent) was more likely to be recognized and thus reported, there would be less misclassification using a 5 percent compared to a 0 percent cut point. Thus, an objective of this study was to evaluate the association between herd factors and high (greater than 5 percent) incidence of digital dermatitis.

Univariable associations between herd-level factors and digital dermatitis are shown in Table D1 on the next page. Association of certain variables with digital dermatitis was indeterminate in terms of cause and effect. For example, both level of hoof trimming and use of footbath were strongly associated with digital dermatitis incidence. Since this was a cross-sectional study, however, the temporality of this association could not be assessed. While it is possible that these practices may lead to transmission of digital dermatitis, both of these practices are often implemented as digital dermatitis treatment measures. Therefore, these variables were not included in logistic regression models. Their roles as causes or effects should be evaluated further in other studies. Use of recycled flush water was not used in the logistic model because of the low frequency of usage on dairy operations. Chemical disinfection of hoof trimming equipment between cows was not used in the logistic model since stratified analysis showed it was not associated with digital dermatitis after stratification by washing of hoof trimming equipment between cows.

Table D1. Percent of operations with greater than 5 percent incidence of papillomatous digital dermatitis and univariable associations.

Variable and Level	% Operations with Digital Dermatitis	Standard Error	P-value*
Region:			
West	48.4	(± 3.1)	<0.001
Midwest	29.4	(± 2.0)	
Northeast	43.6	(± 3.4)	
Southeast	17.0	(± 4.9)	
Herd size:			
Less than 100 cows	28.2	(± 1.8)	<0.001
100-199 cows	51.6	(± 3.7)	
200 or more cows	63.2	(± 3.4)	
Land lactating cows access on daily basis in winter:			
Both pasture and drylot	21.0	(± 4.2)	<0.001
Neither pasture nor drylot	39.7	(± 3.1)	
Drylot only	36.6	(± 2.2)	
Pasture only	10.7	(± 3.0)	
Land dry cows access on daily basis in winter:			
Both pasture and drylot	32.1	(± 4.7)	0.003
Neither pasture nor drylot	41.3	(± 3.6)	
Drylot only	34.0	(± 2.2)	
Pasture only	21.2	(± 3.4)	
Surface moisture of ground or floor lactating cows stand on most of the time in winter:			
Always wet/standing water	53.5	(± 3.4)	<0.001
Wet one-half of the time	33.5	(± 3.2)	
Usually dry	28.5	(± 2.3)	
Predominant flooring type that lactating cows walk on:			
Concrete - grooved	49.2	(± 3.0)	<0.001
Concrete - textured	23.7	(± 3.5)	
Concrete - slat or smooth	32.3	(± 2.8)	
Dirt, pasture, or other	23.3	(± 4.1)	
Flush water used for flushing manure from cow housing areas recycled for multiple flushes:			
Yes	57.6	(± 7.6)	0.004
No or no flush water used	33.9	(± 1.6)	
Freestall housing facility used for lactating cows:			
Yes	48.5	(± 2.8)	<0.001
No	28.2	(± 1.9)	

Continued on next page

Table D1 (continued). Percent of operations with greater than 5 percent incidence of papillomatous digital dermatitis and univariable associations.

Variable and Level	% Operations with Digital Dermatitis	Standard Error	P-value*
Tiestall or stanchion housing facility used for lactating cows:			
Yes	30.2	(± 2.2)	<0.001
No	40.7	(± 2.2)	
Drylot housing facility used for lactating cows:			
Yes	31.4	(± 2.2)	0.10
No	37.3	(± 2.5)	
Percent of cow inventory born off the operation:			
0%	15.9	(± 2.1)	<0.001
More than 0 and less than 25%	39.2	(± 2.7)	
25% or more	52.1	(± 3.6)	
Percent of cows that had hooves trimmed at least once in previous 12 months:			
0%	11.0	(± 2.4)	<0.001
1-9%	17.9	(± 3.1)	
10-59%	42.2	(± 3.2)	
60-100%	64.9	(± 3.1)	
Does hoof trimmer also trim cattle hooves on other operations:			
Yes	48.3	(± 2.2)	<0.001
No or no hoof trimming	18.1	(± 2.1)	
Hoof trimming equipment routinely washed with water between cows:			
Yes or no hoof trimming	19.2	(± 2.3)	<0.001
No	45.6	(± 2.1)	
Hoof trimming equipment routinely chemically disinfected between cows:			
Yes or no hoof trimming	19.0	(± 2.3)	<0.001
No	43.7	(± 2.1)	
Footbath:			
Used throughout the year	71.4	(± 3.8)	<0.001
Used only seasonally	52.8	(± 4.8)	
Not used	23.6	(± 1.7)	

*P-value from chi-square tests of independence between independent variables and papillomatous digital dermatitis incidence, with variance adjusted for study design stratification.

Several factors in addition to region and herd size were associated with greater than 5 percent incidence of digital dermatitis in the final logistic regression model (Table D2). These factors included: type of land that lactating cows accessed on a daily basis in winter, percent of cows born off the operation, the primary hoof-trimmer who trimmed hooves on other operations, predominant flooring type where lactating cows walked, and washing of hoof trimming equipment between cows when trimming hooves.

Table D2. Papillomatous Digital Dermatitis Risk Factors for U.S. Dairy Operations, 1995.

Variable and Level	Odds Ratio*	95% Confidence Level
Region:		
West	1.7	0.8-3.9
Midwest	1.8	0.8-4.0
Northeast	3.4	1.5-7.8
Southeast	1.0	——
Herd size:		
Less than 100 cows	1.0	——
100-199 cows	2.0	1.4-3.0
200 or more cows	2.7	1.7-4.5
Land lactating cows access on daily basis in winter:		
Both pasture and drylot	2.0	0.8-4.9
Neither pasture nor drylot	2.6	1.1-6.3
Drylot only	4.3	1.9-9.7
Pasture only	1.0	——
Predominant flooring type that lactating cows walk on:		
Concrete - grooved	2.7	1.5-4.7
Concrete - textured	1.0	——
Concrete - slat or smooth	1.8	1.0-3.1
Dirt, pasture, or other	1.2	0.6-2.4
Percent of cow inventory born off the operation:		
0%	1.0	——
More than 0 and less than 25%	4.1	2.6-6.3
25% or more	7.9	4.9-13.0
Hoof trimmer also trims cattle hooves on other operations:		
Yes	2.8	1.9-4.2
No or no hoof trimming	1.0	——
Hoof trimming equipment routinely washed with water between cows:		
Yes or no hoof trimming	1.0	——
No	1.9	1.2-2.8

* Odds ratio is estimate of relative risk, or increased risk of disease, compared to reference level (where odds ratio = 1).

Two factors associated with digital dermatitis incidence were related to cow hoof environment. Herds where lactating cows had daily access to dry lot outside areas only were at higher risk of digital dermatitis incidence (odds ratio (OR) = 4.3) and those where lactating cows had daily access to neither dry lots or pasture were at intermediate risk (OR= 2.6), compared to the reference population where lactating cows had daily access to pastures only.

A second environmental factor associated with digital dermatitis incidence was flooring type. Herds where the predominant flooring type where lactating cows walked was grooved concrete were at highest risk (OR = 2.7) compared to the reference population of herds with textured concrete flooring. Also at higher risk were herds where the predominant flooring type was smooth or slatted concrete (OR = 1.8).

Causative mechanisms through which these two factors lead to increased digital dermatitis may include concrete abrasive properties, slipperiness, and other factors associated with hoof environment and flooring such as cow housing and cow movement patterns. One potential mechanism, however, through which both of these environmental factors may predispose dairy herds to higher incidence of digital dermatitis is related to exposure of hooves to continual moisture and poor hoof hygiene. Moisture softens hooves which leads to increases in wearing and may lead to hoof abrasions which could provide entry points for microorganisms. Stall moisture has been previously associated with lameness prevalence in Wisconsin and Minnesota herds (Wells and others, 1995). Rodriguez-Lainz and others (1996b) reported an association between digital dermatitis incidence and corral moisture in southern California dairy operations with dirt drylot corrals. In that study, muddiness of the feed bunk and cow loafing areas after rains was evaluated by hoof trimmers, herd veterinarians, and herd managers to assess moisture. In the NAHMS Dairy ‘96 Study, moisture levels, as evaluated by herd managers, were associated with digital dermatitis incidence in the univariable analysis, but not after adjusting for the effects of other variables. One reason for the different findings was the lack of moisture assessment by herd veterinarians and hoof trimmers in this study that was available in the California study. Veterinarians and hoof trimmers may have better reference bases for assessing relative moisture levels than herd managers through visiting large numbers of operations on a regular basis.

The percent of cows born off the dairy operation was strongly associated with digital dermatitis incidence, with evidence for a dose-response relationship, as herds with greater than or equal to 25 percent of cows born off the operation were at much greater risk of high digital dermatitis incidence (OR = 7.9) and those with 1-24 percent of cows born off the operation at intermediate risk (OR = 4.1), compared to herds with no cows born off the operation. Rodriguez-Lainz and others (1996b) previously showed a strong association between introduction of heifers and digital dermatitis prevalence in southern California dairy herds. This NAHMS study supports the finding on a national scale, suggesting that digital dermatitis is initially brought onto dairy operations by affected cows or heifers introduced from other herds. It is also possible that introduced cattle or heifers may have been more susceptible to infection than those already on the operation. While introduction of cattle is unavoidable on most dairy operations, effects of introduction of affected cattle might be reduced by other means, such as careful screening of introduced cattle to prevent disease entry.

The NAHMS Dairy ‘96 Study identified two other biosecurity factors related to digital dermatitis incidence. Herds where the primary hoof trimmer also trimmed cows’ hooves on other operations were 2.8 times more likely to have high incidence of digital dermatitis compared to herds where the

primary hoof trimmer did not trim hooves on other operations or where cows' hooves were not trimmed. Also, herds where hoof trimming equipment was not washed between use on cows were 1.9 times more likely to have high incidence of digital dermatitis than those where the equipment was washed or where no hooves were trimmed. While recognizing the possibility that bringing a hoof trimmer on the operation that also trimmed on other operations may have been an effect, rather than cause of digital dermatitis on some operations, these associations indicate potential transmissibility among cows via fomites (i.e., hoof trimming equipment), emphasizing the contagious nature of this disease and the importance of breaking the chain of transmission through sanitation practices to prevent or reduce spread to other cows and herds.

While region and herd size were associated with digital dermatitis, these variables are surrogates for variations in management practices such as feeding practices and housing systems, climate, and other environmental factors not directly evaluated in this study. Large herds were more likely to report high incidence of digital dermatitis than small or mid-sized herds. Although the West region had the highest incidence (Table D2), the region with the highest risk of digital dermatitis, after adjusting for other factors, was the Northeast. This finding was one indication that the variation in digital dermatitis incidence in the Northeast was not explained as well by other variables in the model, compared to that in the West region.

Strengths of this analysis were the broad geographic distribution of dairy herds representing the various management systems used by dairy producers across the U.S. and the random sampling of producer participants, both of which allowed generalization to the entire U.S. dairy herd. This analysis supported previous research showing association of introduction of cattle with digital dermatitis. In addition, other biosecurity concerns were identified including washing hoof trimming equipment between cows and hoof trimmers who trim cattle hooves on multiple operations. Environmental factors (flooring type and daily access to outside areas) were also identified. These factors need to be considered in digital dermatitis control efforts and evaluated in further research.

A limitation of this study was that reporting of digital dermatitis relied upon retrospective assessments of disease occurrence by herd managers. Many digital dermatitis cases go unrecognized on dairy operations (Rodriguez-Lainz and others, 1996c). Also, some cases of disease are likely to be forgotten through time by producers. This reporting bias could influence risk factor analysis if it changed the digital dermatitis status of the herd. A 5 percent digital dermatitis incidence instead of 0 percent was used to define separate analysis groups to reduce this potential bias.

Based on results from this study, dairy managers should consider their biosecurity programs and cow hoof environment when assessing digital dermatitis control plans. Specific biosecurity management considerations include introduction of noninfected cattle to the operation when purchasing decisions are made and avoidance of fomite transmission through strict sanitary procedures during the hoof trimming process.

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PRODUCTS*

and Related Study Objective(s)

1. Describe baseline dairy health and management practices.

- Part I: Reference of 1996 Dairy Management Practices, May 1996
- Biosecurity Practices of U.S. Dairy Herds, May 1996
- Economic Opportunities for Dairy Cow Culling Management Options, May 1996
- Part II: Changes in the U.S. Dairy Industry, 1991-1996, September 1996
- Management Practices Associated with High-Producing Dairy Herds, February 1997

2. Describe management practices related to production of quality dairy products.

- Part III: Reference of 1996 Dairy Health and Health Management, November 1996
- Antibiotic Injection Practices on U.S. Dairy Operations, February 1997

3. Profile manure management systems.

- Part III: Reference of 1996 Dairy Health and Health Management, November 1996
- Waste Handling Facilities and Manure Management on U.S. Dairy Operations, February 1997

4. Describe the incidence of digital dermatitis (hairy heel warts).

- Digital Dermatitis on U.S. Dairy Operations, February 1997

5. Estimate national and regional prevalances of *M. paratuberculosis* (Johne's disease), bovine leukosis virus, and *Neospora* in adult dairy cows.

- High Prevalence of BLV in U.S. Dairy Herds, February 1997
- M. paratuberculosis on U.S. Dairy Operations, expected summer '97

6. Evaluate factors related to shedding of *Salmonella* and *Escherichia coli* 0157 in adult dairy cows.

* Released as of May 15, 1997. Additional products are planned.

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