The Relationship Between Antibiotic Residue Violations and Somatic Cell Counts in Wisconsin Dairy Herds

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ABSTRACT

The objective of this retrospective observational study was to characterize somatic cell counts (SCC) on Wisconsin dairy farms and to determine the relationship between SCC and the risk of antibiotic residue violation. Monthly official state regulatory data were used when both the bulk tank SCC value and antibiotic test results were available for the same date. Data were collected from Wisconsin dairy farms from January 1995 through November 1998 and consisted of results of tests performed on 805,772 grade A and 176,763 grade B milk samples. Herd-year SCC averages were used to classify herds (≤250,000; 251,000 to 400,000, 401,000 to 550,000, 551,000 to 700,000, >700,000), and the relative risk of antibiotic residue by SCC class was determined. Arithmetic mean SCC values were 334,634 and 480,029 for grade A and grade B milk, respectively. SCC values were significantly higher for samples with positive antibiotic residue tests for grade A milk during all 4 yr tested. The SCC values were significantly higher for samples with positive antibiotic residue tests for grade B milk for 3 of 4 yr. The rate of antibiotic residue violation per 1000 herd-years increased with SCC class for both grade A and grade B milk. The relative risks of antibiotic residue violation by SCC class were 1.0, 1.43, 2.38, 2.78, and 7.10 for grade A milk and 1.0, 1.11, 2.67, 4.33, and 5.43 for grade B milk. Programs to reduce the level of subclinical mastitis on dairy farms may have an additional benefit of reducing the risk of antibiotic residue violations.
(**Key words:** antibiotic residues, somatic cell counts, inhibitors, milk quality)

INTRODUCTION

Antibiotic residues in milk are a rare result of treatment of dairy cattle with antibiotics. Antibiotic residues are undesirable for public health reasons and because of their potential impact on the manufacturing process (Allison, 1985). United States milk regulations prohibit the presence of antibiotics in milk intended for human consumption (Anonymous, 1997b). The desire to protect hypersensitive individuals from exposure to specific antibiotics (primarily penicillin) and to reduce the remote possibility of the emergence of antibiotic resistant organisms in milk has resulted in an effective and extensive surveillance program for detection of antibiotic residues. A number of studies have looked at causes of antibiotic residues in milk (Booth and Harding, 1986; McEwen et al., 1991; Oliver et al., 1990; Wilson et al., 1998). The treatment of mastitis is the most common reason that antibiotics on dairy farms (Allison, 1985). The use of lactating and dry cow intramammary antibiotics and mistakes regarding withholding periods of milk are the most frequently cited reasons for antibiotic residues (Booth and Harding, 1986; McEwen et al., 1991). Bulk tank SCC measures the prevalence of IMI in dairy herds (Eberhart et al., 1982). The prevalence of contagious pathogens such as *Streptococcus agalactiae* and *Staphylococcus aureus* are associated with bulk milk SCC levels (Wilson et al., 1997). A large majority of dairy producers believe that residues are important, but few believe that a violation is likely to occur on their farm (Wilson et al., 1998). In one study, farmers who experienced a drug residue violation used more intramammary treatments and did not seek veterinary advice as frequently as farmers who did not (McEwen et al., 1991). Identification of risk factors to discriminate between farms that are at higher risk for antibiotic residues would allow cost-effective targeting of regulatory, educational, and consultative resources. The objective of this retrospective observational study was to characterize SCC on Wisconsin dairy farms and to determine the relationship between SCC and the risk of antibiotic residue violation.

MATERIALS AND METHODS

Data for this retrospective study were obtained from the Wisconsin Department of Agriculture, Trade and Consumer Protection. The data included results of official milk quality tests from all licensed dairy farms in the state of Wisconsin for the period of January 1995 through November, 1998. The data included SCC, re-

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sults of antibiotic residue screening tests, herd identification, and various regulatory results. The data were reduced to include only the first official regulatory sample each month to ensure that multiple tests on individual farms were excluded. Separate analyses were performed for grade A and grade B milk. Each monthly SCC result was classified as Low (SCC ≤250,000), Medium (SCC 251,000 to 600,000), or High (SCC > 600,000). Monthly data were also classified into four seasons: Winter (December to February), Spring (March to May), Summer (June to August), and Fall (September to November). Descriptive statistics were calculated for the classified data using PROC FREQ of SAS (1990). For analyses related to antibiotic residues, data were included if both the bulk tank SCC and antibiotic test results were available for the same date. The SCC of herds with at least one residue violation within a calendar year were compared to herds without residue violations using PROC GLM. Herd-year SCC averages were calculated for herds that had 12 monthly data points per year (for 1998, herd-year SCC were calculated for herds with 11 mo of data). Herd-year SCC were used to classify the herds into one of five SCC categories: ≤250,000; 251,000 to 400,000; 401,000 to 550,000; 551,000 to 700,000; and >700,000 cells/ml. The rate of violative residue for each SCC category was calculated as the number of positive residue tests per 1000 herd-years. PROC FREQ was used to determine the relationship between SCC class and residue violation. Epi-Info (2000) was used to calculate the relative risk of residue by SCC class. Data from grade A SCC class ≤250,000 were used as the baseline comparison to calculate relative risk for both grade A and grade B milk.

RESULTS AND DISCUSSION

Descriptive Statistics

The original data consisted of results from 933,578 grade A milk samples and 190,910 grade B milk samples. After exclusion of retested samples and samples with incomplete data, the final data set consisted of results from 805,772 grade A milk tests and 176,763 grade B milk tests. Testing for SCC is not performed on most milk samples that test positive for antibiotics. Therefore, the samples with positive antibiotic residue tests and SCC values for the same date were a subset of the overall number of antibiotic residue violations. There is no systemic reason that samples testing positive for antibiotic residues are selected for SCC testing (Tom Leitzke, 1998, personal communication, Wisconsin Dept. of Agriculture, Trade and Consumer Protection, so selection bias should not influence the results of this study.

The arithmetic mean SCC was 334,634 (SD 198,324) and 480,029 (SD 306,850) for grade A and grade B tests, respectively. Median SCC were 290,000 and 420,000 for grade A and grade B tests, respectively. The mean SCC are slightly higher than other recent reports documenting milk shed SCC values. Allore et al. (1997) reported an arithmetic mean SCC of 326,000 cells/ml in 3450 herds located in New York, New Jersey, and Pennsylvania. The USDA Centers for Epidemiology and Animal Health surveyed 35% of US milk from 1994 to 1997 and reported a geometric mean value of 297,000 cells/ml (Anonymous, 1997a). Our SCC results may have been higher because data were not adjusted for volume of milk shipped. In our study, there was no way to discriminate between large and small herds, and SCC is reported to decline as herd size increases (Anonymous, 1997a). The distribution of herds into SCC categories differed by grade (Table 1). More grade B tests were classified as High and fewer grade B tests were classified as Low than were grade A tests. The USDA study reported that >70% of US dairy herds and milk meet the European standard for ≤400,000 cells/ml (Anonymous, 1997b). In our study, 91% of grade A SCC tests were ≤600,000 cells/ml, but only 73% of grade B tests met this standard. Minor differences in the distribution of herds across SCC classification occurred by year, but trends were not apparent for either grade.

The SCC classification was associated with season for both grades of milk (Table 2). More SCC tests were classified as high during the summer compared with the other seasons. Seasonal trends in SCC values are well recognized (Allore et al., 1997; Anonymous, 1997a) and are generally attributed to environmental conditions that encourage exposure to mastitis causing pathogens.

Monthly SCC Data

The SCC values were significantly higher for samples with positive antibiotic residues tests for grade A milk during all 4 yr studied (Table 3). SCC values were significantly higher for samples with positive antibiotic residues for grade B milk for 3 of 4 yr (Table 3). The difference in mean SCC between grade A herds that experienced positive antibiotic residues and herds that did not was 93,000 to 132,000 cells/ml depending on year analyzed. For 3 out of 4 yr, the mean SCC values for grade B herds that experienced positive antibiotic residue results exceeded 600,000 cells/ml (Table 3). The extremely poor SCC values reported for these herds (in the bottom 10% of SCC values reported by the state) indicate that milk quality was not a priority on these farms.

Table 1. Percentage of SCC tests by year, grade, and SCC category[1] for Wisconsin dairy farms, January 1995 to November 1998.

Year	Grade	SCC Classification			Chi-square
		Low	Medium	High	P value
		%			
1995	A	41.32	50.39	8.30	
	B	23.89	50.34	25.77	
1996	A	39.64	51.39	8.96	
	B	21.81	50.15	28.05	
1997	A	40.55	50.88	8.57	
	B	23.20	49.42	27.38	
1998[2]	A	39.70	51.59	8.70	
	B	23.17	50.57	26.25	
Overall %	A	40.34	51.03	8.63	
(Number)		(376,632)	(476,414)	(80,532)	
	B	23.02	50.11	26.86	$X^2 = 57{,}713$
		(43,953)	(95,670)	(51,287)	$P < 0.0001$

[1]Low (SCC ≤250,000), medium (SCC 251,000 to 600,000), high (SCC >600,000).

[2]January to November data only are included.

Table 2. Percentage of SCC tests by grade, season[1], and SCC category[2] for Wisconsin dairy farms, January 1995 to November 1998.

Grade	Season[1]	SCC Classification[2]			Chi-Square
		Low	Medium	High	P value
		%			
A	Winter	44.68	47.51	7.81	
	Spring	41.98	49.77	8.25	
	Summer	34.24	55.34	10.43	
	Fall	40.73	51.32	7.95	
Overall %		40.34	51.03	8.63	$X^2 = 6{,}111$
(Number)		(376,632)	(476,414)	(80,532)	$P < 0.0001$
B	Winter	25.21	48.72	26.07	
	Spring	25.19	49.85	24.96	
	Summer	19.69	50.91	29.39	
	Fall	22.00	50.94	27.06	
Overall %		23.02	50.11	26.86	$X^2 = 678$
(Number)		(43,953)	(95,670)	(51,287)	$P < 0.0001$

[1]Winter (December to February), spring (March to May), summer (June to August), fall (September to November).

[2]Low (SCC ≤250,000), medium (SCC 251,000 to 600,000), high (SCC >600,000).

Table 3. SCC values by grade, year, and antibiotic residue status[1] for Wisconsin dairy farms, January 1995 to November 1998.

Year	Antibiotic residue status[1]	Grade A milk samples			Grade B milk samples		
		Number	SCC LSMEAN	P-value	Number	SCC LSMEAN	P-value
1995	Yes	71	422,493		29	662,414	
	No	228,347	329,412	0.0001	53,675	469,649	0.0005
1996	Yes	87	458,897		36	636,944	
	No	210,679	338,796	0.0001	48,050	492,782	0.0070
1997	Yes	83	455,169		34	717,059	
	No	197,516	335,003	0.0001	41,745	481,929	0.0001
1998	Yes	52	468,500		15	558,000	
	No	168,937	335,870	0.0001	33,179	475,351	0.2883

[1]"Yes" indicates that the herd had at least one antibiotic residue violation within the indicated calendar year.

Table 4. Frequency of antibiotic residue violations by herd-year SCC classification for Wisconsin dairy farms, January 1995 to November 1998.

Detected antibiotic residue		SCC cells/ml (in thousands)				
		≤250	251 to 400	401 to 550	551 to 700	>700
Grade A milk						
No	Number of herd-years	15,897	19,896	9,981	3,441	512
Yes	Number of herd-years	43	77	64	26	10
Detected residues per 1000 herd-years		2.70	3.90	6.40	7.50	19.20
Relative risk of antibiotic residue		1.00[1a]	1.43[ab]	2.38[b]	2.78[bc]	7.10[c]
Grade B milk						
No	Number of herd-years	1604	3059	2891	2031	1437
Yes	Number of herd-years	1	13	21	24	21
Detected residues per 1000 herd-years		0.60	4.20	7.20	11.70	14.40
Relative risk of antibiotic residue			1.11[2a]	2.67[ab]	4.33[b]	5.34[b]

[1]Used as baseline for calculation of relative risk for both grade A and grade B milk samples.

[2]Relative risk calculated by combining data for SCC classification up to 400,000.

[a,b,c]Relative risks within a row without a common superscript vary ($P < 0.05$).

Herd-Year Data

There were 49,857 grade A herd-years and 11,102 grade B herd- years included in the final analysis. Herd-year SCC class was related to the frequency of residue violation for both grade A and grade B milk ($P < 0.0001$). An increasing frequency of residue violation was seen as herd-year SCC increased (Table 4). The relative risk of antibiotic residue violation was not significantly different between herd-year classes until herd-year SCC exceeded 400,000 cells/ml. The relative risk of antibiotic residue violation increased with herd-year SCC class after herd-year SCC exceeded 400,000 cells/ml. The highest rate of antibiotic residue violation was seen in grade A herds with a herd-year SCC value of >700,000 cells/ml. The risk of antibiotic residue violation for herds in this category was 7 times greater than the risk of antibiotic residue violation for grade A herds with herd-year SCC ≤250,000. The overall Mantel- Haenszel weighted relative risk of antibiotic residue was 2.11 ($P < 0.0001$) and 2.77 ($P < 0.0001$) for grade A and grade B milk, respectively, indicating that herd-year SCC >250,000 results in a doubling of the risk of experiencing a violative antibiotic residue.

High SCC values indicate that the herd has a high prevalence of subclinical mastitis, most commonly caused by *S. aureus* or *S. agalactiae* although other pathogens may be involved (Wilson, 1997). It is reasonable to expect herds with high SCC may be treating cows with intramammary antibiotics. An increased frequency of use of lactating and dry cow intramammary antibiotics has been related to the occurrence of antibiotic residue violations (Allison, 1985; McEwen et al., 1991). Additional risk factors include variation in antibiotic dosage or duration and the use of multiple drugs for treatment (Oliver et al., 1990). In our study the highest rate of violative antibiotic residue occurred in grade A herds with herd-year SCC >700,000 cells/ml. The US regulatory limit for SCC is 750,000 cells/ml (Anonymous, 1997b). Repeated violations of this limit result in significant financial penalties and potential loss of grade A status. Herds in danger of violation of the SCC limit are possibly treating more cows with antibiotics in an attempt to reduce the SCC and maintain their grade A milk permits.

Most producers do not believe that an antibiotic residue violation is likely to occur on their farm (Wilson et al., 1998). However, the most commonly cited reasons for antibiotic residue violations are mistakes in withholding periods for milk after antibiotics have been administered or the accidental use of milk from antibiotic-treated cows (Booth and Harding, 1986; Wilson et al., 1998). Fewer than half of Wisconsin dairy farmers included in a small survey reported that all cows that received antibiotic treatments had a written treatment record (Wilson et al., 1998). Farmers who experienced antibiotic residue violations have been shown to seek less veterinary advice before treating cows with intramammary antibiotics compared with farmers who did not experience residue violations (McEwen et al., 1991). This study indicates that herds with high SCC are at increased risk for antibiotic residue violations. The identification of critical control points is one part of a Hazard Analysis Critical Control Program. A critical control point for antibiotic residues may be reduction in the prevalence of contagious mastitis on dairy farms (as evidenced by low SCC). Most dairy farms do an excellent job of preventing antibiotic residues in milk. The targeting of veterinary advice, educational programs, and regulatory efforts toward high SCC farms may be the most cost effective way to proceed with antibiotic residue prevention programs.

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