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Supplemental Table S1. Description of Bedding Types and Bedding Processing Practices for 168 Dairy Farms Participating in the Study

Parameter	Number	Percentage
Bedding type used [1]		
Manure Solids	33	19.6
Organic Non-Manure	58	34.5
Shavings	34	20.2
Straw	17	10.1
Other Organic [2]	7	4.2
Reclaimed Sand	31	18.5
New Sand	46	27.4
Manure Solids Herds		
Basic Processing		
Composted	10	30.3
Digested	2	6.0
Sun dried	9	27.3
Raw/Green	12	36.4
Screw Press		
Yes	19	55.9
No	15	44.1
Mechanical drying		
Yes	4	11.8
No	30	88.2
Reclaimed Sand Herds		
Method of separation		
Mechanical	10	32.3
Passive sand lanes	21	67.7
Storage method		
Covered / housed	9	29.0
Uncovered	22	71.0
New Sand Herds		
Sand type		
Sugar sand	15	39.5
River sand	23	60.5
Washed prior to purchase		
Yes	19	42.2
No	26	57.8

[1] Results are reported for winter (2016) survey only. Note: For summer (2016) survey, 2 NS herds had converted to MS, one NS herd had converted to RS, 2 MS herds had converted to OB, one MS herd had converted to RS, and one O herd had converted to MS.

[2] Other organic materials sampled included corn stalks (n=1), casella organics (n=1), fiber bed (n=1), rice hulls (n=1), or mixes including shavings + paper (n=1), shavings + sunflower hulls (n=1) and manure solids + ash (n=1).

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Supplemental Table S2. Description of Housing and Bedding and Manure Management for 168 Dairy Farms Participating in the Study

Parameter	Categorical Descriptors		Continuous Descriptors	
	Number	Percentage	Mean (SD)	Range
Lactating cow housing				
Primary housing				
Bedded pack	7	4.2		
Dry lot	4	2.4		
Tie-stall	13	7.7		
Free stall	144	85.7		
Brisket locator in stall for free stalls and tie-stalls				
Yes	76	55.4		
No	70	44.6		
Laying surface				
Deep bedded [1]	110	65.5		
Mattress or concrete	58	34.5		
Ventilation				
Ventilation system				
Mechanical - cross ventilated	9	5.4		
Mechanical - tunnel ventilation	25	14.9		
Natural - curtain barn	4	2.3		
Natural - dry lot (open)	130	77.4		
Adequacy of ventilation - reported by producer				
Good	135	80.4		
Fair	32	19.0		
Poor	1	0.6		
Access to outside paddock				
Yes	35	20.8		
No	133	79.2		
Free stall stocking density (cows/stalls; %)	144		107.5 (15.4)	37.5 - 150
Dry lot or bedded pack stocking density (m^2 per cow)	11		20.1 (16.0)	6.1 - 48.8
Bedding Management in Cow Resting Area				
Bedding depth (cm)	168		17.3 (15.0)	0.64 - 91.4
Frequency scrape stalls or resting surface (times/wk)	166		16.3 (7.5)	0.04 - 56
Frequency scrape alleyways (times/wk)	166		27.9 (38.7)	0.2 - 337
Frequency of adding new bedding (times/wk)	166		20.5 (16.9)	0.1 - 28
Frequency tilling/raking yard or bedded pack (times/wk)	11		8.0 (6.2)	0 - 14
Use of bedding conditioner				
Yes	18	10.7		
No	150	89.3		
If yes, frequency add conditioner (times/month)	17		20.5 (16.9)	2 - 56
Complete removal/replacement of deep bedding [1]				
Yes - regularly	22	20.0		
Yes - infrequently	23	20.9		
Never	65	59.1		
If yes, weeks from replacement to sampling [2]	76		44.7 (48.5)	0 - 276

[1] Considers herds using deep bedding in free stalls, bedded packs or dry lots

[2] Reported for both summer and winter sampling events

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Supplemental Table S3. Description of Routine Milking Procedures for 168 Dairy Farms Participating in the Study

Parameter	Number	Percentage
Milking Frequency		
2X	90	53.6
3X	78	46.4
Milking System		
Parlor (herringbone/parallel/rotary)	149	88.7
Automatic milking system (robot)	7	4.2
Tie stall barn milking	12	7.1
Frequency of washing/spraying milking units		
Routinely between milking individual cows	44	26.3
Routinely between pens	36	21.6
Occasionally, only if unit gets soiled	87	52.1
Routinely Forestrip as part of milking preparation		
Yes	146	86.9
No	22	13.1
Routine use of pre-dip		
Yes	158	94.1
No	10	5.9
Use of automatic teat scrubber		
Yes	18	10.7
No	150	89.3
Routinely wipe teats dry prior to unit attachment		
Yes	147	87.5
No	21	12.5
Routine use of post-dip after unit detachment		
Yes	166	98.8
No	2	1.2

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Supplemental Table S4. Description of Mastitis Control Practices for 168 Dairy Farms Participating in the Study

Parameter	Number	Percentage
Primary method for detecting clinical mastitis		
Forestrip during milking preparation in parlor	151	90.4
Other	16	9.6
Records are kept of clinical mastitis events		
Always	118	70.2
Sometimes	29	17.3
Never	21	12.5
Method of recording clinical mastitis events		
Computerized records	92	62.6
Paper records	55	37.4
Do you culture milk from clinical mastitis cases?		
Always	52	30.9
Sometimes	66	39.3
Never	50	29.8
Do you culture milk from fresh cows?		
Always	16	9.5
Sometimes	38	22.6
Never	114	67.9
Do you culture milk from cows with an elevated SCC?		
Always	14	8.3
Sometimes	78	46.4
Never	76	45.2
Location of lab used for bacteriological culture of milk		
On-farm lab only	37	28.0
Local veterinary clinic lab only	61	46.2
Reference lab (e.g. university or state lab) only	23	17.4
Combination of labs (on farm / local vet / reference lab)	11	8.3
Long acting intramammary antibiotic infused at dry off		
Always	161	95.8
Sometimes	3	1.8
Never	4	2.4
Internal or external teat sealant applied at dry off		
Always	135	80.4
Sometimes	1	0.6
Never	32	19.0
Nulliparous heifers are treated prior to first calving		
Heifers are pretreated with either teat sealant or antibiotic	12	7.2
No, heifers are not pretreated	154	92.8
Cows are routinely vaccinated to prevent mastitis		
Yes	130	77.4
No	38	22.6
Udders are clipped or flamed		
Yes	88	52.4
No	80	47.6
Tail switch management		
Tails are docked	80	47.6
Switches are trimmed	55	32.7
No tail docking or switch trimming	33	19.6

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Supplemental Table S5. Results of univariable analysis identifying factors that were unconditionally associated with at least one of the four udder health outcome parameters at P < 0.20. Table reports Coefficient estimate (SE), P value for udder health outcome variables.

Explanatory Variable of Interest	Categories	Udder Health Measure (Dependent Variable)			
		AVLS	IMI [2]	NIMI [3]	CRON [4]
New Bedding (log_{10} cfu/cc) [1]					
Total Bacteria Count		2.37 (0.07) , 0.25	0.51 (0.24), 0.037	0.39 (0.12), 0.002	0.10 (0.16), 0.52
Coliforms		0.023 (0.015), 0.12	0.84 (0.29), 0.005	0.51 (0.14), 0.0003	0.20 (0.18), 0.25
Klebsiella spp.		0.060 (0.021), 0.004	1.11 (0.37), 0.004	0.56 (0.21), 0.01	0.36 (0.24), 0.14
SSLO [5]		0.022 (0.012), 0.069	0.49 (0.22), 0.024	0.25 (0.11), 0.023	0.14 (0.14), 0.34
Staph [6]		0.034 (0.018), 0.066	1.02 (0.33), 0.002	0.30 (0.18), 0.10	0.78 (0.21), 0.0002
Used Bedding (log_{10} cfu/cc) [1]					
Total Bacteria Count		-0.019 (0.047), 0.69	-0.014 (0.84), 0.99	0.16 (0.46), 0.74	-0.59 (0.55), 0.28
Coliforms		0.016 (0.017), 0.35	0.84 (0.29), 0.005	0.38 (0.16), 0.016	0.47 (0.19), 0.016
Klebsiella spp.		0.011 (0.012), 0.34	0.41 (0.21), 0.059	0.054 (0.12), 0.65	0.31 (0.14), 0.027
SSLO [5]		0.014 (0.02), 0.48	-0.069 (0.37), 0.85	0.049 (0.20), 0.81	-0.15 (0.24), 0.53
Staph [6]		0.011 (0.009), 0.21	0.44 (0.16), 0.005	0.34 (0.09), 0.0001	0.16 (0.10), 0.12
Bedding type (vs. New sand)	Manure solids	0.27 (0.10), 0.019	3.86 (1.76), 0.13	3.07 (0.71), <0.0001	2.05 (1.21), 0.24
	Organic non-manure	0.093 (0.098)	2.05 (1.69)	0.27 (0.63)	1.35 (1.18)
	Reclaimed sand	-0.035 (0.11)	0.25 (1.94)	0.42 (0.75)	-0.19 (1.34)
Predominant breed (vs. Other)	Holstein	-0.38 (0.14), 0.007	-5.02 (2.37), 0.035	-2.44 (0.90), 0.0077	-2.30 (1.72), 0.083
Herd size (vs. ≤ 200 cows)	> 500	-0.052 (0.096), 0.076	-1.25 (1.66), 0.38	2.26 (0.61), 0.0003	-2.04 (1.15), 0.052
	201 to 500	-0.23 (0.10)	-2.50 (1.81)	0.33 (0.67)	-2.94 (1.24)
Milk yield (kg/year) (vs. low ≤ 10,000)	High (> 12,000)	-0.53 (0.12), <0.0001	-8.34 (2.01),0.0002	-1.44 (0.79), 0.15	-6.04 (1.43), 0.0002
	Moderate	-0.45 (0.11)	-6.87 (1.98)	-1.46 (0.79)	-4.89 (1.41)
Test day average DIM		0.005(0.001),<0.0001	0.063 (0.023),0.007	0.033 (0.012), 0.007	0.048 (0.015), 0.002
Region (vs. West)	Midwest	-0.069 (0.12), 0.035	-2.21 (2.06), 0.003	-3.14 (0.78),<0.0001	-1.47 (1.42), 0.003
	Northeast	-0.42 (0.17)	-9.52 (2.80)	-5.18 (1.06)	-6.18 (1.94)
	South	-0.19 (0.22)	-5.61 (3.66)	-1.51 (1.40)	-5.64 (2.69)
Season (vs. Winter)	Summer	0.0003 (0.028), 0.99	1.10 (0.51), 0.03	0.22 (0.32), 0.49	0.48 (0.32), 0.14
Lactating cow housing (vs. Free stall)	Bedded Pack	0.50 (0.18), 0.013	4.91 (3.06), 0.022	1.27 (1.43), 0.63	6.82 (2.20), 0.003
	Dry lot	0.33 (0.22)	0.62 (3.73)	1.62 (1.56)	1.32 (2.54)
	Tie-stall	0.33 (0.15)	7.45 (2.50)	-0.14 (1.0)	5.01 (1.72)

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Ventilation system (vs. Tunnel)	Cross	-0.019 (0.18), 0.14	-0.057 (3.19), 0.09	-0.28 (1.33), 0.73	0.87 (2.16), 0.03
	Natural / Dry lot	-0.21 (0.11)	-3.89 (1.91)	-0.57 (0.74)	-2.95 (1.32)
Ventilation (vs. Good)	Fair or Poor	0.27 (0.10), 0.009	5.08 (1.74), 0.004	0.48 (0.67), 0.48	3.93 (1.21), 0.002
Access outside yard (vs. No)	Yes	0.28 (0.080), 0.0006	2.59 (1.42), 0.071	1.62 (0.62), 0.011	1.91 (0.96), 0.049
Milking system (vs. Tie stall)	Parlor	-0.26 (0.15), 0.23	-7.38 (2.54), 0.015	-0.13 (1.03), 0.95	-4.09 (1.75), 0.061
	Robot	-0.23 (0.25)	-8.14 (4.19)	0.27 (1.65)	-4.95 (2.92)
Spray off milking unit (vs. occasionally)	Between cows	-0.19 (0.099), 0.17	-2.45 (1.68), 0.34	-0.19 (0.64), 0.38	-1.12 (1.19), 0.61
	Between pens	-0.051 (0.11)	-0.39 (1.80)	0.81 (0.68)	-0.75 (1.27)
Predip use (vs. No)	Yes	-0.24 (0.18), 0.18	-5.49 (2.96), 0.066	1.16 (1.12), 0.30	-4.68 (2.07), 0.025
Mechanical Teat scrubber (vs. No)	Yes	0.085 (0.13), 0.51	2.66 (2.17), 0.22	1.55 (0.84), 0.068	1.13 (1.51), 0.46
Wipe teats dry (vs. No)	Yes	-0.13 (0.13), 0.31	-2.94 (2.12), 0.17	-0.14 (0.80), 0.86	-2.35 (1.48), 0.12
Postdip use (vs. No)	Yes	-0.65 (0.38), 0.089	-4.63 (6.48), 0.48	0.96 (2.42), 0.69	-6.03 (4.53), 0.19
Tail switch management (vs. Nothing)	Dock tails	-0.10 (0.10), 0.22	-0.63 (1.78), 0.49	-1.15 (0.68), 0.13	0.023 (1.24), 0.48
	Trim switch	0.053 (0.11)	1.29 (1.95)	-0.16 (0.74)	1.31 (1.37)
Culture clinical mastitis (vs. Never)	Always	0.03 (0.10), 0.81	0.17 (1.77), 0.90	1.74 (0.66), 0.03	-0.79 (1.24), 0.41
	Sometimes	0.063 (0.099)	0.71 (1.69)	0.75 (0.63	0.65 (1.18)
Culture fresh cows (vs. Never)	Always	0.030 (0.14), 0.93	-0.63 (2.31), 0.46	2.89 (0.90), 0.006	-1.57 (1.64), 0.34
	Sometimes	0.035 (0.095)	1.84 (1.63)	0.64 (0.62)	0.97 (1.13)
Culture high SCC cows (vs. some/never)	Always	-0.30 (0.14), 0.03	-6.04 (2.32), 0.01	-1.61 (0.92), 0.08	-3.67 (1.61), 0.024
Dry off antibiotic (vs. some/never)	Always	-0.20 (0.19), 0.29	-4.73 (3.21), 0.14	0.50 (1.31), 0.71	-4.18 (2.18), 0.057
Dry off teat sealants (vs. some/never)	Always	-0.056 (0.093), 0.54	-1.21 (1.61), 0.45	-0.15 (0.68), 0.82	-1.83 (1.10), 0.10
Pretreat heifers (vs. some/never)	Always	-0.28 (0.16), 0.08	-3.16 (2.73), 0.25	-0.89 (1.02), 0.38	-1.86 (1.92), 0.33
Bulk tank Mycoplasma culture (vs. Neg)	Positive	0.25 (0.09), 0.006	3.45 (1.65), 0.038	2.04 (0.90), 0.025	2.01 (2.06), 0.059
Bulk tank Staph aureus culture (vs. Neg)	Positive	0.11 (0.05), 0.013	2.00 (0.82), 0.016	1.00 (0.44), 0.024	0.57 (0.54), 0.29

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Significant if $P \leq 0.05$; Trend if $0.05 < P \leq 0.10$
[1] BBC (log_{10},cfu/cc); modeled separately for unused and used bedding, and for each bacteria group
[2] IMI: Proportion of cows on test day with Linear Score ≥ 4.0
[3] NIMI: Proportion of cows with LS < 4.0 on previous test day and LS ≥ 4.0 on current test day.
[4] CRON: Proportion of cows with LS ≥ 4.0 on both the previous and current test day.
[5] SSLO: Streptococci or streptococci-like organisms [6] Staph: *Staphylococci* spp.