Association between farm management practices and the development of disease in the digestive and respiratory tract in young stock on Dutch dairy farms

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Preface

Initially this study aimed to investigate which management factors contributed to the development of diarrhea or respiratory disease in veal calves. Then, the question arose whether an optimum age for transferring calves from individual housing to group housing could be found, considering the development and prevention of diarrhea and respiratory disease. Little variability was observed in days spent in individual housing. An association with development of disease was not found.
While exploring the data many relevant bio-medical, food related and environmental determinants for disease development were found.

Abstract

Data used in this paper was collected in a telephonically taken questionnaire within 200 Dutch dairy farmers with relatively high or low antibiotic usage in the calves in the age up to 56 days, over the period of June 2012 up to June 2013. Assumed is that by merging these two, evenly distributed, groups a relevant, average overview of the Dutch dairy sector was established.
This study shows that on 63% of the farms diarrhea is a problem in the young calves. On 37.5% of the farms respiratory disease is a problem. The calves get an average of 5.89 liters of colostrum within the first 24 hours and spend 14 days in individual housing before they are transmitted to group housing.
Statistical relevant risk- and protective factors were found for the development of diarrhea and respiratory disease. For diarrhea a major risk factor found was cleaning of the group housing facility based on an all-in-all-out principle. The odds for developing diarrhea is 3.2 times higher when the calves are exposed to such kind of.
More protective factors were found within the bio-medical items. The odds for developing diarrhea is 0.2 if the cows are vaccinated Bovine Viral Diarrhea (BVD). The odds for developing diarrhea is 0.2 if the farm is official declared BVD free.
For respiratory disease risk factors are food- and bio-medical related. The odds for developing respiratory disease is 2.6 if the farmer feeds the individual housed calves manually with artificial milk. The odds for developing respiratory disease is 3.4 if the farmer only uses antibiotics which are recorded in the farm animal health plan without exceptions.
Protective factors are also found within the food items. The odds for developing respiratory disease is 0.4 if the older, group housed, calves are fed milk using a feeding-trough.

For further research it would be recommended to extend the amount of observations and to make use of a controlled trial study design. This would increase the power of the results and make it possible to test our assumptions.

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1. Introduction

GD Animal Health (GD) has started a research project to investigate the opportunities to further reduce the antibiotic usage in the Netherlands (1). Farms with high and low use of antimicrobials, based on Defined Daily Dose per Animal over a Year (DDDA/Y) were selected and approached. To gain insight in company specific management factors the GD developed an questionnaire which consisted of over 80 questions considering dry cow management, birth management, calf feeding, calf housing, calf grouping, climate, survey and treatment of disease and so on(2). This paper makes use of the data collected in the GD questionnaire.

At present the most common way to manage calf housing is to house the calves as soon as possible after birth for 10 to 14 days in an individual pen or hutch. After these two weeks the calves move to group housing facilities. Another method is to move the calves from individual housing to group housing after weaning or at about a month of age. This is because at these two moments the risk of disease occurrence is reduced. (3), (4), (5)
Others advise to house calves in individual boxes for 2 till 3 weeks based on the fact that individual housing is known to reduce horizontal transmission of infectious diseases.(6)
Individual housing ranging from a couple of days up to 8 weeks before transferring them to group housing has also been described.(7), (8), (9) None of these publications contain scientifically relevant evidence on optimal transfer age.

Another way to house the newborn calves is directly in a group of 3 or more individuals. This is a less labor intensive but the chance of developing respiratory disease is up to 2.8 times greater. (8), (10) (11) The likelihood of developing a severe diarrhea is slightly less compared with individual housing. (3) This observation is not consistent with expectations. Expected is a higher risk for diarrhea and even death due to group housing compared with individual housing due to a higher infection burden and poorer hygiene.(12), (13), (14), (15) This alteration could be explained by the large number of different environmental and herd specific factors that is potentially involved in development of some diseases.

The main objective in this study was to investigate if there were certain relevant management factors (such as housing or feeding) that contributed to the development or prevention of disease in the digestive and respiratory tract. Furthermore this study aims to find an optimum age for transferring the calves from individual housing to group housing, in relation to the development and prevention of diarrhea and respiratory disease.

§2.1 Study design

GD Animal Health (GD) has started a research project, commissioned by ABRES (AntiBiotic RESistence) cattle, funded by the Product Board Dairy and Product Board for Livestock and Meat to investigate the opportunities to further reduce the antibiotic usage in the Netherlands. The Product Boards selected 300 farms from the central database for the registration of antibiotics in the bovine sector between June 2012 up to June 2013. The selection was based on the realized DDDA/Y. The sectors outliers, within the group calves in the age up to 56 days on Dutch dairy and suckling cow farms, were selected. For the dairy sector 100 farms were selected for low antibiotic usage as well as high antibiotic usage.
To gain insight in company specific management factors the GD made up a questionnaire which consists of over 80 questions regarding dry cow management, birth management, calf feeding, calf housing, calf grouping, climate, survey and treatment of disease and so on.(2) This paper is part of the bigger GD study and makes use of the data collected in the GD questionnaire.

This study is based on the data collected in the GD questionnaire and is designed as a cross-sectional survey within the population of Dutch dairy farmers. It's assumed that by combining the questionnaire-data from as well the high antibiotic users as the low antibiotic users a relevant and average overview of the Dutch dairy sector is made that can be used in this analysis. Due to the design of the study it's not possible to evaluate correlation between certain variables and the outcome variables. However statistical relevant association between variables and the outcome variables can be found.

§2.2 Data analysis

The Outcome variables in this study were the number of days spent in individual housing, development of diarrhea (yes/no) and respiratory disease (yes/no).

Independent variables, obtained in the enquiry, with a prevalence of less than 10% of the observations were not considered. This resulted in a dataset with 98 variables with 200 observations.

Descriptive analysis determining the prevalence, mean, median and IQR in different variables was carried out in order to give a brief overview of the dairy sector.

Univariate analysis, using logistic regression, was made for the outcome variables to calculate the Odds Ratio (OR), 95% Confidence Interval (CI) and P-Value (P). Only the variables with $P \leq 0.15$ are displayed in the results of the univariate analysis.

After calculation of the OR and CI, correlation between variables was checked to avoid co-linearity before building the final model. $Rho \geq 0.5$ was used as a cutoff point.

2. Results

§3.1 Descriptive data

Table 3.1.1. gives an overview of 200 farms that were recruited in this study.

On 63% of the farms diarrhea is a problem in the young calves. 37.5% of the farmers says respiratory disease are a problem. The calves get an average of 5.89 liters of colostrum within the first 24 hours and spend 14 days in individual housing before they are transmitted to group housing.

Farm variables	Category: N (%)	Mean (SD)	Median (q25;q75)
Health problems in calves up to 8 weeks of age(diarrhea)	*Yes:* 126 (63) *No:* 74 (37)		
Health problems in calves up to 8 weeks of age(respiratory)	*Yes:* 75 (37.5) *No:* 125 (62.5)		
Giving birth on a straw bedding	*Yes:* 159 (79.5) *Other:* 41 (20.5)		
Immediate providing of colostrum after birth (daytime) [a]	*Yes:* 149 (74.5) *Other:* 51 (25.5)		
Total amount of colostrum in the first 24 hours (liters)	168 (84)	5.89 (1.65)	
Immediate housing in individual calf pens [b]	*Yes:* 190 (95) *Other:* 10 (5)		
Days spend in individual housing	194 (97)		14.00 (12.00;21.00)
Number of calves in group housing	200 (100%)	6.53 (4.37)	
Feeding the group housed calves	*Artificial milk:* 141(70.5) *Natural bulk milk:* 49 (24.5)		
Age of weaning (weeks)	196 (98)	9.94 (2.24)	

Table:3.1.1 farm overview

[a] The calves are fed with colostrum directly after birth by milking the mother cow by hand or by robot.

[b] When the calves are separated from their mother they are housed individually until they are old enough to be housed in groups.

§3.2 Univariate analysis

Table 3.2.1 displays the selected determinants for diarrhea to be present in calves, in the age up to 8 weeks. The variables can be divided, based on the OR, in risk factors (with OR>1) and protective factors (with OR<1) related to outcome variable

So, for example, the OR for developing diarrhea is 1.8 times higher if the farmer uses antibiotics based on his own opinion and he also changes the duration of the treatment based on his own opinion. But when a farmer only uses antibiotics to treat sick calves after a vet has seen the patient the OR for developing diarrhea is 0.3.

Health problems (diarrhea)	N	Category N (%)	OR	95% CI (…-…)	P-value (≤0.150)
Bio-medical					
Use of antibiotics to treat sick calves is only after consulting a vet [p]	200	*Yes:* 36 (18) *No:* 164 (82)	0,3	0,163-0,714	0.004
Use of antibiotics and duration of the treatment is based on own opinion [r]	200	*Yes:* 58 (29) *No:* 142 (71)	1,8	0,931-3,527	0.080
Group treatment with antibiotics has been carried out [r]	200	*Yes:* 62 (31) *No:* 138 (69)	1.7	0.876-3.182	0.120
Farm BVD status certificated official free [p]	200	*Yes:* 81 (40.5) *Unknown:* 77 (38.5)	0.3	0.174-0.685	0.019
Cows are vaccinated for BVD ° [p]	200	*Yes:* 30 (115) *No:* 170 (85)	0,3	0,148-0,727	0.006
The young stock is vaccinated for BVD ° [+ p]	200	*Yes:* 19 (9.5) *No:* 181 (90.5)	0,4	0,149-1,015	0.054
The calves up to 8 weeks of age suffer from disease in the respiratory tract [r]	200	*Yes:* 75 (37.5) *No:* 125 (62.5)	1.7	0.931-3.162	0.083
Food related					
Individual housed calves are fed with bulk milk [p]	194	*Yes:* 72 (39.3) *No:* 111 (60.7)	0,4	0,210-0,709	0.002
Individual housed calves are fed manually with artificial milk * [r]	194	*Yes:* 114 (58.8) *No:* 80 (41.2)	1,7	1,033-3,366	0.039
Group housed calves are fed manually with artificial milk * [r]	200	*Yes:* 93 (46.5) *No:* 107 (53.5)	1,9	1,063-3,449	0.030
Group housed calves are fed automatically With artificial milk [p]	200	*Yes:* 48 (24) *No:* 152 (76)	0,5	0,254-0,948	0.034
Group housed calves are fed with bulk milk [p]	200	*Yes:* 49 (24.5) *No:* 151 (75.5)	0,6	0,300-1,109	0.099
Group housed calves are fed with dairy cow rations [+ r]	200	*Yes:* 16 (8) *No:* 184 (92)	2,7	0,749-9,891	0.128
Environmental					
Cleaning of group housing facility is based on all-in-all-out principle [r]	183	*Yes:* 117 (63.9) *No:* 66 (36.1)	2.2	1.190-4.100	0.012
Other					
Farmer is pleased with young stock raising method and health of the calves [p]	200	*Yes:* 149 (74.5) *No:* 51 (25.5)	0.3	0.151-0.695	0.004
Young stock raising has no priority for the farmer [+ r]	200	*Yes:*18 (9) *No:* 182 (91)	3,2	0,894-11,443	0.074
Young stock raising takes a lot of time in the farmers opinion [p]	200	*Yes:* 127 (63.5) *No:* 73 (36.5)	0,6	0,337-1,148	0.129

Table: *3.2.1 univariate analysis of diarrhea in calves*
* variables are dropped out in multivariate analysis due to correlation
[+] variables are considered important but did not met the criteria as described in §2.4 data analysis
° Bovine Viral Diarrhea
[p] protective factor in the development of diarrhea
[r] risk factor in the development of diarrhea

Table 3.2.2 displays the selected determinants for respiratory disease to be present in calves, in the age up to 8 weeks.

The OR for developing respiratory disease is 2.9 if there is group treatment with antibiotics.. When the group housed calves are fed with bulk milk, the OR for having respiratory disease is 0.2.

Health problems (respiratory)	N	Category N (%)	OR	95% CI (…-…)	P-value (≤0.150)
Bio-medical					
Use of antibiotics after consulting a vet * [p]	200	*Yes:* 36 (18) *No:* 164 (82)	0,4	0,178-0,963	0.041
Antibiotics are only used when recorded in the farm health plan [r]	200	*Yes:* 106 (53) *No:* 94 (47)	4,4	2,351-8,314	0.000
When using antibiotics the farmer strictly follows his farm health plan concerning the duration of the treatment* [p]	200	*Yes:* 148 (74) *No:* 52 (26)	0,4	0,233-0,846	0.014
Use of antibiotics and duration of the treatment is based on own opinion [r]	200	*Yes:* 58 (29) *No:* 142 (71)	2,1	1,119-3,892	0.021
Group treatment with antibiotics has been carried out [r]	200	*Yes:* 62 (31) *No:* 138 (69)	2.9	1.546-5.336	0.001
When calves are sick the first treatment is with electrolytes * [p]	200	*Yes:* 143 (71.5) *No:* 57 (25.8)	0,5	0,271-0,948	0.033
The cows are vaccinated [p]	200	*Yes:* 133 (66.5) *No:* 67 (33.5)	0,6	0,315-1,047	0.070
Cows are vaccinated for IBR [-r]	200	*Yes:* 29 (14.5) *No:* 171 (85.5)	2,8	1,235-6,166	0.013
The cows are vaccinated for BVD ° [r]	200	*Yes:* 30 (15) *No:* 170 (85)	1,8	0,839-4,006	0.129
The jungstock is vaccinated [p]	200	*Yes:* 133 (66.5) *No:* 67 (33.5)	0,5	0,286-0,954	0.034
The young stock is vaccinated for IBR [-] * [r]	200	*Yes:* 25 (12.5) *No:* 175 (87.5)	2,9	1,218-6,785	0.016
The calves up to 8 weeks of age suffer from diarrhea [r]	200	*Yes:* 126 (63) *No:* 74 (37)	1,7	0,931-3,162	0.083
Food related					
Individual housed calves are fed manually with artificial milk [r]	194	*Yes:* 114 (58.8) *No:* 80 (41.2)	2,4	1,268-4,378	0.007
Individual housed calves are fed with bulk milk [p]	194	*Yes:* 69 (35.6) *No:* 125 (64.4)	0,6	0,329-1,146	0.126
Individual housed calves are fed with high cell culture milk [p]	194	*Yes:* 37 (19.1) *No:* 157 (80.9)	0,6	0,250-1,221	0.143
Group housed calves are fed automatically [+r]	200	*Yes:* 45 (22.5) *Other:* 3 (1.5)	3.0	0.253-35.589	0.007
Group housed calves are fed automatically With artificial milk * [r]	200	*Yes:* 48 (24) *No:* 152 (76)	2,8	1,433-5,416	0.003
Group housed calves are fed milk in a trough [+p]	200	*Yes:* 39 (19.5) *Other:* 3 (1.5)	0.4	0.035-5.525	0.030
Group housed calves are fed with bulk milk [p]	200	*Yes:* 49 (24.5) *No:* 151 (75.5)	0,2	0,107-0,557	0.001
Group housed calves are fed with milk from cows which are treated with antibiotics [+p]	200	*Yes:* 16 (8) *No:* 184 (92)	0,4	0,099-1,304	0.120
Environmental					
The calving area is cleaned every day [r]	200	*Yes:* 21 (10.5) *Other:* 29 (14.5)	3.3	1.008-10.618	0.008
The calving area is cleaned after each calving [p]	200	*Yes:* 125 (62.5) *Other:* 29 (14.5)	0.8	0.359-1.912	0.110
Calves is group housing are housed on a straw bedding upon a screen floor * [+p]	200	*Yes:* 13 (6.5) *Other:* 2 (1)	0.1	0.003-2.603	0.039
Other					
Farmer is pleased with young stock raising method and health of the calves [p]	200	*Yes:* 149 (74.5) *No:* 51 (25.5)	0.2	0.096-0.376	0.000

Young stock raising takes a lot of time in the farmers opinion [p]	200	*Yes:* 127 (63.5) *No:* 73 (36.5)	0,6	0,332-1,081	0.089
At the farm poultry is also present [p]	200	*Yes:* 39 (19.5) *No:* 161 (80.5)	0,5	0,232-1,116	0.092

Table: *3.2.2 univariate analysis of respiratory disease in calves*
* variables are dropped out in multivariate analysis due to interrelationships
[+] variables are considered important but did not met the criteria as described in §2.4 data analysis
[-] Infectious Bronchitis
° Bovine Viral Diarrhea
[p] protective factor in the development of diarrhea
[r] risk factor in the development of diarrhea

Table 3.2.3 shows the association for days spend in individual housing compared with the development of diarrhea and respiratory disease in the calves, in the age up to 8 weeks.

No association is found, between the development of disease and days spend in individual housing, using Spearman's correlation.

An ANOVA test, within the data used, reveals very little variance. Therefor a significant P-value could not be obtained. In this case 97% of the farmers keep the young calves for 14 days in individual housing before transferring them into group housing.
Although we could not find any association, due to a lack of variance in the dataset, fully exclude the existence of an optimum age is not possible too. If almost all farmers (97%) keep the calves for 14 days in individual housing before transferring them to group housing, this could be an optimum age which is proved in practice not supported by statistics.

Days spend in individual housing	**N**	**Category N (%)**	**OR for 1 day increase**	**95% CI (…-…)**	**Correlation**	**P-value**
Diarrhea	200	*Yes:* 126 (63) *No:* 74 (37)	1 or <0.001	0.001-∞	0.041	0.500
Respiratory disease	200	*Yes:* 75 (37.5) *No:* 125 (62.5)	1 or ∞	0.001-∞	-0.05	0.463

Table: 3.2.3 univariate analysis of days in individual housing

§3.3.1 Multivariate analysis of diarrhea

A final multivariate logistic regression model was built for the outcome variables while suppressing missing data as well as correlated variables to calculate the OR, 95% CI and P. An overview of the excluded correlated variables could be found in the appendix. Election of the variables depended on the P-value; variables with $0.05 \geq P \leq 0.1$ are kept in the final model. A forward, backward and stepwise selection of variables was made for model building. Finally the backward method fitted the data the best considered the Akaike Information Criteria (AIC).

For the development of diarrhea there is only one risk factor found.
The OR for developing diarrhea is 3.2 if cleaning is based on an all-in-all-out principle.

The OR for developing diarrhea is 0.3 if the farmer only uses antibiotics after consulting a vet. When the cows on the farms are vaccinated with BVD the OR for developing diarrhea is 0.3. If the farm is declared officially BVD free the OR for developing diarrhea within the calves is also 0.3.
The OR for developing diarrhea is 0.2 if the farmer feeds the individual housed calves with bulk milk. When the group housed calves are fed automatically with artificial milk the OR for developing diarrhea is 0.3. If the farmer is pleased with his young stock raising method the OR for developing diarrhea is 0.1.

Multivariate analysis diarrhea	N	Category N (%)	OR	95% CI (…-…)	P-value (≤0.05)
Bio-medical					
Diarrhea is present in the calves in the age up to 2 months	177	*Yes:* 112 (63.3) *No:* 65 (36.7)			
Use of antibiotics to treat sick calves is only after consulting a vet [p]	177	*Yes:* 32 (18.1) *No:* 145 (81.9)	0.3	0.116-0.857	0.024
Farm BVD status certificated official free ° [p]	177	*Yes:* 74 (41.8) *Unknown:* 68 (38.4)	0.3	0.104-0.617	0.003
The cows are vaccinated for BVD ° [p]	177	*Yes:* 24 (13.6) *No:* 153 (86.4)	0.2	0.062-0.612	0.005
Food related					
Individual housed calves are fed with bulk milk [p]	177	*Yes:* 62 (35.0) *No:* 115 (65.0)	0.2	0.102-0.527	0.001
Group housed calves are fed automatically with artificial milk [p]	177	*Yes:* 47 (26.6) *No:* 130 (73.4)	0.3	0.126-0.790	0.014
Environmental					
Cleaning of group housing facility is based on all-in-all-out principle [r]	177	*Yes:* 106 (59.9) *No:* 71 (40.1)	3.2	1.422-7.093	0.005
Other					
Farmer is pleased with young stock raising method and health of the calves [p]	177	*Yes:* 131 (74.0) *No:* 46 (26.0)	0.1	0.024-0.252	0.000

Table 3.3.1 multivariate analysis of diarrhea in calves
[p] protective factor in the development of diarrhea
[r] risk factor in the development of diarrhea
° Bovine Viral Diarrhea

§3.3.2 Multivariate analysis of respiratory disease

For the development of respiratory disease there are only two protective factors in the multivariate analysis. The OR for developing respiratory disease is 0.4 if the group housed calves are fed milk using a feeding-trough.
If the farmer is pleased with his young stock raising method the OR for developing respiratory disease is 0.2.

If the farmer only uses antibiotics that are recorded in the farm health plan the OR for developing respiratory disease is 3.4.
The OR for developing respiratory disease is 2.6 if the farmers feeds the individual housed calves manually with artificial.
When the group housed calves are fed automatically the OR for developing respiratory disease is 2.5.

Multivariate analysis respiratory disease	N	Category N (%)	OR	95% CI (…-…)	P-value (≤0.05)
Bio-medical					
Respiratory disease is present in the calves in the age up to 2 months	194	*Yes:* 73 (37.6) *No:* 121 (62.4)			
Antibiotics are only used when recorded in the farm health plan [r]	194	*Yes:* 104 (53.6) *No*: 90 (46.4)	3.4	1.564-7.464	0.002
Food related					
Individual housed calves are fed manually with artificial milk [r]	194	*Yes:* 114 (58.8) *No:* 80 (41.2)	2.6	1.191-5.712	0.017
Group housed calves are fed automatically [+ r]	194	*Yes:* 45 (23.2) *Other:* 3 (1.6)	2.5	0.151-42.189	0.040
Group housed calves are fed milk in a feeding-trough [+ p]	194	*Yes:* 38 (19.6) *Other:* 3 (1.6)	0.4	0.022-6.876	0.040
Other					
Farmer is pleased with young stock raising method and health of the calves [p]	194	*Yes:* 144 (74.2) *No:* 50 (25.8)	0.2	0.088-0.449	0.000

Table 3.3.2 multivariate analysis of respiratory disease in calves
[+] variables are considered important but did not met the criteria as described in §2.4 data analysis
[p] protective factor in the development of diarrhea
[r] risk factor in the development of diarrhea

3. Discussion

This study reveals a set of determinants for development of diarrhea and respiratory disease. Some are common to both conditions such as automatic feeding of the calves; others are related specifically to the development of diarrhea (e.g. farm BVD status) or respiratory disease (e.g. manual feeding). Understanding the drivers in disease development in the veal calf sector is of vital importance since it can contribute to improve farm management practices and in last instance to reduce these common health problems in livestock.

Determinants expected for both diarrhea and respiratory disease development are mainly food related and environmental related. During this study some expectations were altered because some determinants showed not to be measurable with the data collected in the farmers enquiry (e.g. ventilation of the stable the calves were housed).
Other determinants (e.g. cleaning based on all-in-all-out principle and feeding the calves with artificial milk) showed unexpected directions of effects for the development of disease.

This study reveals cleaning of the group housing facility based on an all-in-all-out principle to be a risk for developing diarrhea. However the exact opposite is found in other studies. Cleaning after calving season was set to be a protective factor. And cleaning before the calving season started would just increase the risk for developing diarrhea.(16)

Feeding the calves with artificial milk was found to be a risk factor in the development of respiratory disease. Whether feeding with bulk tank milk is more beneficial than with artificial milk has been previously discussed with contradictory results. (17) Godden et al. also found artificial milk to be a risk factor when compared with natural milk. Increasing the risk for respiratory disease and even death among the young calves.(18)

Other effects were supported by previously carried out studies. Vaccinations seems to halve the odds for finding a BVD infected calf within a population. Thereby also lowering the risk for developing diarrhea.(19)

Even though we have great interesting results, the development of disease is a very complicated process. In practice it could be that the effects involved could be to entangled to really make the difference for the livestock. Some effects found could also be under the influence of reverse causality so an direct interpretation of the OR is in some cases not possible. Another factor that certainly influenced the data is that disease, our outcome variable, is self-reported and self-monitored by the farmers. A big over or, more likely, under reporting could be the case because nobody like to acknowledge their mistakes. No corrections are employed for these non-foreseen effects.

Because our data is collected in a case control study on antimicrobial usage among the sectors outliers in the Dutch dairy industry some effects could be biased. The strict effect could be measured using a “dummy model” comparing our results in the multivariable model with the dummy model. Unfortunately the GD dataset did not allow us to make a dummy model because of privacy regulations.

No significant associations could be found for days spend in individual housing and the development of diarrhea or respiratory disease in the calves. This is caused by a lack of variance within the dataset. Therefor a significant P-value could not be obtained and no significant associations could be found. However this does not mean that we can fully exclude the existence of an optimum age.

In future research it should be useful to extend the amount of observations even more and approach all the Dutch dairy farmers instead of 200 of the sectors outliers. This could alter the result. In this way we should be able to test our proposition for these 200 farmers presenting to be an average of the Dutch dairy sector. In this way it should also be possible to find an optimum age for the calves to transfer from individual housing to group housing considering prevention of developing disease.

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Appendix

To verify if there are variables that can not be used in the final model figure 3.2.4 and figure 3.2.5 are built for respectively diarrhea and respiratory disease using spearman's correlation. As is shown below the figure there are quite some correlated variables, with Rho≥0.5 as a cutoff point, that are not usable in the final model.

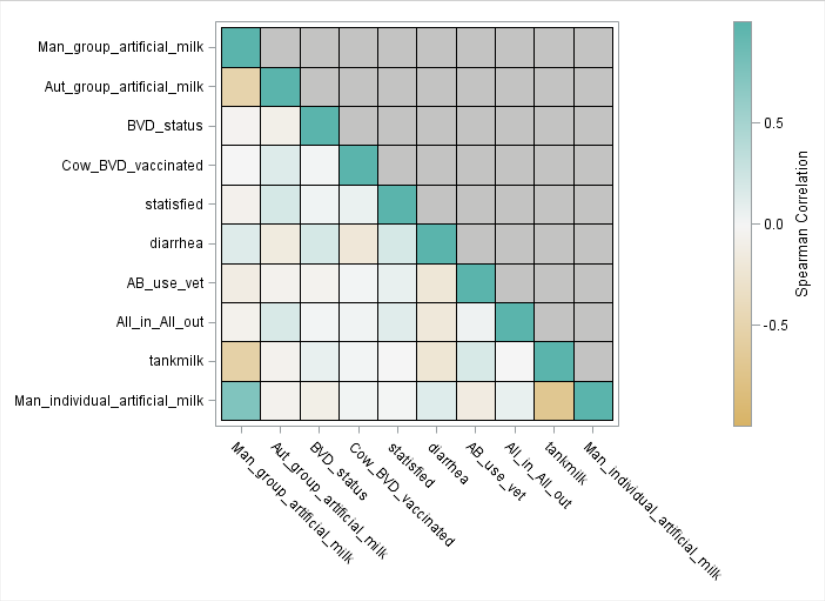

Figure 3.2.4 correlation between variables for diarrhea

For diarrhea the non-usable variables are:
-Auto_group_artificial_milk * Man_Group_artificial_milk
-Bulk milk * Man_Group_artificial_milk
-Man_individual_artificial_milk * Man_Group_artificial_milk
-Man_individual_artificial_milk * Bulk milk

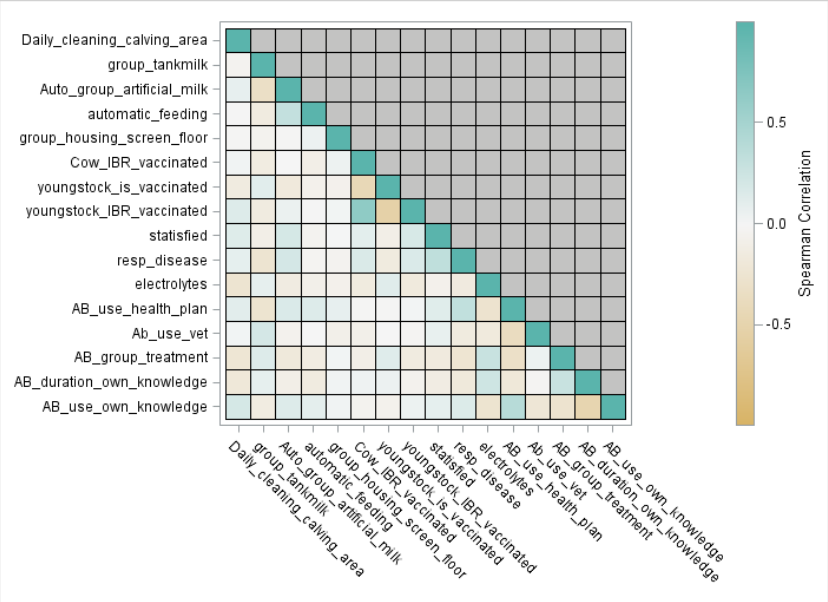

Figure 3.2.5 correlation between variables for respiratory disease

For respiratory disease the non-usable variables are:
-Auto_group_artificial_milk * Group_bulk milk
-Young stock_is_vaccinated * Cow_IBR_vaccinated
-Young stock_IBR_vaccincated * Young stock_is_vaccinated
-Young stock_IBR_vaccincated * Cow_IBR_vaccinated
-AB_use_own_knowledge * AB_duration_own_knowledge

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