**Introduction**

This study seeks to determine thefactors that influence piglet mortality due to overlay in sows. Specifically, they are interested in determining whether crate type, parity, number of heat lamp present, number of time spent in a posture and also the time spent in the each of the postures/behavior pre and post farrowing impact piglet overlay in sows. The 6 postures considered are:

* kneeling,
* lying on belly,
* lying on the left side,
* lying on the right side,
* sitting, and
* standing

Also, the following 4 shifting postures were also considered

* rolling
* lying to sitting
* lying upright
* stand to kneeling

We note that the count of times and the times in seconds spent in these postures pre and post farrowing was collected for each of the sows.

**Data Cleaning**

The data cleaning started by removing specific sows that do not have a complete data for the pre and post farrowing period. Each postures data were collected in an interval of 3 hours in the space of 24 hours (12AM-3AM, 3AM-6AM, 6AM-9AM, 9AM-12PM, 12PM-3PM, 3PM-6PM, 6PM-9PM, 9PM-12AM), this was later reduced into two segment (Day (6AM to 6PM) and Night (6PM to 6AM). A new variable called Behavior\_Time was created by combining the behavior type with the time category, which will allows us to perform analysis of specific behaviors during different parts of the day. The data set which contains three distinct farrowing stage (Pre, during, and Post Farrowing) was divided and we merged only pre and post farrowing data together. The final dataset contains the following variables.

Dependent Variable: Ovelay(High/Low)

**Independent Variables**

|  |  |  |
| --- | --- | --- |
|  | Pre-Farrowing | Post-Farrowing |
| Parity Heat\_lamps crate\_category | **Time spent in Postures** Pre\_Time\_Standing\_Night Pre\_Time\_Standing\_Day  Pre\_Time\_Sitting\_Night Pre\_Time\_Sitting\_Day  Pre\_Time\_LyingonRight\_Night Pre\_Time\_LyingonRight \_Day  Pre\_Time\_LyingonLeft\_Night Pre\_Time\_LyingonLeft \_Day  Pre\_Time\_LyingonBelly\_Night Pre\_Time\_LyingonBelly\_Day  Pre\_Time\_Kneeling\_Night Pre\_Time\_Kneeling \_Day  **Number of times spent in postures**  Pre\_NumEvents\_standing\_Nig Pre\_NumEvents\_standing\_Day  Pre\_NumEvents\_sitting\_Nig Pre\_NumEvents\_sitting\_Day  Pre\_NumEvents\_lyingonright\_Nig Pre\_NumEvents\_lyingonright\_Day  Pre\_NumEvents\_lyingonleft\_Nig Pre\_NumEvents\_lyingonleft\_Day  Pre\_NumEvents\_lyingonbelly\_Nig Pre\_NumEvents\_lyingonbelly\_Day  Pre\_NumEvents\_kneeling\_Nig Pre\_NumEvents\_kneeling\_Day  **shifting postures**  Pre\_NumEvents\_rolling\_Nig Pre\_NumEvents\_rolling\_Day  Pre\_NumEvents\_lying\_sit\_Nig Pre\_NumEvents\_lying\_sit\_Day  Pre\_NumEvents\_lying\_upright\_Nig Pre\_NumEvents\_lying\_upright\_Day  Pre\_NumEvents\_stand\_kneel\_Nig Pre\_NumEvents\_stand\_kneel\_Day | **Time spent in Postures** Pos\_AvgTime\_Standing\_Night Pos\_AvgTime\_Standing\_Day  Pos\_AvgTime\_Sitting\_Night Pos\_AvgTime\_Sitting\_Day  Pos\_AvgTime\_LyingonRight\_Night Pos\_AvgTime\_LyingonRight \_Day  Pos\_AvgTime\_LyingonLeft\_Night Pos\_AvgTime\_LyingonLeft \_Day  Pos\_AvgTime\_LyingonBelly\_Night Pos\_AvgTime\_LyingonBelly\_Day  Pos\_AvgTime\_Kneeling\_Night Pos\_AvgTime\_Kneeling \_Day  **Number of times spent in postures**  Pos\_NumEvents\_standing\_Nig Pos\_NumEvents\_standing\_Day  Pos\_NumEvents\_sitting\_Nig Pos\_NumEvents\_sitting\_Day  Pos\_NumEvents\_lyingonright\_Nig Pos\_NumEvents\_lyingonright\_Day  Pos\_NumEvents\_lyingonleft\_Nig Pos\_NumEvents\_lyingonleft\_Day  Pos\_NumEvents\_lyingonbelly\_Nig Pos\_NumEvents\_lyingonbelly\_Day  Pos\_NumEvents\_kneeling\_Nig Pos\_NumEvents\_kneeling\_Day  **shifting postures**  Pos\_NumEvents\_rolling\_Nig Pos\_NumEvents\_rolling\_Day  Pos\_NumEvents\_lying\_sit\_Nig Pos\_NumEvents\_lying\_sit\_Day  Pos\_NumEvents\_lying\_upright\_Nig Pos\_NumEvents\_lying\_upright\_Day  Pos\_NumEvents\_stand\_kneel\_Nig Pos\_NumEvents\_stand\_kneel\_Day |

Parity: Number of times sows have given birth

Heat Lamp: Number of heat lamp in the sows house.

Crate type: Three crate type

* TSL: Traditional type
* ECSL: Same space with TSL for sow but a bit bigger for piglet
* ESCSL: Bigger space for sow, bigger space for piglet.

**Descriptive**

The following tables display the frequency and percentage of sow overlay (i.e., cases where a sow lay on her piglet) based on Parity, Heat Lamps, and Crate Category. Overall, 51 sows (42.50%) experienced overlay, while 69 sows (57.50%) did not.

Among sows that experienced overlay (n = 51), 10.00% were parity 1, 15.00% parity 2, 8.33% parity 3, and 9.17% parity 4. Sows with parity 2 had the highest proportion of overlay cases. In contrast, among the sows that did not experience overlay (n = 69), parity 1 had the highest percentage (29.17%), followed by parity 2 (15.00%).

Table 1:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Parity | | | |  |
| Overlay | 1 | 2 | 3 | 4 | Total |
| High | 12 (10%) | 18 (15%) | 10 (8.33%) | 11 (9.17%) | 51(42.50%) |
| Low | 35 (29.17%) | 18 (15%) | 10 (8.33%) | 6 (5%) | 69(57.50%) |

Among sows that experienced overlay, 21.67% were in environments with one heat lamp, and 20.83% had two heat lamps. For sows without overlay, 33.33% had one heat lamp and 24.17% had two.

Table 2:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Heat Lamps | |  |
| Overlay | 1 | 2 | Total |
| High | 26 (21.67%) | 25 (20.83%) | 51 (42.50%) |
| Low | 40 (33.33%) | 29 (24.17%) | 69 (57.50%) |

Within the overlay group, 14.17% of sows were in ECSL crates, 15.83% in ESCSL, and 12.50% in TSL. Among those without overlay, 21.67% were in ECSL, 16.67% in ESCSL, and 19.17% in TSL.

Table 3:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Crate Category | | |  |
| Overlay | ECSL | ESCSL | TSL | Total |
| High | 17 (14.17%) | 19 (15.83%) | 15 (12.50%) | 51 (42.50%) |
| Low | 26 (21.67%) | 20 (16.67%) | 23 (19.17%) | 69 (57.50%) |

**Analysis**

A binary logistic regression was conducted to examine the effects of sow parity, crate type, number of heat lamps, and average time spent in the following postures behavior (kneeling, lying on belly, lying on the left side, lying on the right side, sitting, standing, rolling) before and after farrowing on the likelihood of piglet mortality due to overlay. The overall model was statistically significant, indicating that the predictors reliably distinguished between overlay and non-overlay outcomes, Likelihood χ²(30) = 54.8697, p = 0.0037.

**Estimate**

The result showed that sows who have given birth once (Parity 1) was a significant negative predictor (B = -2.952, p = .0015) of overlay, indicating that a sow with first-time parity decreases the odds of overlay compared to sows who have given birth 4 times. The odds of overlay in sows who have only given birth once are 0.052 times the odds in sows who have given birth 4 times (OR = 0.052, 95% CI [0.008, 0.323]), indicating that first-parity sows have a lower risk of overlay compared to fourth-parity sows. The odds of overlay in sows who have only given birth twice and thrice are 0.442 and 0.904 times the odds in sows who have given birth 4 times indicating that second and third time parity sows have a lower risk of overlay compared to fourth-parity sows. However, there was no significant differences in the odds of overlay between sows whose have given birth two, three and four as the p-value was greater than 0.05.

The odd of overlay in sows with one heat lamp are 0.718 times the odds in sows with heat lamp of 2 (OR = 0.718, 95%CI[0.235, 2.194], indicating that sows with 1 heat lamp has a lower odds of overlay compared to sows with 2 heat lamp, although this differences was not statistically significant.

The odd of overlay in sows who belong to the ECSL crate category is 1.340 times that of sows with TSL crate category (OR = 1.340, 95%CI[0.377, 4.757]), although this differences was not statistically significant. The odd of overlay in sows who belong to the ESCSL crate category is 0.988 times the odds in sow with TSL crate category (OR = 0.988, 95%CI[0.242, 4.030]).

Among the average time spent in the posture-related predictors, time spent sitting in the night during pre-farrowing was a significant predictor of overlay (B = 0.00025, p = .036). This indicates that for a one-unit increase in time spent sitting during pre-farrowing, we expect a 0.00025 increase in the log-odds of overlay, holding all the other variables constant.

Time spent standing in the night during post farrowing was also a significant predictor of overlay (B = 0.000123, p = .0495), indicating that given a one-unit increase in time spent standing post-farrowing, we expect a 0.000123 increase in the log-odds of overlay, holding all the other variables constant.

Time spent sitting in the day during post-farrowing (B = -0.000635, p = .0161) significantly predicted overlay in sows. This result showed that for a one-unit increase in time spent sitting post-farrowing, we expect a 0.000635 decrease in the log-odds of overlay, while holding all the other independent variables constant.

Time spent lying on belly in the day during post-farrowing (B = 0.00041, p = .0099) significantly predicted overlay in sows. This result showed that for a one-unit increase in time spent sitting post-farrowing, we expect a 0.00041 increase in the log-odds of overlay, while holding all the other independent variables constant.

Looking at the odds ratios for all postures both pre- and post-farrowing, most values are close to 1, suggesting that the time spent in these postures does not have a significant effect on the odds of overlay in sows. This indicates that posture-related behavior around farrowing may not be a strong predictor of overlay under the conditions studied.

Table 4:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameter | Estimate | OR | 95% Confidence Interval | | Pr > ChiSq |
| Lower | Upper |
| Intercept | 2.3042 |  |  |  | 0.3039 |
| parity(1) | -2.952 | 0.052 | 0.008 | 0.323 | 0.0015 |
| parity(2) | -0.8165 | 0.442 | 0.093 | 2.101 | 0.3046 |
| parity(3) | -0.1004 | 0.904 | 0.135 | 6.048 | 0.9175 |
| heat\_lamps(1) | -0.3307 | 0.718 | 0.235 | 2.194 | 0.5616 |
| crate\_category(ECSL) | 0.2925 | 1.340 | 0.377 | 4.757 | 0.651 |
| crate\_category(ESCSL) | -0.0125 | 0.988 | 0.242 | 4.030 | 0.9861 |
| Pos\_TimeSpent\_standing\_Nig | 0.000123 | 1.000 | 1.000 | 1.000 | 0.0495 |
| Pre\_TimeSpent\_standing\_Nig | -0.00005 | 1.000 | 1.000 | 1.000 | 0.1756 |
| Pos\_TimeSpent\_standing\_Day | -0.00004 | 1.000 | 1.000 | 1.000 | 0.5614 |
| Pre\_TimeSpent\_standing\_Day | 0.000058 | 1.000 | 1.000 | 1.000 | 0.3601 |
| Pos\_TimeSpent\_sitting\_Nig | 0.000148 | 1.000 | 1.000 | 1.000 | 0.3743 |
| Pre\_TimeSpent\_sitting\_Nig | 0.000254 | 1.000 | 1.000 | 1.000 | 0.036 |
| Pos\_TimeSpent\_sitting\_Day | -0.00012 | 1.000 | 0.999 | 1.000 | 0.6651 |
| Pre\_TimeSpent\_sitting\_Day | -0.00063 | 0.999 | 0.999 | 1.000 | 0.0161 |
| Pos\_TimeSpent\_lyingonright\_Nig | 0.000004644 | 1.000 | 1.000 | 1.000 | 0.7602 |
| Pre\_TimeSpent\_lyingonright\_Nig | -0.00001 | 1.000 | 1.000 | 1.000 | 0.4088 |
| Pos\_TimeSpent\_lyingonright\_Day | -0.000000593 | 1.000 | 1.000 | 1.000 | 0.9865 |
| Pre\_TimeSpent\_lyingonright\_Day | -0.00002 | 1.000 | 1.000 | 1.000 | 0.5394 |
| Pos\_TimeSpent\_lyingonleft\_Nig | -0.00000754 | 1.000 | 1.000 | 1.000 | 0.6644 |
| Pre\_TimeSpent\_lyingonleft\_Nig | 0.000012 | 1.000 | 1.000 | 1.000 | 0.4854 |
| Pos\_TimeSpent\_lyingonleft\_Day | 0.000019 | 1.000 | 1.000 | 1.000 | 0.522 |
| Pre\_TimeSpent\_lyingonleft\_Day | -0.00006 | 1.000 | 1.000 | 1.000 | 0.1047 |
| Pos\_TimeSpent\_lyingonbelly\_Nig | -0.00012 | 1.000 | 1.000 | 1.000 | 0.1171 |
| Pre\_TimeSpent\_lyingonbelly\_Nig | -0.0001 | 1.000 | 1.000 | 1.000 | 0.1238 |
| Pos\_TimeSpent\_lyingonbelly\_Day | 0.000414 | 1.000 | 1.000 | 1.001 | 0.0099 |
| Pre\_TimeSpent\_lyingonbelly\_Day | 0.000055 | 1.000 | 1.000 | 1.000 | 0.6432 |
| Pos\_TimeSpent\_kneeling\_Nig | -0.00015 | 1.000 | 0.998 | 1.001 | 0.8513 |
| Pre\_TimeSpent\_kneeling\_Nig | 0.000282 | 1.000 | 0.999 | 1.001 | 0.5516 |

A binary logistic regression was conducted to examine the effects of sow parity, crate type, number of heat lamps, and the number of times sows spent in the following postures behavior (kneeling, lying on belly, lying on the left side, lying on the right side, sitting, standing, rolling, lying to sit, lying to upright, stand to kneel) before and after farrowing on the likelihood of piglet mortality due to overlay. The overall model was statistically significant, indicating that the predictors reliably distinguished between overlay and non-overlay outcomes, Likelihood χ²(30) = 86.5575, p = 0.0003.

The result showed that Parity (1) was a significant negative predictor (B = -6.653, p = .0008) of overlay, indicating that sows who have only given birth once (parity 1) decreases the odds of overlay compared to sows who have given birth 4 times. There was no significant differences in the odds of overlay between sows whose have given birth two, three and four as the p-value was greater than 0.05.

Crate category (ESCSL) was a significant predictor (B = 2.6148, p = 0.0442) of overlay in sows, indicating that sows with crate category ESCSL increases the odd of overlay compared to sows with crate category TSL. There was no significant differences in the odds of overlay between sows who were is ECSL and TSL crate, as the p-value was greater than 0.05.

Among the different postures pre and post farrowing for day and night, we saw that the following significantly predicted overlay in sows, ***Pre-farrowing:*** *numbers of sitting during day (B = -0.3882, p = 0.0147), numbers of lying on the right during the day (B = 0.1225, p = 0.0131), numbers of lying on belly during the day (B = -0.1102, p = 0.0355), number of kneeling in the night (B = -0.1011, p = 0.0393), number of lying sit during the day (B = 0.1444, p = 0.0214) and number of stand kneel in the night (B = 0.1046, p = 0.0169),* ***Post Farrowing:*** *number of lying on the right during the day (B = -0.2287, p = 0.0231) and numbers of rolling during the night (B = -0.2497, p = 0.0089).*

This result showed that for a one-unit increase in the number of sitting events during the day for sows pre-farrowing, the log odds of overlay decrease by 0.3882. In terms of odds ratio, this corresponds to a 32% decrease in odds (OR = 0.678), suggesting that more daytime sitting pre-farrowing is associated with reduced risk of overlay. A one-unit increase in lying on the right side during the day pre-farrowing increases the log odds of overlay by 0.1225 (OR = 1.13), indicating a 13% increase in odds. For the lying on belly during the day pre-farrowing, the odds of overlay decrease by approximately 10% (OR = 0.896). An increase in kneeling during the night pre-farrowing is associated with a 9.6% reduction in the odds of overlay (OR = 0.904). For lying-sit transitions during the day pre-farrowing, odds of overlay increase by 15.5% (OR = 1.155). For stand-kneel transitions at night pre-farrowing, odds of overlay increase by 11% (OR = 1.11). For post-farrowing, a one-unit increase in lying on the right during the day is associated with a 20% decrease in odds of overlay (OR = 0.796) and an increase in rolling at night post-farrowing results in a 22% decrease in odds (OR = 0.779). This result suggests that some pre-farrowing postures such as increased sitting during the day, lying on belly during the day, and kneeling protects sows from overlaying while others like *lying on the right during the day,* lying-sit during the day, and stand-kneel transitioning in the night may increase the risk of overlay in sow. The post-farrowing behavior such as rolling at night and lying on the right side during the day reduces the risk of overlay in sow.

All other predictors, including heat lamps and other postures, were not statistically significant (p > .05), suggesting no strong evidence of association with overlay in this model.

Table 5:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameter | Estimate | OR | 95% Confidence Interval | | Pr > ChiSq |
| Lower | Upper |
| Intercept | -0.1103 |  |  |  | 0.9537 |
| Parity(1) | -6.653 | 0.001 | <0.001 | 0.064 | 0.0008 |
| Parity(2) | -2.2272 | 0.108 | 0.008 | 1.38 | 0.0868 |
| Parity(3) | -1.8804 | 0.153 | 0.009 | 2.548 | 0.1906 |
| heat\_lamps | -0.0566 | 0.945 | 0.135 | 6.597 | 0.9545 |
| crate\_category(ECSL) | 0.5162 | 1.676 | 0.155 | 18.105 | 0.6708 |
| crate\_category(ESCSL) | 2.6148 | 13.665 | 1.07 | 174.437 | 0.0442 |
| Pos\_NumEvents\_standing\_Nig | -0.086 | 0.918 | 0.755 | 1.115 | 0.386 |
| Pre\_NumEvents\_standing\_Nig | -0.1105 | 0.895 | 0.782 | 1.025 | 0.1088 |
| Pos\_NumEvents\_standing\_Day | -0.0497 | 0.951 | 0.708 | 1.279 | 0.7421 |
| Pre\_NumEvents\_standing\_Day | 0.1206 | 1.128 | 0.831 | 1.532 | 0.4394 |
| Pos\_NumEvents\_sitting\_Nig | 0.067 | 1.069 | 0.865 | 1.322 | 0.5363 |
| Pre\_NumEvents\_sitting\_Nig | 0.1178 | 1.125 | 0.991 | 1.277 | 0.0689 |
| Pos\_NumEvents\_sitting\_Day | -0.1038 | 0.901 | 0.628 | 1.294 | 0.5738 |
| Pre\_NumEvents\_sitting\_Day | -0.3882 | 0.678 | 0.497 | 0.927 | 0.0147 |
| Pos\_NumEvents\_lyingonright\_Nig | 0.00824 | 1.008 | 0.921 | 1.103 | 0.8578 |
| Pre\_NumEvents\_lyingonright\_Nig | -0.0345 | 0.966 | 0.919 | 1.016 | 0.1784 |
| Pos\_NumEvents\_lyingonright\_Day | -0.2287 | 0.796 | 0.653 | 0.969 | 0.0231 |
| Pre\_NumEvents\_lyingonright\_Day | 0.1225 | 1.13 | 1.026 | 1.245 | 0.0131 |
| Pos\_NumEvents\_lyingonleft\_Nig | 0.047 | 1.048 | 0.956 | 1.149 | 0.3148 |
| Pre\_NumEvents\_lyingonleft\_Nig | 0.00615 | 1.006 | 0.949 | 1.067 | 0.8371 |
| Pos\_NumEvents\_lyingonleft\_Day | 0.0505 | 1.052 | 0.914 | 1.211 | 0.4825 |
| Pre\_NumEvents\_lyingonleft\_Day | 0.0765 | 1.08 | 0.962 | 1.211 | 0.1919 |
| Pos\_NumEvents\_lyingonbelly\_Nig | 0.0109 | 1.011 | 0.95 | 1.076 | 0.7331 |
| Pre\_NumEvents\_lyingonbelly\_Nig | 0.000101 | 1 | 0.962 | 1.04 | 0.996 |
| Pos\_NumEvents\_lyingonbelly\_Day | 0.1406 | 1.151 | 0.989 | 1.34 | 0.0694 |
| Pre\_NumEvents\_lyingonbelly\_Day | -0.1102 | 0.896 | 0.808 | 0.993 | 0.0355 |
| Pos\_NumEvents\_kneeling\_Nig | 0.0795 | 1.083 | 0.915 | 1.282 | 0.3555 |
| Pre\_NumEvents\_kneeling\_Nig | -0.1011 | 0.904 | 0.821 | 0.995 | 0.0393 |
| Pos\_NumEvents\_kneeling\_Day | 0.1145 | 1.121 | 0.8 | 1.572 | 0.5069 |
| Pre\_NumEvents\_kneeling\_Day | 0.0933 | 1.098 | 0.897 | 1.343 | 0.3649 |
| Pos\_NumEvents\_rolling\_Nig | -0.2497 | 0.779 | 0.646 | 0.939 | 0.0089 |
| Pre\_NumEvents\_rolling\_Nig | 0.0402 | 1.041 | 0.96 | 1.129 | 0.3328 |
| Pos\_NumEvents\_rolling\_Day | 0.0942 | 1.099 | 0.833 | 1.449 | 0.5047 |
| Pre\_NumEvents\_rolling\_Day | -0.2309 | 0.794 | 0.61 | 1.032 | 0.0851 |
| Pos\_NumEvents\_lying\_sit\_Nig | 0.0113 | 1.011 | 0.899 | 1.137 | 0.8505 |
| Pre\_NumEvents\_lying\_sit\_Nig | -0.0388 | 0.962 | 0.921 | 1.005 | 0.0838 |
| Pos\_NumEvents\_lying\_sit\_Day | 0.047 | 1.048 | 0.879 | 1.249 | 0.6002 |
| Pre\_NumEvents\_lying\_sit\_Day | 0.1444 | 1.155 | 1.022 | 1.307 | 0.0214 |
| Pos\_NumEvents\_lying\_upright\_Nig | 0.1015 | 1.107 | 0.927 | 1.321 | 0.2617 |
| Pre\_NumEvents\_lying\_upright\_Nig | 0.1354 | 1.145 | 0.974 | 1.346 | 0.1008 |
| Pos\_NumEvents\_lying\_upright\_Day | 0.0144 | 1.014 | 0.724 | 1.421 | 0.9333 |
| Pre\_NumEvents\_lying\_upright\_Day | -0.1439 | 0.866 | 0.607 | 1.236 | 0.4277 |
| Pos\_NumEvents\_stand\_kneel\_Nig | -0.0142 | 0.986 | 0.901 | 1.079 | 0.7573 |
| Pre\_NumEvents\_stand\_kneel\_Nig | 0.1046 | 1.11 | 1.019 | 1.21 | 0.0169 |
| Pos\_NumEvents\_stand\_kneel\_Day | 0.0224 | 1.023 | 0.871 | 1.2 | 0.7838 |
| Pre\_NumEvents\_stand\_kneel\_Day | -0.1445 | 0.865 | 0.724 | 1.035 | 0.1126 |