Research Square

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Killing Underweighted Low Viable New-Born Piglets – A First Step to a Reliable and Comprehensive Decision

Lukas Geiping
Tierärztliche Hochschule Hannover: Tierarztliche Hochschule Hannover https://orcid.org/0000-0001-7648-402X
Maria Hartmann
Stiftung Tierärztliche Hochschule Hannover: Stiftung Tierarztliche Hochschule Hannover
Lothar Kreienbrock
Stiftung Tierärztliche Hochschule Hannover: Stiftung Tierarztliche Hochschule Hannover
Elisabeth grosse Beilage (elisabeth.grosse.beilage@tiho-hannover.de)
Tierärztliche Hochschule Hannover: Tierarztliche Hochschule Hannover

Research

Keywords: Pig, neonate, death, mortality, survival, vitality, welfare

Posted Date: September 24th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-915709/v1

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Abstract

Background

The aim of this study was to estimate the mortality risk within the first days of life for underweight or low-vital neonatal piglets. This risk estimation should start a discussion concerning the pre-conditions for the killing of compromised new-born piglets for the prevention of unnecessary pain and suffering. In a field study, various clinical and laboratory variables were examined in 529 piglets out of four farms. Body weight, crown-rump-length, rectal temperature, a 4-stage vitality score, an intrauterine-growth-retardation score, glucose, lactate, haemoglobin and immunocrit were assessed on the first day of life. Vitality was scored by three factors: movement, abdominal palpation and colour of the skin. Afterwards death or survival of the piglets was monitored up until the fifth day of age.

Results

Body weight, crown-rump-length, rectal temperature, vitality score, IUGR-score, glucose and immunocrit were significantly associated with the probability of death (univariate model, $p = < 0.0001$). The final predictive multivariate model comprised the factors body weight, rectal temperature and vitality score. Piglets with a rectal temperature ≤ 37.5°C and moderate vitality score were found to have the highest probability to die until day 5 of age.

Conclusion

The clinical findings, identified by this model, allow the estimation of mortality risk for a new-born piglet within the first days of life. In a further analysis veterinarians, farmers and ethics need to clarify which probability of death justifies the killing of a new-born piglet.

Introduction/background

The management of low-viable new-born piglets is a distinct challenge for farmers. Reduced viability is associated with factors such as large litter size, low birth weight, longer duration of birth and reduced colostrum intake (1–4). The requirement to manage low-viable pigs has increased as litters sizes have grown the last decade (5, 6). As litter sizes often exceed the number of functioning teats, management tools like split nursing to ensure colostrum intake just after birth (7) and the use of nurse sows suckle redundant piglets (8) haven been developed. However, these tools cannot solve the problems of underweighted pigs or those with low viability. Even turn back to genetics with lower litter sizes will reduce but not completely solve this problem as underweighted and low-viable can occur at any litter size (9). Mortality rates among such piglets are heightened significantly (10) and consequently some farmers have tended to kill new-born pigs which they expect to die within the first days of life. The farmers argue killing low weight or low-viable piglets is enhancing animal welfare by preventing these pigs from longer lasting suffering (11). Animal welfare activists however retort that killing these pigs is not justified as it is primarily done for economic reasons (12). Indeed, any decision regarding underweighted or low-viable new-born piglets easy to make as welfare and life of the piglet need to be protected (13). While not killing a compromised piglet may affect welfare by exposing this individual piglet to a high chance of long-lasting suffering and death through starvation or crushing, killing compromised piglets avoids any welfare impairment but conflicts with the general protection of life (14). Balancing those requirements in a way acceptable for the animal, the farmer as well as most of the society is far from easy. The study described here is aimed at the identification of clinical variables appropriate for prediction of the death of underweight piglets until day 5 of age. These variables may become part of a guideline enabling farmers to arrive at a justified decision about killing a new-born piglet.

Based on previous literature variables under study were selected (15) and tested for their capacity to predict the death of a piglet until day 5 of age. The selection was aimed at criteria easy to recognise for the farmer. Body weight, rectal temperature, crown-rump-length, a vitality score and a score describing intra-uterine growth retardation (IUGR) were assessed to fulfil these criteria. Moreover, four blood measurements (glucose, lactate, haemoglobin, immunocrit), not easily available under on-farm conditions, were assessed to undermine the clinical data since such scores are often treated as being influenced by the examiner (“subjective”), whereas laboratory measurements are usually rated being “objective”.

Material And Methods

Herd characteristics

The study was conducted on three commercial pig producing farms and one research farm in Lower Saxony and North Rhine Westphalia from May to October 2020. The sow herds belong to three genetic lines (BundesHybridZuchtProgramm, Topigs, Danish Genetics) frequently used in Germany. In all herds, sows were inseminated with semen from Pietrain boars. In each herd, litters from three consecutive batches were included in the study. The study comprised a total of 529 piglets out of 99 litters (Table 1), ten piglets were excluded from further analysis due to missing data.

Table 1
Number of sows and according piglets included in the study.

Herd	Sows (n)	Piglets (n)
1	22	124
2	31	147
3	22	111
4	24	147

- Sow management

Approximately one week before the expected farrowing date the sows were moved to conventional farrowing pens equipped with a crate, fully slatted floors and a heated creep area. Herd 1 also used four pens for free farrowing equipped with a partly slatted concrete floor. Farrowing supervision took place during the normal working hours and farrowing induction was not routinely used in any herd. All farms used nurse sows and additional feeders for suckling piglets to ensure adequate milk and feed intake. All sow herds were vaccinated quarterly against porcine reproductive and respiratory syndrome virus, *Erysipelothrix rhusiopathiae* and parvovirus.

- Piglet management

Litters were included 12 to 24 hours after birth (day 1) before cross fostering and before litter equalization was done. Tail docking and teeth grinding were performed on day 2. On day 3 all piglets were treated with an iron preparation and male piglets were surgically castrated according to the German Animal Protection Act (16).

Data collection

For individual identification, all piglets were marked with numbered ear tags on day 1.

- Clinical variables evaluated at day 1

Body weight (BW) at birth was the inclusion criterion and piglets with a body weight ≤ 1.0 kg (low weight group, LW) were compared to piglets with a body weight > 1.0 kg (normal weight group, NW)). While all piglets from a selected litter weighing ≤ 1.0 kg were included in the LW, the number of piglets included in the NW was restricted to two piglets per litter. In total the LW comprises 328 piglets and the NW 191 piglets. For further analysis the study and control group were subdivided based on whether they were dead or alive at day 5 (low weight group alive (LWA) and low weight group dead (LWD), normal weight group alive (NWA) and normal weight group dead (NWD)).

The data recorded on day 1 also comprised the sex, the rectal temperature and the crown-rump length (CRL), defined as the length from the occiput to the base of the tail. The vitality was assessed based on a score from 0 to 3 (Table 2). A score of 0 was given if the piglets showed no signs of reduced vitality. A score of 1 was given for piglets showing one sign of moderately reduced vitality, score 2 was recorded when a piglet showed two signs of moderately reduced vitality and score 3 when one or more signs of severely reduced vitality were diagnosed. Piglets with a score of 3 were categorized as non-viable and were killed immediately by the farmer by blunt force trauma and subsequent bleeding or by the investigator by intravenous injection of a lethal dose of Pentobarbital (Release® 500 mg/ml WDT, dosage: 450 mg/5 kg BW).

The piglets were also scored for IUGR based on the scheme evaluated by (17, 18). A score of 1 (mild IUGR) was given if the piglet showed at least one sign of IUGR and a score of 2 (severe IUGR) when more than one sign was proven (Table 2).

Table 2
Clinical variables evaluated in piglets at day 1.

<table>
<tr><th>Clinical variable</th><th>Measuring unit</th></tr>
<tr><td>Gender</td><td>Female/Male</td></tr>
<tr><td>Body weight (BW)</td><td>Kilogram (kg)</td></tr>
<tr><td>Crown-rump length (CRL)</td><td>Meter (m)</td></tr>
<tr><td>Rectal temperature (RT)</td><td>Centigrade (°C)</td></tr>
<tr><td>Vitality score (VS)</td><td>
<table>
<tr><td>Vitality Criteria</td><td>Unaffected</td><td>Moderate</td><td></td><td>Severe</td></tr>
<tr><td>Colour of the skin</td><td>Pink</td><td>Pale</td><td></td><td>Cyanotic</td></tr>
<tr><td>Movement</td><td>Stable</td><td>Unstable</td><td></td><td>Unable to stand</td></tr>
<tr><td>Abdominal palpation</td><td>Well filled</td><td>Moderately filled</td><td></td><td>Empty</td></tr>
<tr><td rowspan="2">Overall vitality score</td><td>VS 0</td><td>VS 1</td><td>VS 2</td><td>VS 3</td></tr>
<tr><td>No signs of reduced vitality</td><td>1 sign of moderately reduced vitality</td><td>>1 sign of moderately reduced vitality</td><td>≥ 1 sign of severely reduced vitality</td></tr>
</table>
</td></tr>
<tr><td>Intrauterine-growth retardation (IUGR) score</td><td>Score 0 (no IUGR),1 (mild IUGR), 2 (severe IUGR)
based on the criteria
- dolphin like head (yes/no)
- bulging eyes (yes/no)
- wrinkles around nose and eyes (yes/no)</td></tr>
</table>

- Blood measurements evaluated at day 1

Blood (0.5 mL) was collected from all piglets on day 1 by punctuation of the *V. cava cranialis* with a 23 G needle and a 1 mL syringe and used for analysis of laboratory measurements to compare these with the survivability of neonatal piglets (Table 3). A part of the blood was immediately analysed on-farm using three different hand-held devices. With the Accutrend® Plus by Roche glucose and lactate concentrations were measured in whole blood as previously described (19, 20). Both devices were checked before each batch with control solutions provided by the manufacturer (Accutrend® Control G2; BM-Control G2). The range for glucose concentrations measurable with this device ranges from 20 to 600 mg/dl. Values below this range were classified as 19 mg/dl. Lactate concentration was measured from 0.8 to 22 mmol/L; higher values were classified as 23 mmol/L. The Hemocue Hb 201 Analyzer was used to measure haemoglobin concentration (21). The measuring scale runs from zero to 15.9 mmol/L.

To assess the amount of colostrum the piglets have ingested, the immunocrit was measured, as previously described (22). This method is a cost efficient and easy way to determine the IgG-content in serum samples.

Table 3
Blood measurements evaluated in piglets at day 1.

Blood measurement	Measuring unit
Glucose	mg/dL
Lactate	mmol/L
Haemoglobin	mmol/L
Immunocrit	dimensionless

- Post-mortem examination

All piglets included in the study that died or had to be killed until day 5 were weighed and collected for a standardized post-mortem examination (Table 4). Reasons for killing were a vitality of score 3 (Table 2), anomalies or lacerations. The cause of death was recorded (crushing, starvation, infection, anomalies, other) as well as whether the piglet had been killed or died spontaneously. The diagnosis “crushing” was assigned when the piglet had broken bones or when typical internal or external lesions or bleedings were detected. “Starvation” was diagnosed when the piglet was emaciated, and ribs or other prominent bones were easily visible. The diagnosis “infection” included all piglets showing signs of enteritis, pneumonia or arthritis. Under “anomaly” splay legs, blind anus and other congenital malformations incompatible with survival have been summarized. The diagnosis “other” was used when the cause of death could not be ascertained.

Table 4
Post-mortem parameters evaluated in piglets that died or have been killed during the study period.

Variables	Outcome
Death date	Study day
Death	- Spontaneous - Killed
Cause of death / reason for killing	- Crushing - Starvation - Weak/ non-viable - Infection - Laceration/Anomaly - Other
Stomach milk content	Yes/No
Body weight at killing / when found dead	Kilogram

Table 5

Mortality by vitality score (VS) and intrauterine growth retardation (IUGR) in LW and NW groups evaluated at birth in under or normal weighted new-born piglets dying or surviving until day 5 of age.

category	LW		NW	
	n	%	n	%
vitality score (VS)				
0	146	16.4	180	7.9
1	127	46.5	9	33.3
2	29	93.1	0	0
3	26	100	0	0
intrauterine growth retardation (IUGR)				
0	124	22.6	187	4.8
1	133	36.8	3	33.3
2	71	83.1	1	100

Table 6

Logistic regression model for clinical variables related to the death of new-born piglets dying until day 5 of age. ref: reference category, OR: Odds Ratio Estimate, CI: confidence limits. p: level attained for Wald`s test

Risk categories	alive		dead		univariable model				multivariable model			
	n	%	n	%	OR	95%-CI		p	OR	95%-CI		p[a]
low	up	low	up									
Total	372		147		x			x	x			x
Body Weight												
> 1.39kg (ref)	127	96.95	4	3.05	1	x	x	x	1	x	x	
< 0.82kg	37	30.33	85	69.67	72.937	25.080	212.111	**< .0001**	8.298	1.920	35.865	**0.0047**
0.82-0.95kg	89	70.08	38	29.92	13.551	4.671	39.316	**< .0001**	4.381	1.229	15.622	**0.0228**
0.96-1.39kg	119	85.61	20	14.39	5.336	1.772	16.067	**0.0029**	3.160	0.982	10.167	0.0536
Vitality score												
0 (ref)	296	90.80	30	9.20	1	x	x	x	1	x	x	
1	74	54.41	62	45.59	8.265	4.989	13.694	**< .0001**	2.686	1.316	5.480	**0.0067**
2	2	6.67	28	93.33	138.129	31.353	608.539	**< .0001**	24.499	4.442	135.13	**0.0003**
3	-	.	27	100.00	> 999.99	< 0.001	> 999.99	0.9519	> 999.999	< 0.001		0.9941
Intrauterine growth retardation score												
0 (ref)	274	88.10	37	11.90	1	x	x	x	1	x	x	
1	86	63.24	50	36.76	4.305	2.640	7.022	**< .0001**	1.273	0.582	2.785	0.5449
2	12	16.67	60	83.33	37.027	18.231	75.201	**< .0001**	2.367	0.739	7.575	0.1463
Rectal temperature												
> 37.5°C (ref)	324	87.57	46	12.43	1	x	x	x	1	x	x	
≤ 37.5°C	48	32.21	101	67.79	14.818	9.336	23.519	**< .0001**	3.449	1.816	6.549	**0.0002**

[a] p-value Wald's Chi²-Test to the reference category

Table 7
Predicted probability for the death of a newborn piglet until day 5 of age assessed by clinical parameters identified from the multivariable logistic regression model (see table 6).

Body weight (kg)	Vitality Score (0,1,2,3)	Rectal temperature (°C)	Probability of death
< 0.82	1	≤ 37.5	0.64
< 0.82	1	>37.5	0.34
< 0.82	2	≤ 37.5	0.94
< 0.82	2	>37.5	0.82
< 0.82	3	≤ 37.5	1
< 0.82	3	>37.5	1
< 0.82	0	≤ 37.5	0.40
< 0.82	0	>37.5	0.16
0.82–0.95	1	≤ 37.5	0.48
0.82–0.95	1	>37.5	0.21
0.82–0.95	2	≤ 37.5	0.89
0.82–0.95	2	>37.5	0.71
0.82–0.95	3	≤ 37.5	1
0.82–0.95	3	>37.5	1
0.82–0.95	0	≤ 37.5	0.26
0.82–0.95	0	>37.5	0.09
0.96–1.39	1	≤ 37.5	0.40
0.96–1.39	1	>37.5	0.16
0.96–1.39	2	≤ 37.5	0.86
0.96–1.39	2	>37.5	0.64
0.96–1.39	3	≤ 37.5	1
0.96–1.39	3	>37.5	1
0.96–1.39	0	≤ 37.5	0.20
0.96–1.39	0	>37.5	0.07
> 1.39	1	≤ 37.5	0.17
> 1.39	1	>37.5	0.06
> 1.39	2	≤ 37.5	0.66
> 1.39	2	>37.5	0.36
> 1.39	3	≤ 37.5	1
> 1.39	3	>37.5	1
> 1.39	0	≤ 37.5	0.07
> 1.39	0	>37.5	0.02

Sample size calculation and statistical analyses

Calculation of the minimum sample size required for the study was performed using NCSS-PASS-software for a Wilcoxon rank-sum test comparing two groups (type I error 5%, power 80%). The sample size calculated was 564 piglets.

After general description data was analysed using a linear logistic regression analysis following a backward selection for multivariable modelling. Herds and batches per herd were included as random effects in this model to incorporate the hierarchical structure of the data. Body weight (day 1) was transferred into four categories comprising piglets < 0.82 kg (BW 1), 0.82 to 0.95 kg (BW 2), 0.96 to 1.39 kg (BW 3) and > 1.39 kg (BW 4). Rectal temperature was differentiated by two groups with ≤ 37.5°C (RT 1) and > 37.5°C (RT 2) as well as glucose (≤ 70 mg/dL, > 70 mg/dL) and immunocrit (≤ 0.1, > 0.1). Statistical significance was assumed for $p < 5\%$. All statistical evaluations were performed with SAS®, version 9.4 TS level 1M5 (SAS Institute Inc., Cary, NC, United States) using GLIMMIX as model procedure.

Results

Birth weight, vitality score and IUGR-score were significantly associated with a higher chance of mortality (univariate model, Table 6). The other clinical variables crown-rump length (CRL) and rectal temperature (RT) also showed lower values in LW than NW piglets and within both groups, piglets dying until day 5 had lower values compared to survivors (Fig. 1a-c).

The same effects were found in the laboratory measurements glucose and immunocrit but not lactate and haemoglobin (Fig. 2a-d). Higher scores in vitality (VS) and intrauterine growth retardation (IUGR) were associated with higher mortality until day 5 (Table 5).

The variables appropriate to predict the death a new-born piglet until day 5 of age were identified in a logistic regression model. The final multivariate model included the clinical parameters: body weight, rectal temperature and the IUGR- and vitality score. Laboratory measurements were not included as they are not accessible to the farmer. For the discussion and completeness of the data another model was used including immunocrit and glucose (see additional file 1). Crown-rump length was highly correlated with body weight at day 1 (Fig. 3) and, therefore, not considered in the final model. BW 4, RT 2, VS 0 and IUGR 0 were used as reference values. In the multivariate logistic regression model, a bodyweight < 0.82 kg, a vitality score 1 or 2 and a rectal temperature ≤ 37.5°C were identified to have an effect on the prediction of a death of a new-born piglet until day 5 (Table 6).

Based on the adjusted Odds ratios of the results of the logistic model, prognostic values for the probability of a new-born piglet to die until day 5 of age were derived, considering the different combinations of body weight, rectal temperature and vitality score (Table 7).

Mortality in the LW was 41.5 % (n = 136) and in the NW 5.8% (n = 11). In LW 18.4 % and 27.2 % in NW were killed as they showed severely reduced vitality (VS 3). The other piglets died spontaneously, 32.4 % (LW) and 18.2 % (NW) by crushing, 39.7 % (LW) and 27.2 % (NW) due to starvation. In 89.0 % (LW) and 72.7 % (NW) of the piglets the stomach was found empty.

Discussion

Care of new-born piglets is one of the main animal welfare issues in piglet-producing farms (6, 14, 23). While most studies are focused on improvement of piglet survivability (24–26) only a very few publications refer to the requirements for compromised new-born piglets with low chance for survival (2, 23, 27, 28). As the options for intensive care are limited under the standard conditions of piglet production, some farmers chose a pragmatic approach by killing new-born piglets they expect having less economical value (11). However, this practice is neither in accordance with the different animal welfare acts nor accepted by the majority of people in Europe (29). The opposite, also practiced on some farms, ignoring compromised new-born piglets and let them die without or only a little intervention is also not acceptable, as this may result in avoidable pain and/or suffer (30, 31). A first step into a way out of this dilemma might be found in a validated assessment scheme facilitating an estimation of the probability of death of a new-born piglet until five days of age. This scheme is aimed at giving farmers a clear guideline leading to a comprehensive decision about care or killing of a compromised new-born piglet.

Based on literature (10, 20, 32) a set of clinical and laboratory measurements associated with increased mortality in new-born piglets was selected. The selection was focussed on clinical variables that can be assessed easily by farmers and resulted in body weight, rectal temperature, crown-rump-length, a vitality score and an IUGR score. As clinical variables are often estimated being “subjective” compared to “objective” laboratory parameter, additionally a set of laboratory measurements was selected, expected to be appropriate in predicting the death of a new-born piglet (33–35).

The farmers were participating voluntarily in the study. The study herds were managed according to the rules of good farming practice, ensuring standard housing conditions and extensive care of the pigs. By the selection of the study herds we tried to exclude an influence

of poor housing or management on the results.

In a logistic regression analysis the clinical variables body weight, rectal temperature and vitality, measured and scored at the day of birth, have been identified being associated with death of piglets until day 5. Piglets are born without immunoglobulins and are highly dependent on the early intake of colostrum (3). The subjective measurement of milk intake (abdominal palpation) as a part of the vitality score and the objective measurement of the immunocrit in this study clearly underlined the importance on neonatal survival (for the influence of the immunocrit in the logistic regression model: see additional file 1).

Since piglets are born with no brown adipose tissue they are only able to maintain their body temperature through liver and muscle glycogen. These reserves only last for 16 to 24 hours (36). Blood glucose levels are described in various studies as highly significant to survival (33, 34). But the increase of glucose in agony or through catecholamine release in stressful situations aggravates the interpretation (4, 37). The univariate model showed a significant association between mortality and glucose, but the multivariate model showed no significant association (see additional file 1). Rectal temperature proved to be a better indicator of hypoglycaemia and hypothermia and is further easier to assess.

Hypoxia during prolonged births or birth in the last third of a litter leads to an increase of lactate (38, 39). Higher haemoglobin levels at birth make piglets less prone to hypoxia due to the higher oxygen binding capacity (40). No association to survival was seen for both variables in this study.

As a final outcome the probability of death was estimated for various combinations of scores by means of the estimated regression model parameters. A probability of 94 %, 89 % and 86 % to die until day 5 was determined for the combination rectal temperature ≤ 37.5°C and a vitality score 2 in the body weight groups < 0.82 kg, 0.82–0.95 kg and 0.96–1.39 kg (Table 7).

Body weight and rectal temperature can be easily and quickly measured by the farmer. The vitality score (41) is based on findings assessing the colour of the skin, the movement and the filling of the abdomen (Table 2). The vitality score with three items and findings that need to be assigned to one of only three categories (unaffected, moderate, and severe) is estimated to be appropriate for the application by farmers. Otherwise, a short introduction by the herd attending veterinarian will ensure a reliable application.

The results of this study clearly show that the death of a new-born piglet can be predicted by a simple clinical score applicable for veterinarians and farmers. Nonetheless, it needs to be emphasized the proposed method is not ready to be used in practice. Based on these results veterinarians, farmers and particularly ethicists need to clarify in an extensive process which probability of death will justify the killing of a new-born piglet.

Declarations

Acknowledgements:

The authors wish to thank the staff and the herd managers of the participating farms.

Author contributions:

LG developed the study design, performed the data collection and prepared the data for statistical analysis. EgB designed and supervised the study. The statistical analysis was performed by MH and LK. All authors read, edited and approved the final manuscript.

Funding:

The study received no funding.

Availability of data:

Please contact the corresponding author for data requests.

Ethics approval and consent to participate:

Permission to conduct this study was obtained from the Lower Saxony State Office for Consumer Protection and Food Safety (LAVES) and the State Office for Nature, Environment and Consumer Protection of North Rhine Westphalia (LANUV) approval number 33.8-42502-05-20A501 and in accordance with the requirements of the national animal welfare law (15).

Consent for publication:

Not applicable

Competing interests:

The authors declare that they have no competing interests.

Author details:

[1]Field Station for Epidemiology, University of Veterinary Medicine Hanover, Foundation

[2]Institute for Biometry, Epidemiology and Information Processing (IBEI), University of Veterinary Medicine Hanover, Foundation

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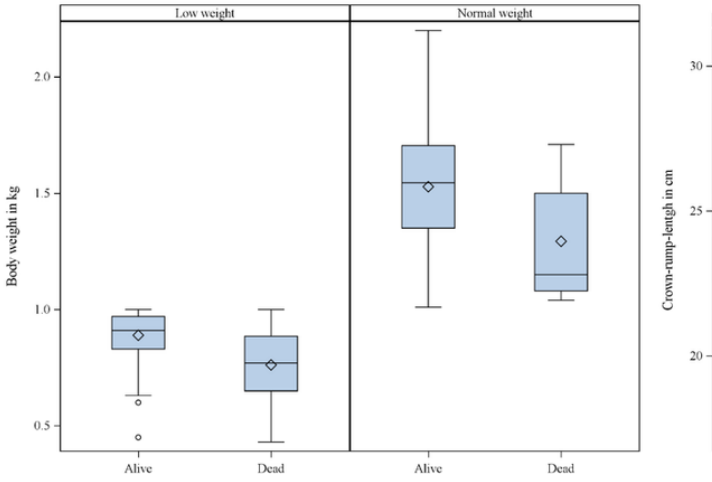
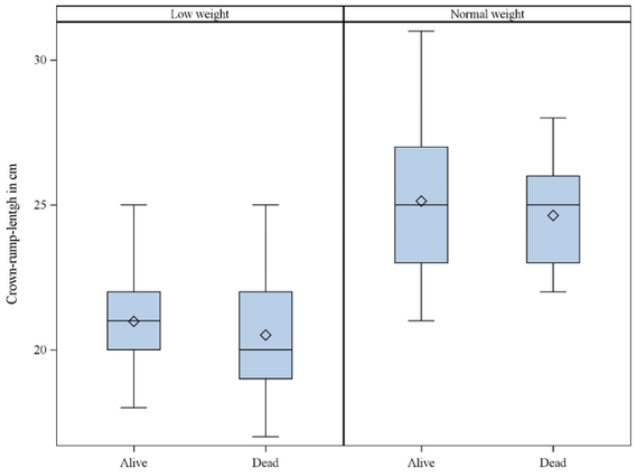
Figures





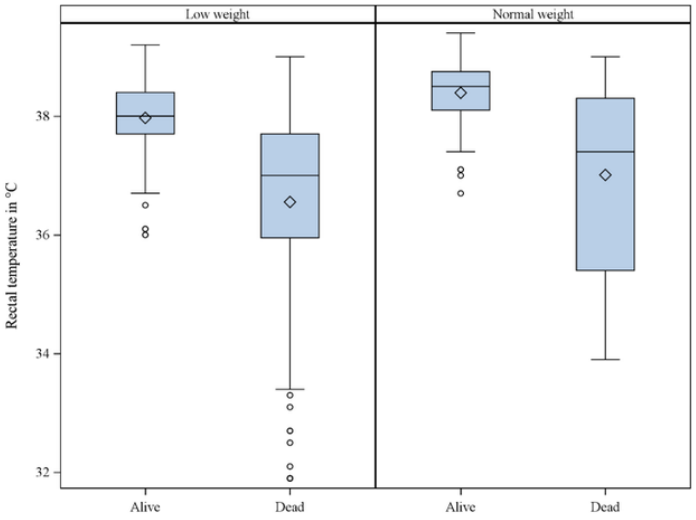


Figure 1

a-c: Descriptive statistics of metric clinical variables in the low weight group and normal weight group dying or surviving until day 5 of age.

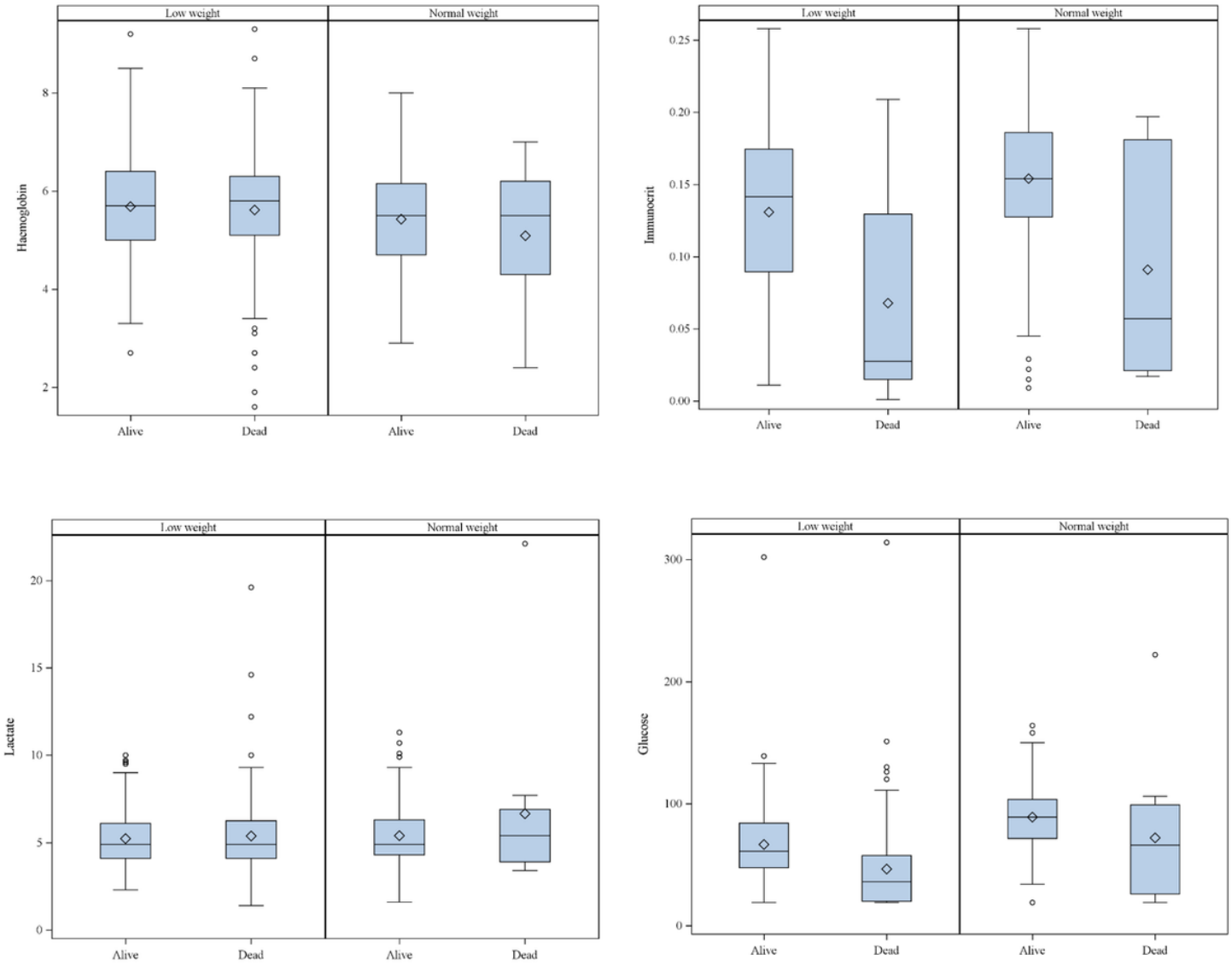


Figure 2

a-d: Descriptive statistics of metric laboratory variables in the low weight group and normal weight group dying or surviving until day 5 of age.

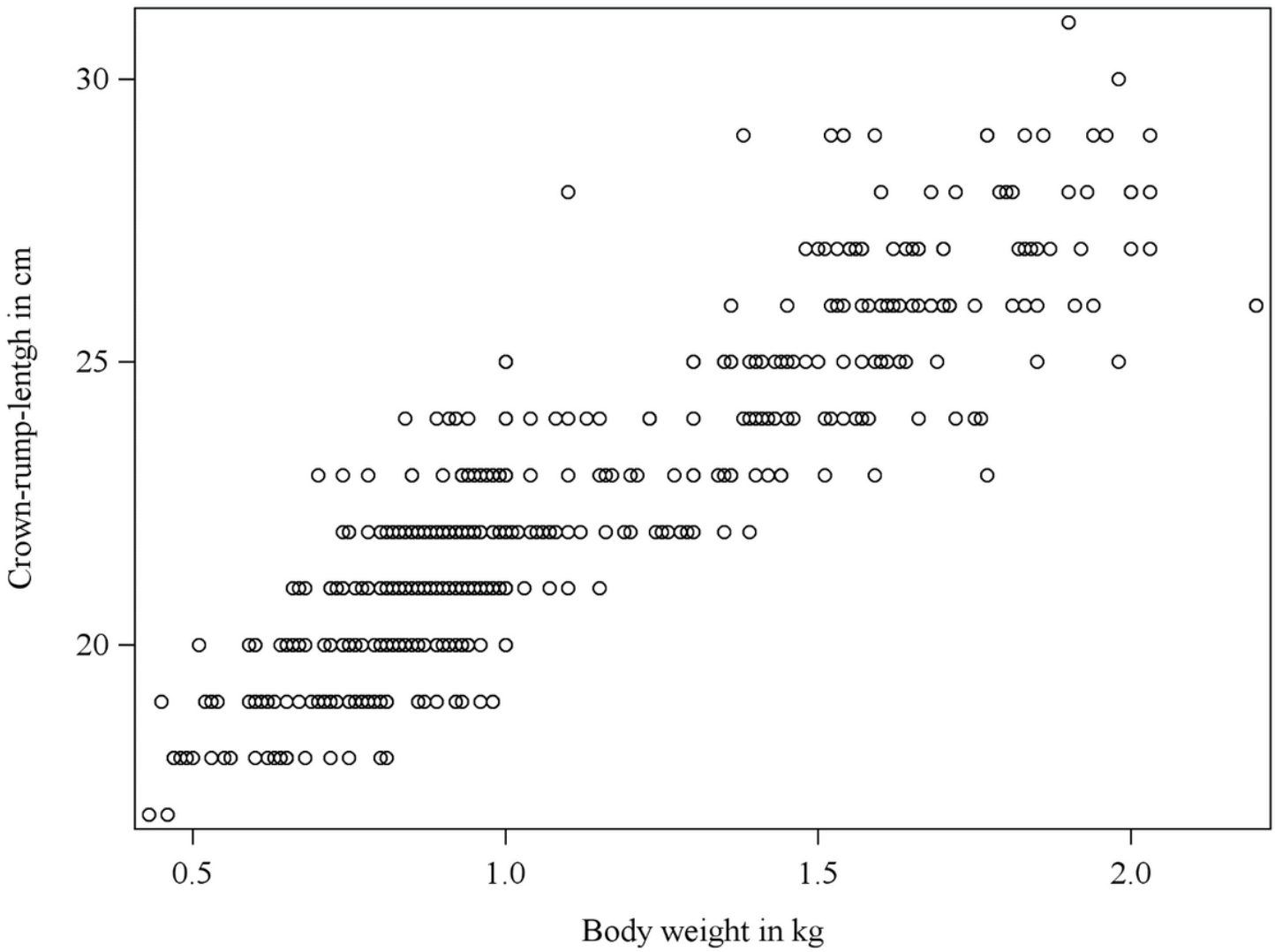


Figure 3

Correlation between bodyweight and crown-rump length at day 1 of age

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