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Determinants of Piglet Mortality

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ABSTRACT

Piglet mortality remains a significant challenge to sustainable pig farming. This review evaluates three major contributors to piglet mortality: crushing, starvation and diseases. Crushing accounts for up to 50% of piglet mortality, often linked to poor maternal behaviour, poor housing and sow parity. Starvation results from mastitis, poor maternal care, neonatal desertion and competition in large litters, often worsened by low birth weight and poor sow health. Diseases such as porcine reproductive and respiratory syndrome and transmissible gastroenteritis increase mortality, especially in piglets that do not receive adequate colostrum within the first 24 hours of life. Sows in their second to fourth parity offer optimal maternal capacity and colostrum yield. Additionally, housing interventions such as the provision of ellipsoid farrowing crates and where feasible, pens designed to enhance sow welfare and protect piglets, significantly reduce crushing incidents. Technological interventions, including surveillance and the use of electronic devices that prevent the sow from crushing piglets show promise in reducing piglet mortality. Ultimately, improving piglet survival requires not just understanding individual causes but managing the interplay of genetic and environmental factors. We emphasise the need for an integrated management approach that combines pen design, nutritional strategies and the monitoring of sow behaviour to reduce piglet mortality rates.

Keywords: *Colostrum, crushing, diseases, piglet mortality, sow welfare, starvation*

INTRODUCTION

Ghana's livestock sector plays a vital role in the country's economy. In 2022, it contributed approximately 4.9 billion cedis to Ghana's Gross Domestic Product (GDP), which accounted for nearly 13% of agriculture's contribution to GDP (Statista, 2024b). Ghana's livestock data for the year 2022 indicate that pigs had the lowest population of 846,000 among the various livestock species (Statista, 2024a). Despite their relatively small population, pigs have high potential as a model for sustainable poverty alleviation and food security due to their fast growth rate, shorter generational interval, shorter gestation period, efficient feed conversion, high dressing percentage (second only to broilers) and large litter sizes (Mbuthia *et al.,* 2015).

The pork market has shown real progress in meeting the rising demand for meat products in Ghana and as such plays a crucial role in the agricultural sector of many countries globally, providing a valuable source of income and contributing to the nutritional needs of the population (Banson *et al.,* 2014).

Despite the promising outlook, pig farmers face several challenges, including high feed costs, inadequate infrastructure, limited market access and low genetic potential of local breeds (Osei and Adu, 2015). One particularly concerning challenge is the high piglet mortality rate (Alonso-Spilsbury *et al.,* 2007), which significantly impacts the industry's overall profitability.

Piglet mortality refers to the death of young piglets, during their early life stages and is measured by the number of piglets that do not survive perinatally as well as before weaning (Stygar *et al*., 2022). Baxter and Edwards (2018) indicated that despite the accumulation of knowledge aimed at enhancing piglet survival, there has been limited progress in practical implementation over the past three decades. The overall mortality rate per litter, encompassing both stillborn and live-born deaths, has remained relatively high, ranging from 16 – 20% (Baxter and Edwards, 2018). On average, two piglets in every litter die before weaning. The death of piglets has negative consequences for pig production, leading to financial losses for farmers, reducing profitability and increasing production costs (Stygar *et al*., 2022). No one would want to invest in a business that is not profitable, so the financial losses discourage investment and expansion in the pig industry, resulting in lost economic opportunities. Therefore, understanding the determinants of piglet mortality and implementing effective strategies to mitigate this issue is of utmost importance. Given the significant impact of piglet mortality on the pig industry, this review aims to identify the key factors contributing to piglet mortality and find practical strategies to reduce its occurrence and enhance the growth of the pig production industry.

MATERIALS AND METHODS

This study was based on the review of scholarly articles, books and other existing literature on the issues of piglet mortality. Literature for the current study was also retrieved from electronic databases such as Google Scholar, PubMed, Scopus and ResearchGate.

RESULTS AND DISCUSSION

CAUSES OF PIGLET MORTALITY

Crushing

Crushing remains the leading cause of preweaning piglet mortality, responsible for nearly 50% of piglet deaths (Andersen *et al.,* 2005). Although it may appear purely accidental, the risk of crushing is strongly influenced by three major factors: genetic predisposition, maternal behaviour and care and environmental conditions. These factors do not operate in isolation but interact in ways that influence the probability of crushing incidents.

Genetic Factors

Genetic background plays a significant role in shaping sow behaviours that protect or endanger piglets. Several studies have highlighted differences in maternal instincts and carefulness during farrowing and lactation. For instance, Min pig sows have consistently demonstrated better maternal behaviour compared to Large White and Landrace sows. They show a greater tendency to perform pre-lying behaviours such as turning around cautiously before lying down, thereby reducing the chances of crushing piglets (Cui *et al.,* 2011; Huang *et al.,* 2021). Min pig sows also respond more attentively and quickly to piglet distress calls, further decreasing the incidence of fatal accidents.

Crossbreeding studies have reinforced these observations. Damin and Changmin sows, which carry Min pig ancestry, similarly exhibit stronger maternal responsiveness and a lower rate of crushing compared to purebred commercial breeds (Liu *et al.,* 2013). These findings suggest that certain maternal traits such as careful posture changes and heightened responsiveness to piglet distress are heritable. However, the relationship between genetics and behaviour is complex. While certain breeds are predisposed to better maternal instincts, environmental factors and management practices can still significantly influence outcomes.

Maternal behaviour and care

Even within breeds, individual differences in sow behaviour profoundly affect the risk of crushing. The way a sow moves, lies down and interacts with her piglets can determine survival outcomes. Sows that perform pre-lying behav-

iours such as sniffing, rooting and visually inspecting the lying area allow piglets time to move out of harm's way before they lower their bodies (Wischner *et al.,* 2010; Kobek-Kjeldager *et al.,* 2023). In contrast, sows that "flop" down rapidly without sufficient caution dramatically increase the likelihood of crushing (Damm *et al.,* 2005).

Sow attentiveness during nursing and postural changes is also crucial. Non-crushing sows are typically more alert, engaging more frequently in behaviours such as nose-to-nose contact with piglets before changing position (Wischner *et al.,* 2010). Moreover, good nest-building behaviour before farrowing positively correlates with better maternal instincts and lower piglet mortality (De Maria *et al.,* 2023).

Parity further complicates the picture. Primiparous sows often exhibit uncoordinated and careless behaviours during farrowing, such as frequent posture changes and abrupt lying down, which increase the risk of crushing (Li *et al.,* 2023). However, multiparous sows, despite being more experienced, may produce larger litters that make it harder to monitor and to protect all piglets effectively, again raising the risk of crushing (Rangstrup-Christensen *et al.,* 2018). Therefore, both inexperience and large litter size create vulnerabilities at different stages of a sow's reproductive life.

Environmental and housing factors

The physical environment in which sows and piglets are housed exerts a major influence on the risk of crushing. Housing systems range from traditional farrowing crates to free-farrowing pens, group housing and outdoor systems, each presenting different advantages and challenges with respect to piglet crushing.

Temporary crating systems, where sows are confined for a few days around farrowing and then released, have proven effective in reducing early postnatal crushing (Heidinger *et al.,* 2022). By restricting the sow's movements during the piglets' most vulnerable period, these systems can significantly lower piglet mortality without compromising sow welfare.

Conversely, completely loose-housed systems, while better for sow welfare, often result in higher piglet mortality if not carefully managed. Undersized pens, poor pen layout and lack of nesting material can exacerbate the risk by encouraging restless sow behaviour and reducing maternal attentiveness (Grimberg-Henrici *et al.,* 2019; Yun *et al.,* 2019).

The importance of good management practices cannot be overemphasised. Simple interventions such as providing adequate nesting material, supplemental heat sources for piglets and regular monitoring of sow and piglet interactions can drastically reduce crushing incidents (Frandsen and Bak, 2023). Moreover, early stockman intervention to assist weak piglets in accessing colostrum can improve their vitality, helping them escape dangerous situations near the sow. Therefore, environmental factors do not merely present physical hazards but they also interact dynamically with sow behaviour and piglet vitality, shaping the overall risk of crushing in the farrowing environment.

Starvation

Starvation usually occurs when piglets fail to consume enough colostrum and milk (Hasan *et al.,* 2019). However, as with crushing, the causes of starvation often interact. These include inadequate colostrum intake, competition among littermates, udder-related problems such as mastitis and poor maternal behaviour.

Colostrum quality and quantity

The earliest determinant of piglet survival is colostrum intake. Colostrum is not merely the first milk but a rich, highly concentrated source of immunoglobulins, energy and vital nutrients that are critical for piglet vitality and the initiation of immune system development (Quesnel *et al.,* 2012). Due to the epitheliochorial nature of the porcine placenta, piglets are born immunologically naive and must ingest sufficient high-quality colostrum within the first 24 hours of life, before gut closure prevents the absorption of immunoglobulins (Le Dividich *et al.,* 2005).

The quality of colostrum, measured largely by its immunoglobulin concentration, varies between sows but is generally stable across different parities. Nevertheless, the quantity of colostrum produced by a lactating sow is more variable and is influenced by factors such as sow parity and its

body condition score (Decaluwé *et al.,* 2013; Nuntapaitoon *et al.,* 2020). Sows in their second to fourth parity typically produce the highest volumes of colostrum, while older sows show declining yields.

Low colostrum intake is strongly associated with high piglet mortality. Ferrari *et al.* (2014) found that piglets with low birth weights must ingest around 250g of colostrum to match the survival rates of heavier littermates. Failure to meet this intake threshold leaves piglets vulnerable to hypothermia (chilling), hypoglycaemia and ultimately death. Therefore, both quality and quantity of colostrum have significant bearing on early piglet survival.

Competition at the udder

Even if a sow produces sufficient colostrum, competition among littermates can prevent weaker piglets from accessing it. In large litters, especially those exceeding the sow's number of functional teats, intense competition emerges for access to milk (Kobek-Kjeldager *et al.,* 2020). Piglets must quickly secure and defend a teat during the short windows of milk letdown and smaller or less vigorous individuals are often pushed aside.

The consequences of this competition are severe. Smaller piglets receive less colostrum, grow more slowly and suffer higher mortality rates due to both starvation and secondary infections (Charneca *et al.,* 2021). As litter size increases, behaviours such as teat fighting and increased udder massage become more common, indicating higher levels of hunger and stress within the group (Kobek-Kjeldager *et al.,* 2020). Interestingly, older sows appear to maintain a baseline vulnerability to piglet starvation irrespective of litter size. This may reflect a decline in maternal care with age (Andersen *et al.,* 2011). This suggests that the risk associated with competition is not solely dependent on litter size but also on maternal capacity.

Udder health and milk availability

The health status of the sow's udder plays a decisive role in determining whether piglets will receive adequate nutrition. Mastitis, an inflammation of the mammary glands, is particularly detrimental, leading to a reduction in milk quantity and quality within 24 – 48 hours postpartum (Gerjets *et al.,* 2011). Piglets nursing from sows with mastitis often experience stunted growth and a higher likelihood of death due to insufficient milk intake.

Beyond mastitis, agalactia, which is the complete failure of milk production, represents an even more severe risk (Wagner, 1982). Agalactia often stems from poor management during late gestation or the postpartum period and leaves piglets entirely dependent on artificial interventions for survival (Papadopoulos *et al.,* 2010). Without timely and skilled stockman intervention, piglets born to sows with udder problems most certainly suffer starvation. Therefore, the health of the sow's mammary system is not merely a welfare issue but a matter of life and death for neonatal piglets.

Maternal behaviour

Finally, maternal behaviour heavily influences piglet access to colostrum and milk. Attentive sows facilitate frequent and calm nursing opportunities, creating an environment where all piglets, even the weaker ones, can suckle effectively (Gäde *et al.,* 2008). Conversely, inattentive or aggressive sows may desert or refuse to nurse, or even harm piglets through biting or rough movements (Liu *et al.,* 2023) especially after a prolonged farrowing period.

Poor maternal care is often rooted in stress, illness, or suboptimal farrowing environments (Yun *et al.,* 2019). Sows housed in cramped pens are more likely to exhibit restless or negligent behaviours that jeopardise piglet survival. It is therefore very important to provide a well-designed maternity unit in the piggery to enhance piglet survival.

DISEASES

Diseases significantly threaten piglet survival, leading to substantial losses in the pig industry. Understanding the various diseases that affect piglets is crucial for implementing effective preventive measures and ensuring their survival and overall health. Some diseases affecting piglet health include porcine reproductive and respiratory syndrome, transmissible gastroenteritis and African swine fever. These diseases will now be discussed.

Porcine reproductive and respiratory syndrome (PRRS)

Porcine reproductive and respiratory syndrome (PRRS) is one of the most significant viral diseases affecting piglets globally. It is caused by the PRRS virus and leads to high rates of miscarriages, stillbirths and respiratory illness among piglets (Rossow, 1998; Zhang *et al.,* 2022). There are two major variants of the virus, North American and European variants. It is highly contagious, spreading rapidly through direct contact or airborne transmission. PRRS severely compromises the immune system of infected piglets, leaving them very susceptible to secondary infections. Mortality rates following PRRS outbreaks can range from moderate to catastrophic levels, with some studies reporting mortality as high as 80% in piglets infected with highly pathogenic strains (Li *et al.,* 2016). Infected piglets typically suffer from laboured breathing, poor growth rate and increased vulnerability to other pathogens.

Control of PRRS remains a major challenge due to the virus's high mutation rate and its ability to establish long-term infections. No effective vaccine or antiviral treatment currently exists, making strict biosecurity and selective breeding for resistance essential strategies in its management (Zhou *et al.,* 2011; Zhang *et al.,* 2022).

Transmissible gastroenteritis

Transmissible gastroenteritis is a viral disease and a member of the *Alphacoronavirus* genus (Garwes, 1988). The virus was first isolated in 1946 (Doyle and Hutchings, 1946). The virus primarily infects the small intestines of pigs, causing a highly contagious and often fatal in piglets (Chen *et al.,* 2023). The virus is primarily transmitted through the faecal-oral route, respiratory aerosols and from infected sows to piglets through breastfeeding (Garwes, 1988). The severity of the disease is related to the age of the infected pig, with piglets under two weeks old experiencing nearly 100% mortality due to severe diarrhoea, vomiting and dehydration (Garwes, 1988). Adult pigs may only experience transient symptoms such as fever and anorexia. Transmissible gastroenteritis virus invades the small intestinal epithelium after infection, causing severe damage. This includes small intestinal villous atrophy and severe diarrhoea, which are central events leading to the death of infected piglets (Chen *et al*., 2023).

STRATEGIES TO REDUCE PIGLET MORTALITY

Housing and pen design

One of the most direct ways to reduce crushing is through housing design that balances sow welfare with piglet protection. Traditional farrowing crates restrict sow movement to prevent overlay, but has been criticised for severely limiting natural behaviours such as turning, walking and nest-building (Vandresen and Hötzel, 2021). Although effective in reducing crushing, their ethical acceptability continues to be debated.

Alternative pen designs now aim to provide both protection and freedom. The ellipsoid farrowing crate, with its oval frame and bowed bars, allows sows to lie comfortably while maintaining visibility and access to their piglets. Studies have shown that these designs reduce maternal stress and stereotypic behaviours (Lou and Hurnik, 1994; 1998).

Sow welfare and piglet protection (SWAPP) pens offer temporary confinement immediately around farrowing, then release the sow into a more spacious area as piglets gain strength. This design, which includes sloped floors and heated creep areas, has been shown to reduce early crushing without compromising sow mobility in the long-term (Hales *et al.,* 2015; Skovbo *et al.,* 2022). Sloped flooring is another effective modification. Danholt *et al.* (2011) demonstrated that sows in pens with a 10% sloped floor recorded fewer hazardous rolling movements, thereby reducing piglet trapping incidents.

Behavioural monitoring and intervention

Technology-based systems can now detect sow behaviour and intervene before crushing occurs. Camera-enhanced monitoring systems such as those using red, green, blue (RGB), infrared, or depth cameras, identify visual symptoms such as piglets lying in dangerous proximity or distress behaviours (Habineza *et al.,* 2021).

Complementing visual systems, researchers have explored stimulus-triggered sow movement as a proactive safety mechanism. Air-blow and floor vibration systems have been shown to successfully prompt posture changes in sows when pig-

lets are at risk without triggering panic responses (Manteuffel *et al.,* 2014). Integrating these systems with posture-tracking and stress-detection software offers promising avenues for real-time, non-invasive protection of piglets.

Nutritional interventions

Sow nutrition has a direct impact on colostrum yield, milk production and piglet vitality. High-quality colostrum intake in the first 24 hours is critical for immune system development and survival, particularly for small-sized piglets.

Yeast extract supplementation during late gestation and lactation has increased sow feed intake, reduced oxidative stress and improved piglet growth and immunity (Tan *et al.,* 2021). The optimal level appears to be around 10g/kg for both efficiency and economic benefits. Precision feeding, using automated delivery and mathematical models, allows sows to receive tailored nutrient profiles across gestation stages. Domingos *et al.* (2024) found that precision-fed sows produced heavier litters, improved milk yield and demonstrated more efficient feed-to-litter weight conversion, enhancing both sow condition and piglet survival.

Fostering and piglet redistribution

Foster mothering remains one of the most practical and widely used methods to reduce both starvation and competition within large litters. By redistributing piglets among sows based on teat availability and piglet strength, farmers can ensure more equal access to colostrum and reduce mortality due to malnutrition (Heim *et al.,* 2012). However, excessive or poorly timed fostering can create stress in both the transferred piglets and the receiving litter. Timing is crucial and fostering should ideally occur within the first 24 hours, when piglets are still establishing teat order and maternal recognition is minimal (Alexopoulos *et al.,* 2018).

Management and stockmanship

Human intervention plays a critical role in piglet survival. Stockpersons trained to observe sow body language can avoid triggering aggressive behaviour during farrowing and can quickly intervene when weak piglets fail to suckle or are at risk of being crushed (Frandsen and Bak, 2023). Simple management acts, such as cleaning and warming piglets immediately after birth, ensuring heated creep areas, or manually helping piglets grip onto teats, can dramatically reduce early mortality (Andersen *et al.,* 2009). Stockmanship is also central to enforcing hygienic conditions and identifying early signs of disease or sow fatigue that might otherwise go unnoticed in less supervised systems.

CONCLUSIONS

Piglet mortality, caused largely by crushing, diseases and starvation, remains a major challenge in pig production. These three major and intertwined causes of piglet loss are influenced by genetic, maternal and environmental factors. Crushing is strongly linked to sow behaviour, parity of sow and housing design, while starvation is largely associated with inadequate colostrum intake, competition among littermates for udder space, udder health problems and poor maternal care. Diseases such as porcine reproductive and respiratory syndrome, transmissible gastroenteritis and African swine fever further exacerbate piglet mortality by compromising piglet health and survival.

The review brings to the fore that reducing piglet mortality requires an integrated management approach rather than reliance on a single husbandry intervention. Appropriate housing designs, improved sow nutrition, effective fostering practices and good stockmanship can significantly enhance piglet survival. Attention to sow welfare, colostrum management and strict biosecurity measures are also essential in minimising piglet losses.

Ultimately, improving piglet survival will not only enhance animal welfare but also increase profitability within the pig industry. Future research should focus on developing sustainable, affordable, farmer friendly and practical interventions suitable for both commercial and smallholder pig production systems, particularly in developing countries such as Ghana.

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