THE WELFARE-SURVIVAL PARADOX: A COMPARATIVE ANALYSIS OF PRE-WEANING PIGLET MORTALITY IN TRADITIONAL FARROWING CRATES VERSUS MODERN FREE-FARROWING SYSTEMS

E.M. Glugă*, D.N. Enea

University of Agriculture and Veterinary Medicine Bucharest, Romania
Faculty of Animal Productions Engineering And Management

Abstract

The current global swine industry finds itself at an intersection between a shift towards animal welfare, alongside the economic demand of maximising neonatal survival. Traditional farrowing crates have historically been used to restrict maternal movement, mitigating the primary cause of pre-weaning mortality. However, the ethological restrictions that arise from the use of this method has created an intense 109 public debate leading to regulatory scrutiny. This scrutiny in turn pushes the industry towards modern free-farrowing pens, which consequently reintroduce the risk of accidental crushing. The following paper provides a comprehensive comparative analysis of pre-weaning piglet mortality, between the modern free-farrowing systems and the traditional farrowing crates. As a primary objective, we seek to deconstruct the multifactorial causes of neonatal death, focusing on crushing, hypothermia, and starvation. Evaluating how these aetiologies change depending on different farrowing systems. The study also seeks to critically examine the mitigating effects of modern farrowing paradigms, such as temporary confinement, advanced microclimate control and genotypic selection for heightened maternal ethology.

Key words: *farrowing, sow behaviour, welfare, piglets, neonatal survival*

INTRODUCTION

The global swine industry is currently navigating a complex transitional phase, finding itself situated at an intersection between ethical dilemmas, emerging stringent regulations, and an uncompromising economic reality. At the centre of this global transition lies the phenomenon known as the “Welfare-Survival Paradox.” This represents a complex biological, logistical, and ethical conflict found within the management of periparturient sows and their litters. Historically, there has been a universal implementation of conventional farrowing crates, which provide an effective solution to a fundamental biological problem: protecting neonatal piglets from fatal maternal crushing. However, this effectiveness comes with severe ethological restrictions imposed upon the sow through permanent crating, which has given rise to intense ethical, public, and regulatory scrutiny.

A European Citizens' Initiative (ECI) titled "End the Cage Age" has managed to capitalise on the momentum against extreme spatial confinement in intensive agriculture, by securing 1.4 million verified signatures from across the European Union . This initiative’s popularity compelled the European Commission to respond in 2021 and set out plans for legislative proposals [13]. While the European Union's complex legislation continues to navigate judicial and procedural delays, several sovereign

*Corresponding author: glugaeduard@yahoo.com
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states have begun implementing independent regulatory timelines that seek to phase out farrowing crates. The routine use of farrowing crates is already banned in Switzerland, Norway, and Sweden. Meanwhile, Germany has pledged to end the use of sow stalls by 2030, and restrict time spent in farrowing crates to a maximum of five days starting in 2035 [2].

However, despite these sovereign efforts to improve animal welfare, implementing isolated national legislation introduces a severe macroeconomic and ethical vulnerability. As Mata and Paixão [8] argue, unilateral bans risk exporting the underlying problems to countries with weaker regulations, through the the reselling and relocation of decommissioned farrowing equipment. This phenomenon of global welfare leakage is further supported and expanded, warning that when domestic producers are forced to reduce their herd sizes to comply with the requirement for extra space, the global demand for animal protein will shift to other countries [9]. Consequently, these displaced production quotas are frequently met by facilities relying on the very conventional, continuous confinement systems, undermining the intended ethical advancements.

In addition, this new wave of regulatory scrutiny has reignited the issue of accidental piglet crushing. The industry is now tasked with the challenge of replacing the effective mechanical solution of the farrowing crate with an alternative that allows for high maternal behavioural freedom without compromising neonatal survival [4]. Such a mandate creates a real-world logistical problem. Piglet death is inherently the result of multiple interconnected factors within a biological triad, consisting of crushing, hypothermia, and starvation [1, 3]. When piglets are expelled from the warm uterine environment, they rapidly experience chilling and hypothermia. The result is a thermal deficit which induces profound physiological lethargy, in turn this suppresses the piglet's vital drive to locate the udder, leading to inadequate colostrum intake and clinical starvation. This nutritional deprivation, alongside the hypothermic state, leaves the piglet physically too weak to evade a sudden movement from the mother. While the final proximal cause of death is blunt force trauma, the underlying thermal and nutritional factors play a critically interconnected role [7].

Despite the compelling ethical arguments used against permanent crating, there are also the economic factors which must be addressed. Implementing loose farrowing and lactating systems results in a significantly higher production cost [9]. The spatial expansion necessary for loose farrowing pens that permit basic biological locomotion directly reduces the number of farrowing places available within the same farm space, simultaneously, there is the demand of additional capital expenditure for retrofitting or constructing new facilities. Taking into account all of these intersecting biological, economic, and legislative issues, the primary objective of this study is to provide a comprehensive analysis of pre-weaning piglet mortality, comparing modern free-farrowing systems with traditional farrowing crates. More specifically, this research aims to:

- Deconstruct the complex causes behind neonatal death, evaluating how the distinct aetiologies of crushing, hypothermia, and starvation shift depending on the specific farrowing accommodation utilised.
- Critically examine the mitigating effects of modern farrowing methods, particularly the use of temporary confinement (TC) protocols.
- Evaluate advanced engineering and biological solutions, such as the precise thermodynamic manipulation of the farrowing pen microclimate and genotypic selection for increased maternal ethology.

MATERIAL AND METHOD

This study was conducted as a comprehensive narrative review and critical synthesis of existing epidemiological data and macroeconomic models, aimed at evaluating how conventional crates and non-confinement pens influence neonatal survival, maternal welfare, and commercial sustainability. Source selection prioritised peer-reviewed literature focusing on periparturient domestic sows coupled with clear, measurable outcomes directly linked to distinct farrowing environments, cause-specific mortality, and capital costs. The analysis synthesised findings from foundational veterinary pathology, modern epidemiological field studies, and standardised commercial-scale economic models.

RESULTS AND DISCUSSIONS

The systematic evaluation of neonatal survivability clearly shows us effects caused by the removal of mechanical maternal restriction. Glencorse et al. [4] provide empirical meta-analytical data proving that the transition from conventional continuous confinement to non-confinement farrowing pens compromises neonatal safety, resulting in a 14% higher relative risk of pre-weaning piglet mortality. Meanwhile, post-mortem evaluations confirm that the predominant proximal cause in these unconfined systems is maternal crushing. As outlined by the EFSA Panel on Animal Health and Welfare [10], reducing loose pen space below 6.6 m² restricts the sow's locomotory freedom and actively drives up piglet mortality, as the sow lacks the space to safely change her posture. To mimic the safety of a farrowing crate, a massive spatial expansion to 6.6 m² is mandatory. But, as Moustsen et al. [9] argue, implementing this spatial expansion introduces secondary hazards. As a result, the unconfined pen system forces a fatal trade-off, restricting space guarantees mechanical crushing, while providing the necessary space guarantees secondary hazards.

Extrapolating from the physiological frameworks of Edwards [3] and Alonso-Spilsbury et al. [1], we argue for a biological triad as a system where acute chilling induces physiological lethargy, suppressing the neonatal critical drive to locate the udder. In turn, the lack of colostrum intake results in clinical starvation. The terminal reality of this pathological cascade is validated by Spörri-Vontobel et al. [11], who demonstrated that crushing is a complex event event. They established that the risk factors for crushing depend on piglet viability. Large litters predominantly drive the crushing of low-viable piglets, but environmental stressors such as elevated ambient temperatures act as the primary hazard for viable, healthy piglets. However, the inherent spatial hazard of the unconfined pen cannot be entirely mitigated by neonatal vitality. As Kielland et al. [5] note in their evaluation of loose-housed herds, blunt force trauma remains a persistent threat even to large, well-fed, and highly viable piglets.

A solution to this issue has been the introduction of modern temporary confinement protocols, presented as a highly engineered architectural compromise [9]. Because live-born piglet mortality is concentrated within the immediate periparturient window and the subsequent 72 to 96 hours postpartum [15], utilising temporary confinement only during the initial critical period of vulnerability, curtails the manifestations of the biological triad [1, 3], while also allowing the sow behavioural freedom.

There are, however, profound challenges regarding the commercial scalability and environmental sustainability of zero and temporary confinement systems. When evaluating the financial cost, it is necessary to distinguish between specific architectural configurations.

Table 1. Comparison between conventional and zero confinement farrowing enclosures

Element of analysis	Conventional Farrowing Crates	Zero Confinement Enclosures	Source
Primary cause of death	Hypothermia, Starvation, localised crushing.	Blunt Force Trauma	[5] [7]
Pre-Weaning Mortality Risk	Baseline	14% above baseline	[4]
Biological Triad	Minimised	Exacerbated	[1] [2]
Piglet viability	Low viability piglets are protected from crushing but die from starvation and competitive exclusion	Low viability piglets are at a higher risk from large little competition.	[11]

According to Moustsen et al. [9], transitioning to a temporary confinement system with partly slatted flooring (TCPS) require a 14.4% increase in required capital per farrowing place, whereas implementing a fully unrestricted, zero-confinement pen with partly slatted floors (ZCPS) demands a staggering 21.7% increase. Alongside these severe financial implications lies the issue of physical space, dictating that farms retrofitting existing facilities to accommodate these systems will result in a reduction of farrowing places. For example, within a standard 1000-sow operation, retrofitting for a zero-crating system with partially slatted floors will require an approximated 30% reduction of the entire reproductive herd to maintain the existing structural footprint [9]. The resultant macroeconomic reality is the burden of increased baseline financial costs alongside a decrease in total farm output and profit margin. Furthermore, utilising established emission factors from earlier foundational research [12], Moustsen et al. [9] calculated that the expanded spatial footprint required for temporary confinement systems, when coupled with fully slatted floors, increases ambient ammonia emissions by 26% per pen.

Theoretically utilising partly slatted floors within zero confinement enclosures can reduce the exposed slurry surface and consequently lower emissions by 33%, but the practical reality of unconfined maternal movement introduces a severe limitation.

The unconfined space makes the solid floors highly susceptible to faecal and urinary fouling. This fouling not only creates a secondary emitting surface that partially negates the theoretical reduction in ammonia emissions, but it also introduces aggressive bacterial vectors into the neonatal environment. These compromised hygienic conditions elevate the risk of veterinary issues [9].

Alternative or complementary solutions to the Welfare-Survival paradox are advanced biological and thermodynamic interventions. Microclimate manipulations can be implemented to create a strict thermal gradient.

This involves maintaining a general room temperature of 18-20 °C to respect the sow's thermoneutral zone [14], alongside a localised, sensor-regulated creep heating zone of 30-34 °C [15].

This extreme thermal disparity actively attracts the neonates away from the maternal drop zone in order to prevent crushing. The industry is moving towards biological solutions in the form of genotypic selection. The commercial efficacy of the Estimated Breeding Value in modern, non-confined architectures has been validated by Lipori et al. [6].

Table 2. Variation of different factors of technology related to farrowing system [9]

System type	Cost	Change required	Environmental factor/ ambient ammonia
Conventional Farrowing Crate	baseline	baseline	baseline
Temporary Confinement	14.4% extra with partially slatted floors	Requires retro fitting and a potential reduction in farrowing pen	+26% increase in ambient ammonia with fully slatted floors
Zero confinement	21.7% extra with partially slatted floors	30% reduction in herd size, if the same space is maintained.	Increased ambient, but can be mitigated by partially slatted floors. Although that creates the issue of fouling

Table 3. Alternative or complementary solutions to the Welfare-Survival paradox

Actions to be taken	Mechanism	Practicality	Source
Legislative Bans	Laws being implemented throughout the European Union to limit traditional farrowing crate usage.	Politics move slowly. Policy has to be realistic with current limitations. Even with legislation, the problems tend to move elsewhere.	[8] [13]
Genotypic selection	Selectively breed sows that show heightened maternal ethology	It takes a long time for genetics to advance conclusively, and for the result to trickle down to commercial farms	[6]
Microclimate engineering	18-20°C rooms with 30-34°C creep areas to draw piglets away from danger	Can be complex to implement in unconfined pens.	[14] [15]

Their analysis confirms that selecting sows with a high genetic merit for mothering ability provides a measurable strategy to reduce piglet mortality in free-farrowing systems. While the exact biological traits underlying this metric require further study, researchers hypothesise that EBV likely captures enhanced maternal behaviors, such as carefulness during postural transitions, which have been linked to lower crushing rates. Providing a promising genomic strategy to help mitigate the Welfare-Survival paradox.

CONCLUSION

The thorough evaluation of physiological, architectural and macroeconomic factors confirms the complex existence of the Welfare-Survival Paradox. Despite the intense ethical scrutiny garnered by conventional farrowing crates, which impose severe ethological restrictions on the sow, they serve as highly calibrated thermodynamic and physical safeguards for the neonate. Their unconditional removal, without adequate architectural or biological compensation, drastically increases pre-weaning mortality. This mortality is the result of an exacerbated biological triad. Expanding the space of the unconfined pen increases the distance between the potential birthing site and the controlled creep area. This spatial hazard creates a risk of acute hypothermia leading to physiological lethargy, suppressing colostrum intake and ending in clinical starvation and maternal crushing.

Furthermore, prioritising maternal ethology introduces severe macroeconomic constraints. The cost increase for architectural transition ranges from 14 to 22%, while enforcing an up to 30% reduction in herd size. Alongside this, the expanded area increases ambient ammonia emissions by 26% when utilising fully slatted floors. Implementing partly slatted floors introduces a new set of hygienic vulnerabilities. Together, these intersecting factors make a sustainable resolution through the unilateral removal of restrictive hardware unrealistic. Temporary confinement offers a short-term compromise, neutralising the biological triad during the critical initial periparturient window. However, a long-term solution should be sought through a multidisciplinary synthesis. The use of genotypic selection alongside microclimate engineering can help systematically dismantle the risk of an unconfined pen, allowing for ethical compliance within a framework of biological safety and economic viability. The issue arising from this being the slow implementation of these methods, contrasting the impatient legislative push.

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