SWINETECH

Do SmartGuard® stimuli cause sows more long-term distress than conventional methods?

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Introduction

Among live born piglets, 1 in 10 pigs are crushed to death by the sow. Nearly half of crushing-deaths occure during the first 3 days after birth (Weary et al., 1996; Knauer et al., 2013).

Many researchers conceded that the farrowing stall is necessary to reduce mortality from crushing (Weary et al., 1996; Damm et al., 2005; Singh et al., 2017). Despite the widespread use of farrowing crates in the U.S., piglet-mortality from crushing costs U.S. swine producers up to $330 million dollars a year (Lay et al., 2015). Furthermore, if the sow gets up within the first 4-minutes after a crushing event, the piglet can survive; therefor, non-survivors suffer for at least 4 minutes.

When barn managers detect a piglet death, they often will rush to the sow and slap her to motivate her to stand and free the piglet (Hutson et al., 1992). However, humans are variable and they can become very stressed and frustrated when the sow does not respond to the hand-slap. This frustration and variability can lead to lead to mistreatment of the sow.

Artificial intelligence (AI) technology (SmartGuard; SwineTech Inc., Cedar Rapids, IA USA) identifies a piglet distress call and then locates the exact sow to stimulate. This system first provides a vibration warning. If she does not rise, the system then emits an electrical impulse (EI) stimulus. This potentially reduces the risk of human mistreatment.

"Does the Electrical Impulse stimulus cause disruptive stress?"

Nonetheless, electrical-impulse conditioning may be viewed by some people as more distressful for the sow than human hand-slaps, particularly because electric prods cause distress and disrupt behavior (Lewis et al., 2008). Unlike electric prod-use by humans, AI-technology does not get frustrated and is less variable.

SwineTech wanted to ensure their stakeholders and customers that the technology is not as disruptive as conventional methods. Therefore, Mr. Rooda asked Kansas State University assistant Professor, Dr. Hulbert, to conduct an experiment to answer the question, "Does the Electrical Impulse stimulus cause distress that is more disruptive than Conventional methods?"

An independent, controlled research study at

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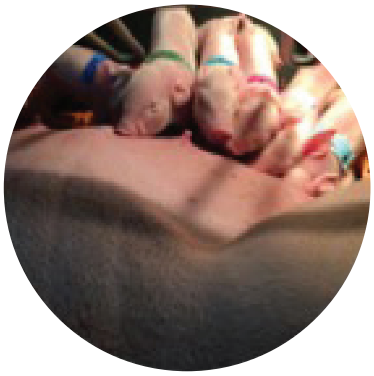


Objective:

To determine the sow behavioral, physiological, and performance outcomes of mitigating a simulated crush event with the stimuli: vibration (control; VIB), conventional (hand-slap; CONV), and the SmartGuard stimuli, vibration + electrical impulse (VIB+EI).

Fifty-six multiparous sows (DNA genetics), housed and managed at Kansas State University facilities (IACUC # 3896), were enrolled three days before the first farrowing. After the last sow farrowed, they were randomized into 3 treatments:

- **Vibration only (control)**
- **3 hand-slaps to hind quarters (conventional)**
- **Vibration followed by electric impulse (SmartGuard stimuli)**

Six sessions were performed to simulate crush-events. All sows were subjected to a 40 second play-back over a speaker (1 per 2 sows) of a piglet's distress call.

Data were collected according to a schedule (Figure 1). Data representing acute stress responses included: 1) heart rate and cortisol before and after treatment; 2) startle response (live observation); 3) coping behaviors (recorded video). Residual-effect data included: 1) circadian cortisol (Area Under the Curve, AUC from all sow blood samples); 2) milk passive transfer to piglet (via total plasma protein, TPP), and; performance (piglet bodyweights, sow feed intake, weight, and reproductive performance measures).

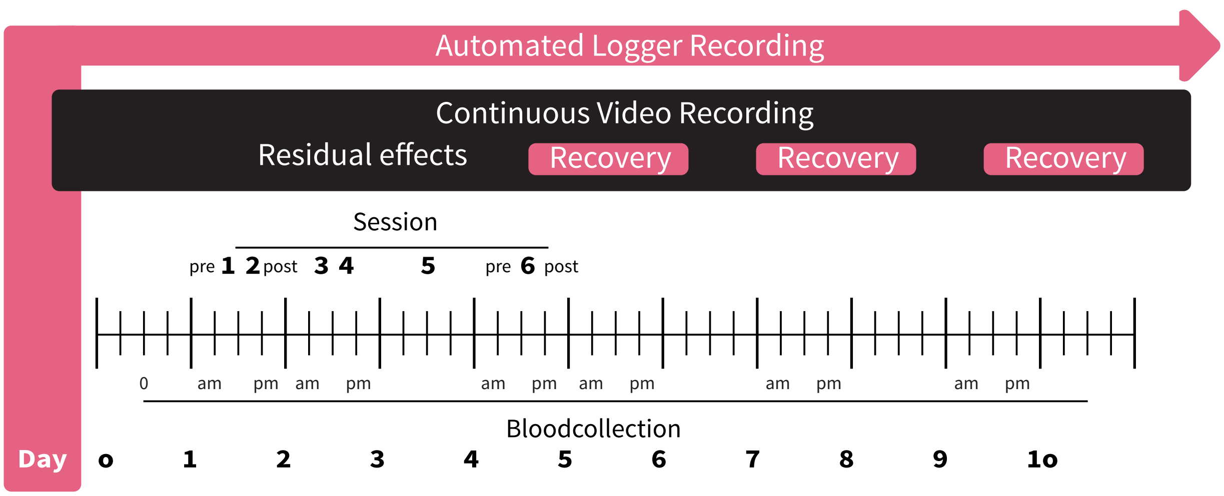
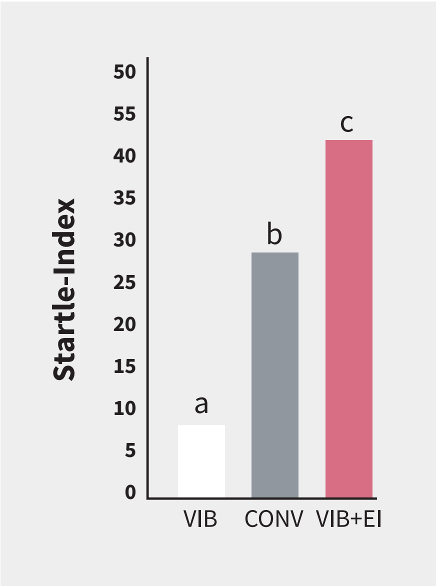


Figure 1.
TimeLine relative to farrowing in days ± 1.4 standard deviation. Six sessions were administered over 4 days post farrowing. Overhead video recording sampled the residual and recovery behaviors and automated devices documented nutritive and non-nutritive oral activities for the entire duration of farrowing. Heart rate monitors and stimuli-devices were attached before session 1. Ear-vein blood from sow was collected to measure circadian and stress-response cortisol at farrowing, in the mornings (0600 h, am), just before and just after the last and first session (pre and post), and for the recovery days (am and pm). Not shown is piglet blood collection at birth and day 7.

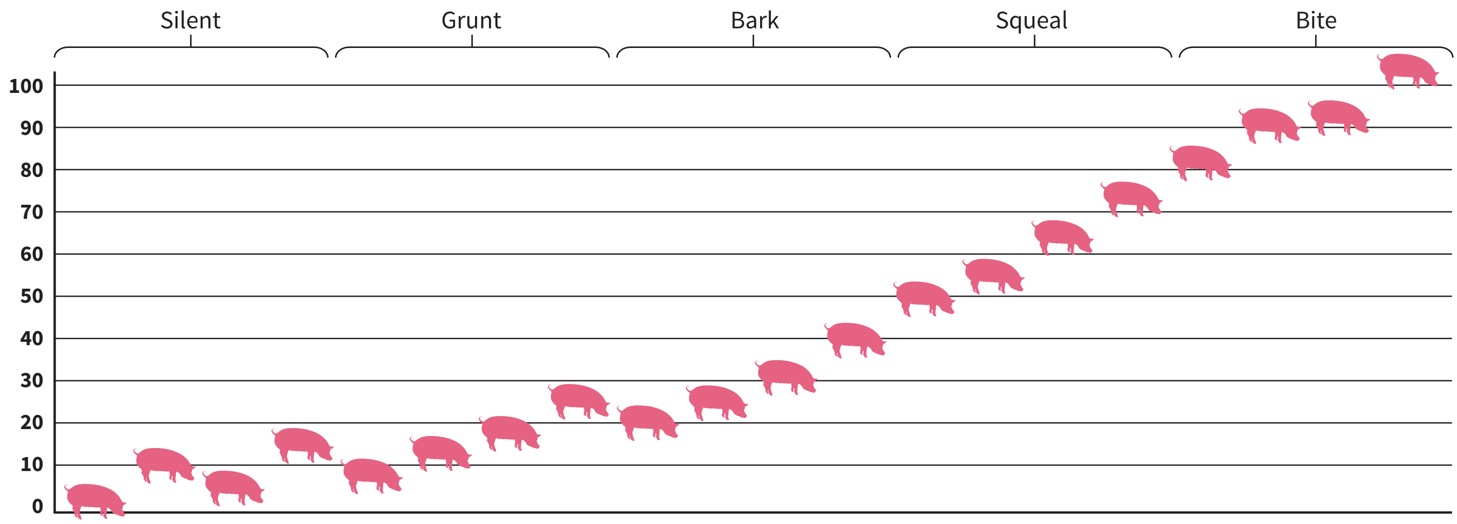
Figure 2.
Startle Index derived from live observations of VIB (n= 16), CONV (n=18), and VIB+EI (n+21) treatments. a, b, c LS means differ; Treatment P < 0.05



As expected, the startle index increased with each treatment (Figure 1). The SmartGuard stimuli are indeed the most effective at motivating the sow to stand, but these sows exhibited the most dramatic response. This is likely due to stimuli being novel and less predictable than hand-slap methods. It's noteworthy that there was one individual that did not stand in the VIB+EI treatment. Individuality and tolerance of stimulus is something to keep in mind as each animal will handle stimulus differently. Some responses are more detrimental such as biting, which could be directed at piglets, however this response was infrequent. All responses were under 50% (Figure 2).

Figure 3.
Startle index as represented by mutually exclusive sow body positions and vocalizations (x-axis). Severity is designated by index scale. Combinations of vocalization and body position were analyzed on a scale of 1-100 using the formula below.

IF: l = lie, s = sit, S = stand, j = jump, i = silent, g = grunt, b = bark, q = squeal and, B = bite :
Startle-Index, % = 0.037{1[1l + 2s + 3S = 6j] + 2[1i + 2g + 4b + 8s + 12B]}



Stimuli Effectiveness & Heart Rate Response

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"SmartGuard stimuli are the most effective at motivating sows to stand, but these activities influence the time for the sow to return to a rest position and, subsequently, resting heart rate."

SmartGuard stimuli (VIB+EI; Table 1) were the most effective at motivating sows to stand or jump up during a piglet distress-call. Also, vibration alone did not motivate sows to stand and hand-slaps (CONV) were 50% less effective than SmartGuard stimuli. There were no treatment, time, or treatment x time differences ($P > 0.10$) for the other heart rate variables (max, average, resting). Nonetheless, VIB-sows' heart rate tended ($P = 0.07$) to return to resting sooner after treatment than both CONV-sows and VIB+EI-sows, respectively (Figure 2). While distress may have contributed to this finding, it is noteworthy that HR and behavior responses are entangled; VIB+EI sows changed from a resting position to an active position more often than VIB and CONV sows.

Figure 4.
Return to resting Heart Rate. Treatments include VIB (n= 16), CONV (n=18), and VIB+EI (n=21). Sows that received vibration (VIB n=16) stimuli tended ($P = 0.07$) to have heart rates return to baseline sooner than VIB+EI treated sows.

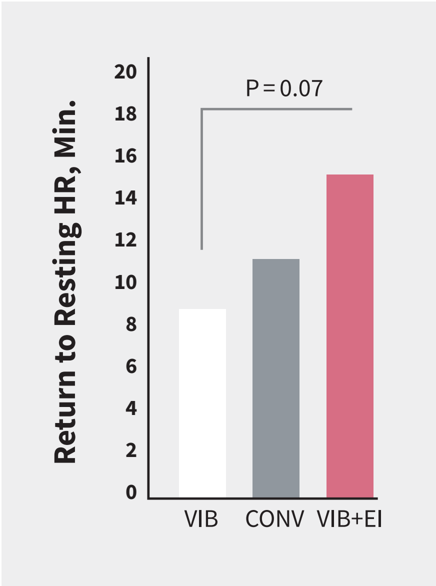


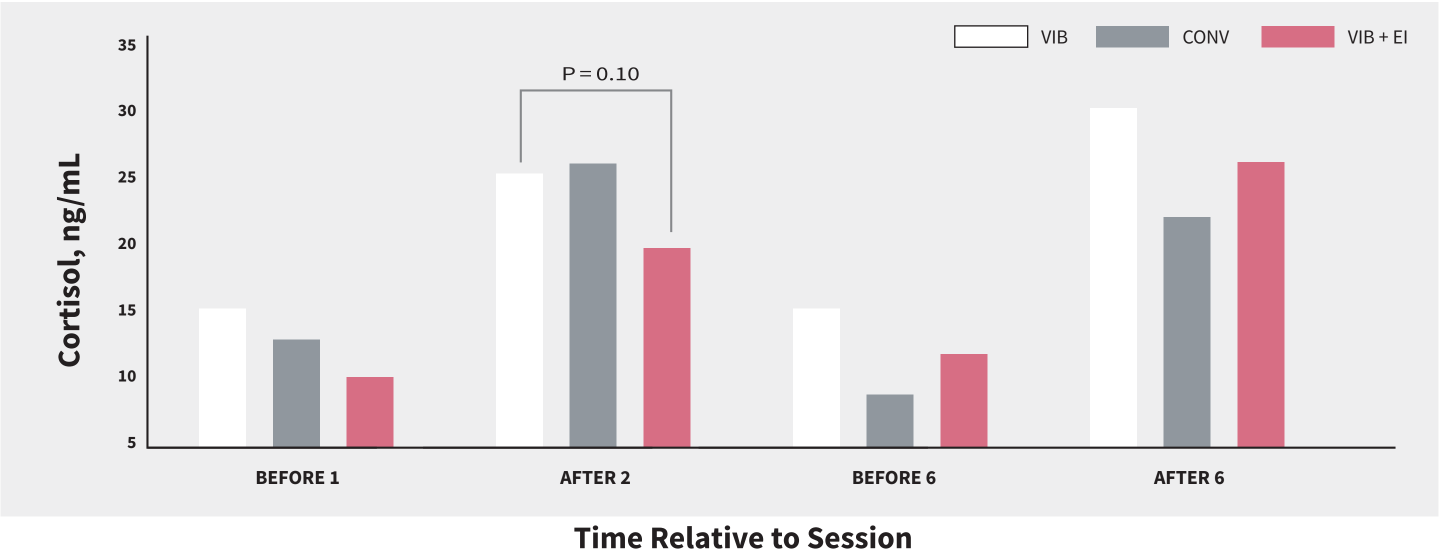
Table 1.
Percent of live observations (Obs) of sows sitting, standing, and/or jumping after treatment. Treatments include VIB (n= 16), CONV (n=18), and VIB+EI (n=21). Included is expected (Exp) and Residual (Res) from Chi-square analyses.

	SIT			STAND			JUMP		
	Obs	Exp	Res	Obs	Exp	Res	Obs	Exp	Res
VIB	7	4.2	1.9	3	3.16	0.01	1	3.6	1.9
CONV	68	48.1	8.2	26	36.2	2.9	32	41.7	2.3
VIB+EI	46	67.1	7.5	62	51.7	2.1	72	59.6	26

$\chi2(8) = 22.6$, $P \leq 0.05$

Acute Cortisol Responses and Circadian Cortisol

Figure 5.
Sow Cortisol secretion before any stimuli (before 1), after the 2nd stimuli, before the last stimuli (Before 6), and after the last stimuli. Treatments include VIB (n= 16), CONV (n=18), and VIB+EI (n=21). (Time P < 0.05; Treatment P > 0.10; Treatment x Time P > 0.10).

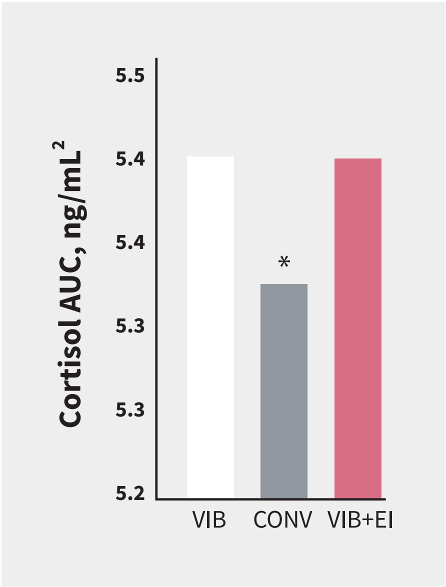


After the second session, VIB+EI sows tended (Figure 5; P = 0.10) to secrete less cortisol than VIB and CONV sows.

Circadian (daily "clock") secretion of cortisol was calculated by measuring area under the curve (AUC). Hand-slapped sows (CONV), had lower AUC (Figure 6) than all other sows.

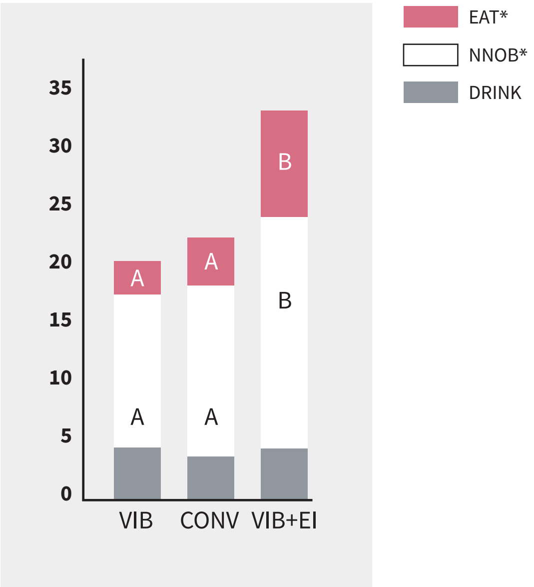
These findings suggest that handslaps may cause "adrenal fatigue." These sows may have had additional cortisol responses when other humans (e.g. managers) were present, but further research is needed to confirm this speculation.

Figure 6.
Circadian cortisol area under the curve (AUC) calculated from all sow plasma cortisol. Treatments include VIB (n= 16), CONV (n=18), and VIB+EI (n=21). * P < 0.05.



Oral-coping Behaviors After Treatment

Figure 7.
Oral behaviors as a percentage of time within 20 minutes post treatment. VIB (n= 16), CONV (n=18), and VIB+EI (n=21). Behaviors include, eat, non-nutritive oral behavior (NNOB) and drink. Treatment differs within behaviors a,b P < 0.05.



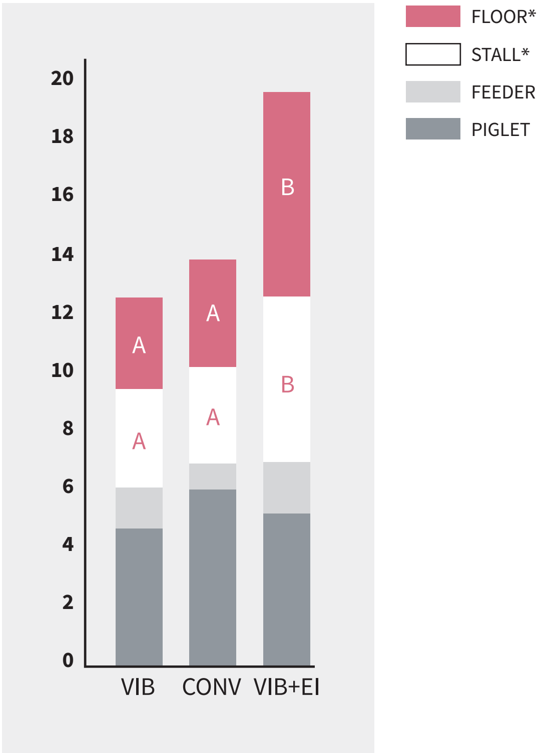
VIB+EI sows spent more of their time in the 20 minutes post treatment eating compared to both VIB and CONV sows. VIB+EI sows also displayed more non-nutritive behaviors after treatment. These NNOB behaviors were mainly directed at the floor, or the farrowing crate. There were no other significant differences for sow feed intake or body weight changes (P >0.10). Average lactation weight loss on a per sow basis was 19.2 lbs, and did not differ between treatment Chi2 = 0.84.

Aggressive responses to treatment that would be detrimental to production would be acts of retaliation towards other sows or piglets.

No aggression or non-nutritive behaviors were seen directed at the piglets at a significant level in any one of the treatments.

"SmartGuard treated sows spend more time eating immediately post treatment."

Figure 8.
Percentage of NNOB directed at each object within 20 minutes post treatment. Treatments include VIB (n= 16), CONV (n=18), and VIB+EI (n=21). Objects include floor, stall, feeder and piglet. Treatment differs within behaviors a,b P < 0.05



"The SmartGuard stimuli cause the sow to perform more oral coping behaviors."

There was no difference in the repertoire of body positions among treatment in the 20 minutes immediately after treatment. However, the time spent nursing 1-4 piglets tended to differ among treatment (P=0.07 figure 9) there was no difference in time spent nursing 5 or more piglets, what these authors consider a 'nursing bout'. This is not surprising as VIB sows spent more time lying in general and this accounts for their udder being more available to the piglets. The significance of teat availability is dictate by treatment sessions. Figure 10 shows that sessions four and five saw VIB sows lying laterally a higher percent of the time after treatment, this trend did not maintain however as all sows spent similar time lying laterally after that. Indicating that this tendency can be attributed to chance.

Figure 9.
Teat availability established by nursing < 5 piglets 20 minutes post treatment. Sows treated in six sessions with either VIB (n= 16), CONV (n=18), and VIB+EI (n=21), were recorded and watched by a trained observer and body positions of lie lateral, lie sternal, sit, stand, jump, nursing 1 and nursing 5 were documented. Nursing 1 included 1-4 piglets present and massaging the udder. Nursing 5, included 5 or more piglets present and massaging the udder.

* indicates tenancy of P < 0.10.

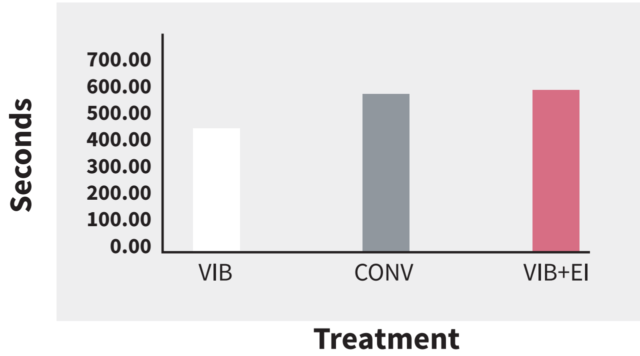
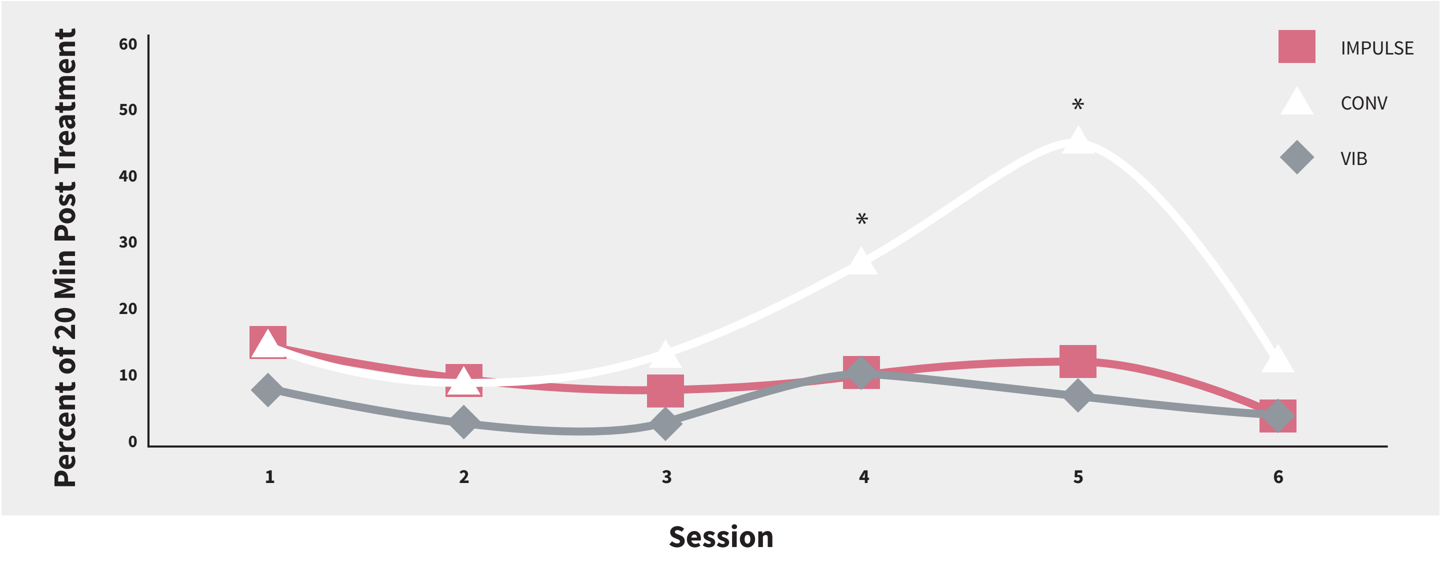


Figure 10.
Treatment by time effect of teat availability established by lateral lying 20 minutes post treatment. Sows treated in six sessions with either VIB (n= 16), CONV (n=18), and VIB+EI (n=21),were recorded and watched by a trained observer and body positions of lie lateral, lie sternal, sit, stand, jump, nursing 1 and nursing 5 were documented. Nursing 1 included 1-4 piglets present and massaging the udder. Nursing 5, included 5 or more piglets present and massaging the udder. * indicates difference of P < 0.05.

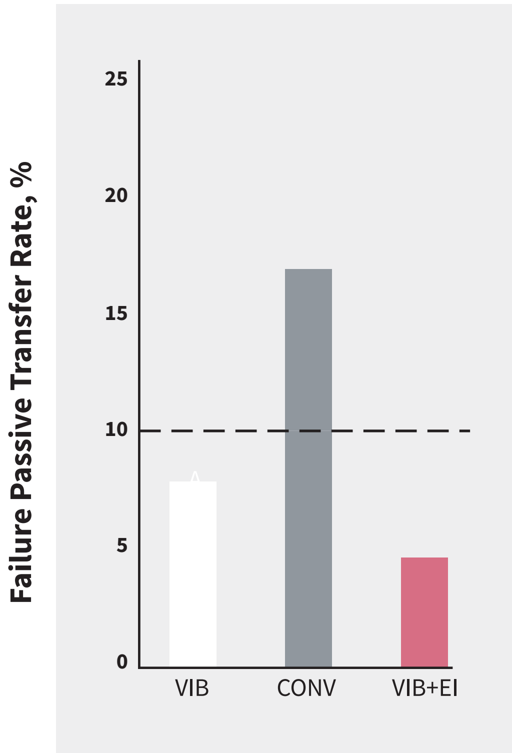


Residual Effects on Nursing Quality

Failure of passive transfer (FPT) was measured by subtracting piglets birth total plasma protein (TPP) from age X TPP. Then, piglets were categorized as FPT or PT. Using chi-square analysis, piglets were expected to have a 10%, but but the FPT-rate was higher (17%; P <0.05) among piglets from hand-slapped sows. (Figure X). This is an additional indicator that handslapped-sows were more distressed chronically than SmartGuard sows because piglets may not have gained access to her teats.

In regards to number weaned, no treatment was different from the barn average of 13. Total litter weight was also similar across treatments indicating that beyond passive transfer there were no other treatment effects on production.

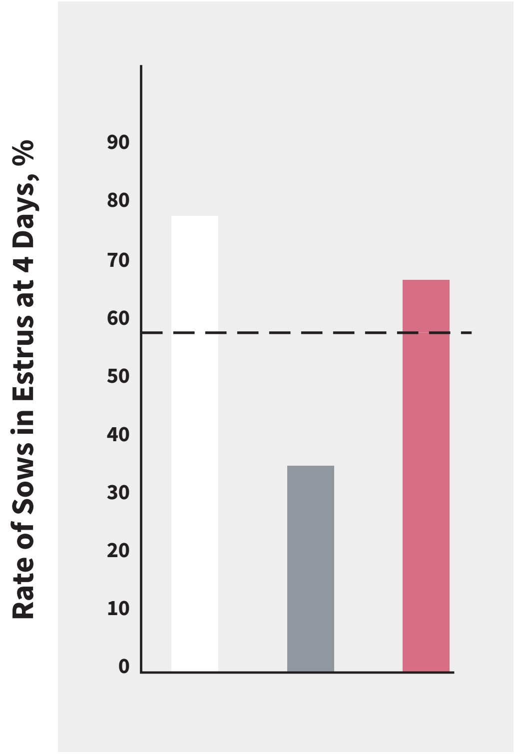
Figure 11.
Failure passive transfer rate among sows treated in six sessions with either VIB (n= 16), CONV (n=18), and VIB+EI (n=21). 3±6 gilts were sampled per sow 7 days after birth. If the net total plasma protein (TPP) values (% Brix) were 0 or negative, they were categorized as Failure of passive transfer. Error bars represent residuals and the dashed-line represents the expected value using Chi-square analysis. $\chi 2(5) = 8.67$, P = 0.013.



"Conventional methods for motivating the sow to stand during a crush event impede nursing quality."

For this experiment, sows came into estrus at either 4 or 5 days after weaning (day 21 ± 3 post farrowing), therefore, sows were categorized as estrus at 4 or 5 days and the rate was analyzed using Chi-square methods. The expected rate for estrus at four days was 59.3%, but the rate was lower (36%; $P < 0.05$) than expected among CONV-sows. This is an additional indicator that hand slapped-sows were more chronically stressed than SmartGuard sows. Conventional methods for motivating the sow to stand may be delaying the wean-to-estrus interval. More data are needed from industry to determine if SmartGuard technology will reduce the wean-to-estrus interval significantly from non-handled sows.

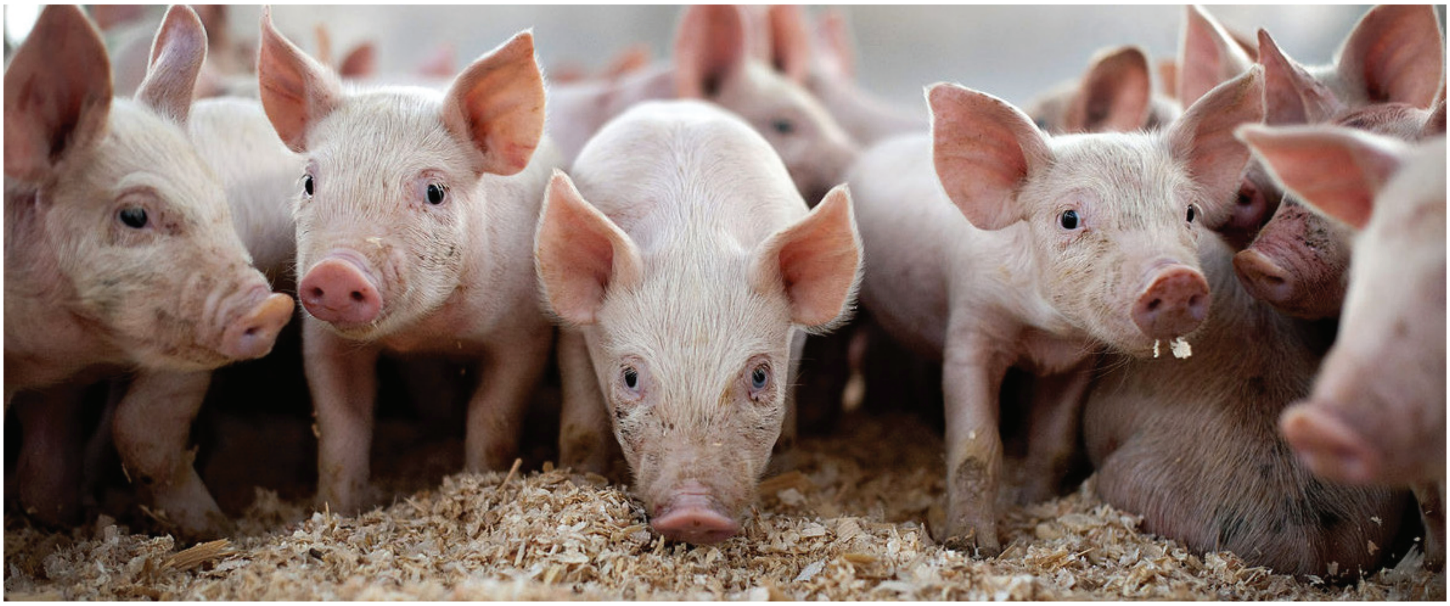
Figure 12.
Rebreeding at day 4 post weaning. Sows treated with either VIB (n= 16), CONV (n=18), and VIB+EI (n=21) were heat checked and re-bred based on the back pressure test in the presence of a boar and a trained technician. Error bars represent residuals and the dashed-line represents the expected value using Chi-square analysis. $\chi2(5) = 8.67$, $P = 0.013$.



"Conventional methods for motivating the sow to stand during a crush event impede reproductive performance."

Residual Effects on Nursing Quality

SmartGuard stimuli may cause the sows to express an acute startle response, but this stressor is not disruptive in the long-term to the sow and her litter.



If this system replaces conventional methods, sows may be less stressed in the presence of humans.

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