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Associations between Sow Body Lesions with Body Condition and Subsequent Reproductive Performance

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Abstract

The objective was to determine the association between foot, leg, vulva and shoulder lesions with body condition and reproduction in group housed sows. Whiteline sows (n = 887) were measured before farrowing and at weaning at a commercial farm in eastern North Carolina. Foot and leg abnormalities included cracked hooves, toe length differences, overgrown hooves and locomotion. Vulva lesions were scored no lesion or lesion present. Shoulder lesions were scored no lesion, abrasion or open wound. Sow body condition measures included the Knauer sow caliper (CS), body weight (WT), visual body condition score (BCS), backfat (BF) and longissimus muscle area (LMA). Sow production traits included number born alive, litter birth weight, number weaned, litter weaning weight, piglet survival (number weaned ÷ (total number born + net transfer)), wean-to-conception interval and average daily lactation feed intake. Data were analyzed in SAS using PROC GLM for continuous traits and PROC GLIMMIX for categorical traits. Vulva lesions were recorded on 17.6% of sows at farrowing and 0% at weaning. No shoulder lesions, abrasions and open wounds were recorded on 100%, 0% and 0%, respectively, of sows at farrowing and 73%, 21% and 6%, respectively, at weaning. Foot and leg abnormalities were not associated with body condition or reproduction. Vulva lesions at farrowing were associated with lower CS, WT, BCS and BF at farrowing, and reduced piglet survival (4.3%). Lower CS at farrowing was associated with increased shoulder abrasions and open wounds at weaning. Backfat and BCS at farrowing had curvilinear associations with shoulder lesions at weaning, a BF of 39 mm and a BCS of 4.2 minimizing lesions. Results suggest vulva and shoulder lesions were associated with thinner sows at farrowing and vulva lesions at farrowing were associated with lower piglet survival.

Keywords

Caliper, Productivity, Shoulder, Sow, Vulva

1. Introduction

Monitoring injuries is a useful method of assessing well-being in sows [1]. For sows housed in stalls increased body weight has been shown to increase injuries, but for group housed sows an increase in body weight may decrease injury frequency [1]. Sow injuries to the feet, vulva and shoulders have been reported in multiple studies [1]-[6], thus identifying strategies to minimize injuries is an important aspect of enhancing sow well-being.

There is a general consensus that sows with poorer body condition have an increased risk of shoulder lesions [2] [3] [4] [6]. However, sow body condition is generally not measured prior to the occurrence of shoulder lesions or with modern, objective body condition tools. Therefore, evaluating sow body condition prior to lactation may offer insights on how to minimize shoulder lesions, and other lesions, prior to their manifestation.

While sow lesions have been linked to poor body condition [2] [3] [4] [6] [7], few studies have evaluated associations among sow lesions with subsequent reproductive performance. Hence, the objective of the current study was to determine associations between foot, leg, vulva and shoulder lesions with body condition and reproductive performance in group housed sows.

2. Materials and Methods

Data

Whiteline sows (n = 887) were measured for body condition and scored for lesions at farrowing and at weaning in a commercial sow farm in eastern North Carolina. All sows from eight consecutive farrowing groups were included in the study. Housing consisted of curtain-sided breeding and gestation barns fitted with cool cell pads, mechanical ventilation and flush gutters. Sows were housed in individual stalls until day 30 of gestation, then allocated to group pens (3.02 × 2.44 m) by size with four to five sows per pen. Pen flooring was 50% solid concrete and 50% slatted with one nipple drinker per pen. Sows lactated in individual farrowing stalls with woven wire flooring. During gestation and lactation, sows were fed diets that met or exceeded NRC requirements [8] and offered water ad libitum. In gestation, sows were hand fed daily and feeding amounts adjusted based on visual body condition score. During lactation, sows were hand fed twice a day for the first eight days of lactation on a step-up program starting with 1.81 kg of feed and increasing feed by 0.9 kg per day. After day eight of lactation, sows were fed three times per day to appetite.

Body condition measures included the sow body condition caliper [9], weight, backfat, longissimus muscle area and visual body condition score. The sow body

condition caliper quantifies the angularity from the spinous process to the transverse process of a sow's back. A sow caliper score of 12 to 15 is considered ideal, representing a back angle of 125˚ to 132.5˚, respectively. Hence, a one unit increase in sow caliper score corresponds to a 2.5˚ degree increase in the angle of the sow's back. Weight at farrowing was captured approximately one week prior to parturition. Therefore, farrowing weight was adjusted to account for piglet and placental weight using the following equation weight (kg) = −19.75 + 0.973 × pre-farrow weight − 1.09 × number of pigs born [10]. A National Swine Improvement Federation certified real-time ultrasound technician measured backfat and longissimus muscle area from a cross sectional 10th rib image using an Aloka 500 V SSD ultrasound machine (Corometrics Medical Systems, Inc., Wallingford, CT). Visual sow body condition was assessed by the first author using a five-point scale with 1 being too thin, 3 representing ideal and 5 being overly fat.

Well-being traits recorded at farrowing and weaning included foot lesions, locomotion, shoulder lesions and vulva lesions. Foot lesions were assessed by a technician and included: cracked hooves (0 = no crack, 1 = crack < 1.3 cm, 2 = crack > 1.3 cm), toe length difference (0 ≤ 1.3 cm difference, 1 = 1.3 cm to 1.9 cm difference, 2 ≥ 1.9 cm difference) and overgrown hooves (0 ≤ 6.4 cm long, 1 = 6.4 cm to 8.3 cm inches long, 2 = > 8.3 cm long) similar to [5]. Locomotion was assessed using a seven-point scale [11]. Sows were scored a seven for locomotion (lame) if they were not bearing full weight on one or more limbs. Vulva lesions were scored on a binary scale where 0 was no lesion and 1 indicated a lesion was present. Similar to [4], shoulder lesions were recorded on a 3 point scale with 0 being no lesion, 1 being an abrasion and 2 an open wound. A score of no lesion was recorded if the skin appeared normal over the point of the shoulder, an abrasion was designated when fibrous tissue nodules were evident at the point of the shoulder [12] and an open lesion score was designated when an open, draining or healing sore was apparent at the point of the shoulder [12].

Reproductive traits included number born alive, litter birth weight, number weaned, litter weaning weight, piglet survival, wean-to-conception interval and average daily lactation feed intake. Piglet survival was calculated as piglet survival = number weaned ÷ (total number born + net transfer).

Statistical Analysis

Data were analyzed using general linear models (PROC GLM) for continuous traits and generalized linear mixed models (PROC GLIMMIX) for categorical traits in SAS 9.3 (SAS Institute, Cary, NC). The PROC GLM procedure is an analysis of variance that computes means using an F-test. The PROC GLIMMIX procedure was used to analyze a response variable from a non-normal distribution and obtain probabilities for a binary or multinomial trait. Like linear mixed models, generalized mixed linear models assume normal (Gaussian) random effects and conditional on the normally distributed random effects, data can have any distribution in the exponential family. A value of $P < 0.05$ was considered statistically significant in all tests. Fixed effects in all models included: farrowing group, barn, parity and the interaction between farrowing group and barn.

For the multinomial trait, shoulder lesion, two intercepts and one regression estimate were given in the output. The first intercept compares sows with a shoulder lesion score of 0 vs. scores of 1 and 2. The second intercept is shoulder scores 0 and 1 vs. a score of 2. The probability of each event was calculated by converting the log odds ratio given in the output to a probability using the following equation: (exp(intercept + (trait level*regression estimate)))/(1 + exp(intercept + (trait level * regression estimate))). For example, the regression estimate of 0.179, intercept of −1.559 for 0 vs. the scores of 1 and 2 and intercept of 0.337 for 0 and 1 vs. 2 were reported for the relationship between sow caliper score and shoulder lesions. A sow with a caliper score of 14 would have a 72.2% probability ((exp(−1.559 + (14 * 0.179)))/ (1+ exp(−1.559 + (14 * 0.179))) = 0.7216) of developing no shoulder lesions and a 94.5% chance of having no shoulder lesions or an abrasion. The probability of having open wounds would then be calculated by subtracting 94.5 from 100% resulting in a sow with a caliper score of 14 having a 5.5% chance of an open shoulder lesion. To calculate the probability of abrasions, the probability of no shoulder lesion and the probability of open wounds were subtracted from 100%, which resulted in a probability of 22.4%.

3. Results

Average sow caliper score, adjusted sow body weight, backfat, longissimus muscle area and body condition score were 15.7 ± 2.2, 219 ± 24 kg, 2.7 ± 0.78 cm, 50.5 ± 6 cm^2 and 3.4 ± 0.65, respectively. Average total number born, number born alive and number weaned were 12.0 ± 2.8, 11.1 ± 2.8 and 10.3 ± 2.5, respectively.

Locomotion and foot lesions

Frequencies of locomotion scores and foot, shoulder and vulva lesions at farrowing and at weaning are shown in Table 1. Ideal locomotion scores were recorded for greater than 96% of sows with 0.7% to 1.3% of sows being classified as lame. Similarly, no foot lesions were noted for more than 99% of sows. Neither locomotion score nor foot lesions were associated ($P > 0.05$) with body condition measures or reproductive performance.

Vulva lesions

Vulva lesions were recorded on 17.6% of sows at farrowing and 0% of sows at weaning. Log odds estimates for associations between sow body condition measures and lesions at farrowing and at weaning are shown in Table 2. A greater probability of vulva lesions at farrowing was associated with thinner sows. As farrowing sow caliper score, body weight, backfat and body condition score increased, the probability of vulva lesions decreased ($P < 0.01$). Partial regression estimates for the association between the presence of vulva lesions at farrowing and reproductive performance are reported in Table 3. The presence of vulva lesions at farrowing decreased ($P < 0.01$) piglet survival by 4.3% compared to sows without vulva lesions. The occurrence of vulva lesions at farrowing was also associated with increased fetal loss (stillborns and mummies). Sows with vulva

Table 1. Frequencies of locomotion and lesion scores at farrowing and at weaning for 887 Whiteline sows.

Trait†	Score							
	0	1	2	3	4	5	6	7
At farrowing								
Locomotion score, %		96.4	2.4	0.6	-	-	-	0.7
Cracked hooves, %	100	-	-					
Toe length difference, %	99.15	0.85	-					
Overgrown hooves, %	99.27	0.61	0.12					
Vulva lesions, %	82.4	17.6						
Shoulder lesions, %	100	-	-					
At weaning								
Locomotion score, %		97.4	1	0.3	-	-	-	1.3
Cracked hooves, %	99.8	0.07	0.13					
Toe length difference, %	99.26	0.74	-					
Overgrown hooves, %	99.19	0.61	0.2					
Vulva lesions, %	100	-						
Shoulder lesions, %	72.7	21.1	6.2					

†Locomotion score = seven-point scale where sows were considered lame (score 7) if they were not bearing full weight on one or more limbs, Cracked hooves (0 = no crack, 1 = crack < 1.3 cm, 2 = crack > 1.3 cm), Toe length difference (0 ≤ 1.3 cm difference, 1 = 1.3 cm to 1.9 cm difference, 2 ≥ 1.9 cm difference). Overgrown hooves (0 ≤ 6.4 cm, 1 = 6.4 cm to 8.3 cm, 2 = > 8.3 cm), Vulva lesion (0 = no lesion, 1 = lesion present), Shoulder lesion (0 = no lesion, 1 = abrasion, 2 = open wound).

Table 2. Log odds estimates for associations between sow body condition measures† and lesions at farrowing and at weaning for 887 Whiteline sows.

Trait	CS	WT, kg	BF, mm	BF², mm	LMA, cm²	BCS	BCS²
Body condition at farrowing							
Shoulder lesions at weaning	0.179*	0.296	0.288*	−0.0037**	0.0045	30.96*	−0.478**
Vulva lesions at farrowing	−0.138*	−0.0100*	−0.027*		−0.0258	−0.612*	
Body condition at weaning							
Shoulder lesions at weaning	0.211*	0.0093*	0.190*	-0.0019**	0.0151	0.751*	

†CS = Sow caliper score; WT = Sow body weight; BF = Backfat depth; LMA = Longissimus muscle area; BCS = Body condition score (1 to 5: 1 = too thin, 3 = ideal and 5 = overly fat). *P < 0.01. **P < 0.05.

lesions at farrowing had 2.4% greater (P < 0.05) fetal loss than sows without vulva lesions.

Shoulder lesions

No shoulder lesions, abrasions and open lesions occurred in 100%, 0% and 0%, respectively, of sows at farrowing and 73%, 21% and 6%, respectively, at

Table 3. Partial regression estimates† for the association between the presence of vulva lesions at farrowing and reproductive performance for 887 Whiteline sows.

Trait	Vulva lesion	SE
Number born alive	−0.062	0.247
Litter birth weight, kg	0.054	0.715
Number weaned	−0.359	0.225
Litter weaning weight, kg	−2.71	2.33
Piglet survival,%	−4.24*	1.82
Wean-to-conception interval, days	−0.258	0.270
Average daily lactation feed intake, kg	−0.095	0.241

†Vulva lesion score of 1 - vulva lesion score of 0. *P < 0.01.

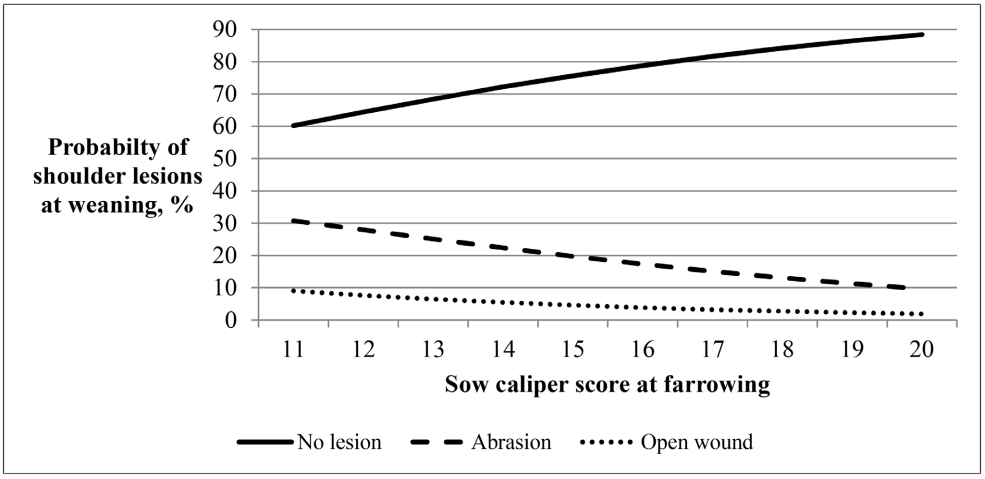

Figure 1. The association between sow caliper score at farrowing with the presence of shoulder lesions at weaning.

weaning. The absence of shoulder lesions was associated (P < 0.05) with sow caliper score (Figure 1), backfat (Figure 2) and body condition score (Figure 3) at farrowing. As sow caliper score increased at farrowing, the probability of both abrasions and open lesions at weaning decreased (P < 0.05). The associations between shoulder lesions with farrowing backfat and body condition score at weaning were quadratic (P < 0.05) where a backfat of 39 mm and a body condition score of 4.2 minimized abrasions and open wounds. The probability of shoulder lesions at weaning decreased (P < 0.01) as sow caliper score, body weight and body condition score at weaning increased. The relationship between shoulder lesions at weaning with backfat at weaning was curvilinear (P < 0.05) with a greater backfat associated with a lower probability of shoulder lesions.

4. Discussion

The present study associated sow body lesions with body condition and reproductive performance. Ideally, the current study would include multiple farms housed

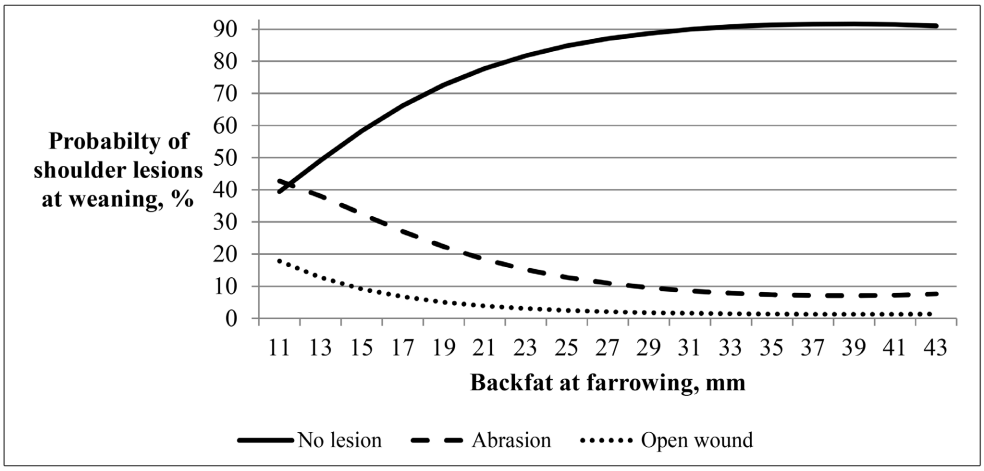

Figure 2. The association between sow backfat at farrowing with the presence of shoulder lesions at weaning.

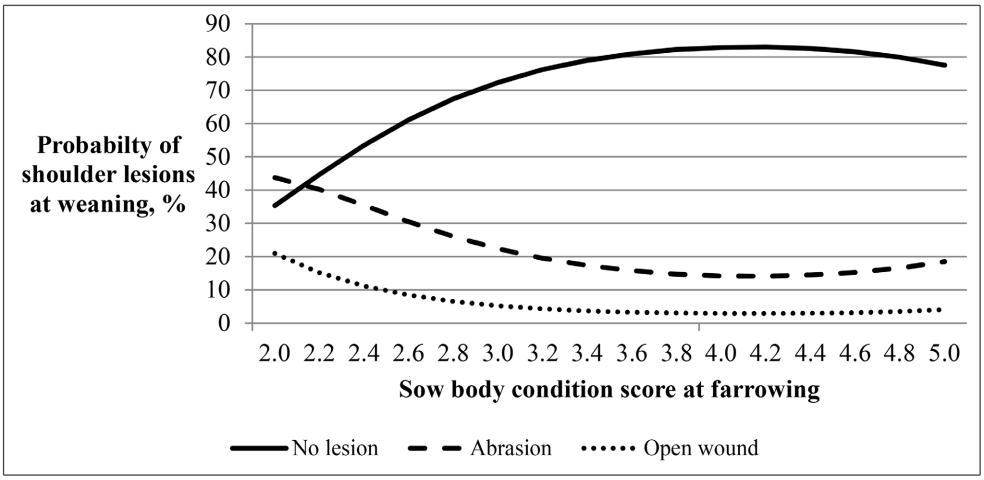

Figure 3. The association between sow body condition score at farrowing with the presence of shoulder lesions at weaning.

under various environmental conditions including different gestation feeding systems and lactation flooring types. Nonetheless, the present study was conducted in a modern, relevant environment. Further, the use of one farm reduced potential confounding between body lesions and reproductive outcomes.

Locomotion and foot lesions

In the present study, 0.7% to 1.3% of sows were classified as lame. In contrast, [13] and [14] reported lameness in 5.7% and 5.5% of sows, respectively. The reason or reasons for the lower percentage of lame sows in the present study remain unclear. The subjective nature of lameness scoring, flooring conditions, genetics, nutrition and management are all possible explanations for differences observed among studies. Perhaps the absence of locomotion problems and foot lesions in the current study was due to superior structural conformation. Sows, in general, were structurally sound and this may have reduced the number of locomotion disturbances and foot lesions in the population.

Neither locomotion score nor foot lesions were associated with sow body condition or reproductive performance. In agreement, [13] reported lameness was not associated with sow body condition or reproduction. In contrast, [7] reported sows culled for lameness had less backfat than sows culled for old age, productivity or reproduction. [14] reported lame sows were more likely to have mummified fetuses when compared to sows that were not lame. [5] reported sows with cracked hooves and toe length differences had increased piglet mortality. The same authors also found sows with overgrown hooves had lower litter weaning weights. In culled sows, [7] reported females with front cracked hooves tended to have lower reproductive throughput and had longer wean-to-conception intervals when compared to sows without front cracked hooves. The same study showed females with rear overgrown hooves tended to have lower reproductive throughput and lower litter size prior to culling. Taken together, previous studies suggest locomotion and foot lesions are at times associated with reproduction. Perhaps the lack of associations seen in the current study between locomotion and foot lesions with reproduction was due to the relatively low prevalence of these abnormalities in the study population.

Vulva lesions

The presence of vulva lesions in late gestation (17.6%) was similar to the 15.2% and 14.9% in group housed sows reported by [15] and [1], respectively. Yet [15] and [1] found vulva lesions in 0% and 1.3%, respectively, of sows housed in stalls.

The present study is perhaps the first to relate vulva lesions with sow body condition and reproductive performance. Attacks on the vulva increase in prevalence the last three weeks of gestation ([15] [16]) and sows that are lower in the social hierarchy may be more prone to this type of attack [17]. [18] found greater sow body weight was correlated with higher social rank. Hence, data from the present study suggests smaller, thinner sows are more at risk for vulva lesions in a competitive feeding environment. Gestating sows in the current study were fed once daily. Perhaps increasing gestation feeding frequency would help mitigate vulva lesions. [19] reported gestating sows fed six times daily had fewer vulva lesions than sows fed twice daily. Besides increasing feeding frequency, the use of high fiber diets may also reduce the incidence of vulva biting [15] [20].

In the current study, sows with vulva lesions had lower piglet survival and a greater number of neonatal piglet deaths. Perhaps this suggests sows with vulva lesions experienced increased stress or poorer nutrition in late gestation when compared to females without vulva lesions. [21] reported gestating sows with increased frequency of stereotypical behaviors, a measure of stress [22], had smaller litter sizes. Under-nutrition during late gestation may serve as a metabolic stressor which may impair reproductive development [23]. Hence results from the present study suggest gestating housing and management systems should be designed to minimize vulva lesions.

Shoulder lesions

The current study classified shoulder lesions as abrasions or open wounds, both of which have been associated with poor health outcomes [4]. In cull sows,

[4] found sows with shoulder abrasions were also associated with the presence of pneumonia. The same authors reported sows with open shoulder wounds were more likely to have peritonitis, pneumonia or pleural adhesions when compared to sows without shoulder lesions. Hence reducing sow shoulder lesions may be a strategy to directly, or indirectly, enhance sow health.

The presence of sows without shoulder lesions at weaning (72.7%) was comparable to the prevalence of 74.2% reported by [6]. [2] reported 88% of sows had no shoulder lesions in late lactation. Open wounds at weaning in the present study (6.2%) were comparable to [2] who reported 5% open wounds. Collectively, the results of these studies suggest minimizing the prevalence of shoulder lesions at weaning should be a goal for pig farmers.

Greater sow caliper score, backfat and body condition score at farrowing were associated with a lower incidence of shoulder lesions. In agreement, [2] [3] [6] reported higher body condition score was correlated with a reduced prevalence of shoulder lesions. Yet many previous studies [2] [3] [6] measured sow condition at weaning. Sow condition at weaning and shoulder lesions at weaning are potentially confounded. Hence, measuring sow condition at farrowing, when compared to evaluating condition at weaning, is a better predictor of shoulder lesions at weaning. Nonetheless, results from the current study suggest optimizing sow condition at farrowing can help mitigate shoulder lesions at weaning. Hence, it is recommended an objective measure of body condition be utilized in gestation to manage sow body reserves with a goal of minimizing shoulder lesions in lactation. Among the objective sow condition methods, monitoring sow backfat is an appropriate strategy to monitor sow body stores. Yet the current authors recommend the use of the sow body condition caliper as the sow caliper requires less labor [24] than monitoring sow backfat.

In the present study, curvilinear associations between sow backfat and body condition score with shoulder lesions were observed. A 10^{th} rib backfat of 39 mm at farrowing minimized the incidence of shoulder lesions at weaning. Often backfat is measured at the last rib. Yet [25] measured both 10^{th} rib and last rib backfat. Perhaps [25] can be used to convert 10^{th} rib backfat from the current study to the more commonly used measure, last rib backfat. Nonetheless, results from the current study can be used to identify a backfat level at farrowing to help minimize shoulder lesions at weaning.

Shoulder lesions were not associated with sow reproduction in the current study. In contrast, [3] and [6] reported the presence of shoulder lesions at weaning were associated with greater litter weaning weight and increased number weaned, respectively. Similarly, [7] reported the incidence of shoulder lesions was associated with greater lifetime piglets produced in cull sows. As the swine industry continues to move towards hyper-prolific sows [26] that are genetically leaner [27], the monitoring of shoulder lesions should increase.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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