RESEARCHREPORT

ANIMAL WELFARE

Title: Pattern of injury and death rates in transported early-weaned pigs: a retrospective study – **NPB #03-146**

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Abstract:
The number of weaned pigs transported per year has increased dramatically. Transport can be a welfare concerns due to the risk of injury and death. There are few reports describing the pattern of the mortality rate associated with pig transportation. The objective of this study was to describe the mortality / injury incidence rate in weaned pigs during transportation and its associated risk factors, particularly, the effect of trip distance. We had data on 2,079 truckloads of weaned pigs carried out between the years 2001 and 2004. Each truckload had records on number of pigs loaded, city of departure, city of destination, date and time of departure and arrival as well as records of deaths and injuries. The affected pigs were those identified by the buyer as being unacceptable due to injuries upon arrival. The median truckload rate for dead or injured pigs per hundred pigs at risk was 0.267 % (n=2041). Quarters 2 and 3 of the year had a slightly higher rate of injuries in comparison to quarters 1 and 4, while no such trend was observed for mortality**.** Origin (defined as state or province), was a significant risk factor for the death/injury rates, even after the geographic distance, year, quarter of the year and size of the truckload were included in the model. Trips longer than 639 miles (the 75th percentile) experienced a 17 % higher rate. When trips were made during cold weather, the rate was lower. In addition, smaller truckloads and year were also influential in the rate. In conclusion, under the conditions studied, transportation did not pose a high risk for injuries or deaths in the population studied.

Introduction
Segregated early weaning (SEW), a management tool initially developed for disease control purposes, has been widely adopted in the swine industry (Robert et al., 1999, Harris, 2000). The benefit of SEW is that by moving weaned pigs off the sow site, they are less likely to become infected with pathogens endemic in the sow herd and thereby, grow more efficiently and with lower mortality. The NAHMS 2000 survey reported that most of the producers with inventory above 10,000 head used segregated early weaning (National Animal Health Monitoring System, 2000). The widespread adoption of SEW as indication of the technological changes in the structure and practices of modern swine production systems that have lead to an increase in both the movement of pigs between farms and the distance traveled to the slaughterhouses (Zanella and Duran, 2000). One of the welfare concerns in SEW transportation is the vulnerability of young pigs to stressors of transportation such as temperature fluctuation, vibration and poor handling during loading and unloading (Robert et al.,1999, Zanella and Duran, 2000).

It has been postulated that stressors are additive in their effects on the piglet and therefore those stressors associated with transportation combined with the stress of weaning may have detrimental consequences on the piglets' well-being. Risk factors for injury during transport include duration of the trip (Berry and Lewis, 2001), truck motion (Bergeron and Lewis, 1999, Perremans et al., 2001), temperature inside the truck (Berry and Lewis, 2001), weather conditions during the journey (Lambooy, 1988), loading density (Agustini, 1976) and the handling and driving practices (Bergeron & Lewis, 1999; Zanella & Duran, 2000). Long trips are riskier because they increase the food and water deprivation and fatigue (Lambooy, 1988). Pigs can lose up to 12.7 % of the body weight due to dehydration (Bergeron and Lewis, 1999). Hicks et al., (1998) reported a significant weight loss (~5 %) in 28 day old weaned pigs subjected to a 4 hour journey compared to un-transported pigs. In a second study, approximately 10 % of weaned pigs subjected to a 24 h journey at 30 ^{o}C lost weight (Berry and Lewis, 2001).

There are few reports describing the pattern of the mortality rate associated with pig transportation. Data from the United Kingdom indicate rates of 0.1 % and 0.061 % among marketed finisher pigs (Warris and Brown, 1994). Holtcamp (2000) reported a mortality of 0.25 % for pigs transported in North Carolina. Grandin (1992) reported that 70 % of all pig deaths recorded at a slaughter plant or in lairage at slaughter plants, were dead on arrival.

Objective
To describe the mortality / injury incidence risk in SEW piglets during transportation and its associated risk factors, particularly the effect of transportation distance.

Materials and Methods
Study population
A total of 2,079 trips were carried out between the years 2001 and 2004, representing 1,803,745 pigs transported. The data for this retrospective study come from the M&F Trading Company (Ames, IA and London, ON). The trucks were standard trailer size, the great majority being 45 feet long and 96 inches wide, with two decks. Bedding was generally wood chips and temperature was controlled manually by adjusting ventilation slots on the side of the trailers. Mean pig age ranged from 16 to 18 days and pigs were commercial genotypes intended for finishing. Health status varied.

Performance and health measurements
Each truckload had records on number of pigs loaded, city of departure, city of destination, date and time of departure and arrival as well as records of deaths and injuries. The affected pigs were those identified by the buyer as being unacceptable due to injuries upon arrival (Table 1). The truckload rate was calculated two ways; firstly as the number injured and/or dead pigs on arrival divided by the number of pig in the truckload (defined per 100 pigs loaded) and secondly, as the number of pigs dead on arrival (DOA) expressed also per 100 pigs loaded. Chronic conditions such as arthritis or abscesses were excluded from the case count (numerator) when the death/injury rate was calculated.

Geographical coordinators
The set of variables included in the analysis were truckload size (# of animals), year (2001, 2002, 2003 and 2004) and quarter of the year (Ja-Mar, Apr-Jun, Jul-Set, Oct-Dec)- trip duration (hours), distance (miles), number of pigs in the load and origin of the load (city or town). The trip distance was calculated as the difference between two points (towns or cities) defined by both geographic coordinates of the departure and arrival points. The source of geographic coordinates was the U.S census Bureau (www.census.gov/cgi-bin/gazeteer), and the National Atlas (http://atlas.gc.ca/site), for the USA and Canada locations, respectively. The geographic distance between the origin and destination points (towns) was estimated by means of the greater circle distance formula (Snyder, 1987).   Daily high and low temperatures for the region of the recipient herd on the delivery date were retrieved.

Data analysis
Descriptive statistics were for each variable was made before the multivariate model was fitted. After that, all factors mentioned above were regressed against the rate of death-injury and the death rate, using a Poisson regression model. Therefore General Estimation Equation (GEE) available in Proc Genmod (Little et al., 1996) was used to fit two multivariate models; one for the death/injury rate and another for death rate. Poisson regression was used to examine the relationship between ambient temperature and DOA. Two sample T-test was used to look at DOA rate by comparing loads that experienced a high of at least 75 degrees versus those that did not.

Results
In 2001 (2 %), 2002 (59.5 %), 2003 (21.3 %) and 2004 (17.0 %) of the trips were performed respectively (Table 2). The median truckload rate for dead or injured pigs per hundred pigs at risk was 0.267 % (n = 2041) (q1=0.125; q3=0.538) (Table 2). Quarters 2 and 3 of the year showed higher values of injuries in comparison to quarters 1 and 4 (Table 2). In the case of the death rate, no trend was observed (Table 2)**.**

The truckloads included in this study were mainly shipped from Canadian provinces (66.03 %, Table 3), specifically from Manitoba, Ontario and Saskatchewan. For destination states, 75.3 % of the shipments came from two states, Iowa and Minnesota (Table 3).

The median rate, stratified by origin, varied substantially among departure locations. For instance, the risk rate was 0.22 % (first and third quartiles, 0.01-0,44), 0.267 (0.135-0.545), 0.193 (0.103-0.375), 0.40 (0.2- 0.68) and 0.344 (0.182-0.709) death/injury cases /100 pigs at risk for Manitoba, Ontario, Saskatchewan, Nebraska and Iowa province or states, respectively. For the death rate, most of the median values were zero and no trend was evidenced by origin.

Origin, defined as state or province, was a significant risk factor for the death/injury rates, even after the geographic distance, year, quarter of the year and size of the truckload were included in the model (Table 3). Regarding the death/injuries rate (Table 4), trips longer than 639 miles (the 75th quartile) experienced a 17 % higher rate (RR=1.17, 95%CI = 1.10-1.26; p-value < 0.0001, Table 4), and, when trips were made during cold weather, the rate was smaller. In addition, smaller truckloads and year were also influential in the rate. The regression model for death rate included distance and truckload factors (Table 4). The risk of dying due to trip distance longer than 639 miles increased by 48 % (RR = 1.48, 95%CI 1.05-2.08, p-value < 0.023, Table 5) and for load size > 1160 also increase by 44 % (RR = 1.44, 95%CI 1.02-2.04, p-value < 0.039, Table 5) .

There was no relationship between high or low temperature with injury rate, but there was with the DOA rate. Figure 1 shows the daily extreme temperatures for one station in northwest Iowa. In our studies it was the high temperatures that led to increased losses. No increases were seen with low extremes. Relative humidity also had no effect, either directly or indirectly in concert with temperature. The relationship was a 0.00772 increase in DOA rate (%) per degree Farenheit (p=.02) in the daily high temperature. For the daily low temperature, the coefficient was 0.01011 (p=.0063). The DOA rates were .1151 for the days experiencing greater than 75 degrees and .0753 for the rest (p=.017).

Discussion and conclusions

There is no data published about mortality or injuries in SEW piglets under transportation conditions to compare the figures collected within this retrospective study. However, the death rate found in this study was not higher than those documented for finisher pig mortality upon the arrival to the slaughter plant. A study conducted in North Carolina estimated that 0.27 % of the marketed pigs died after transportation (Holtcamp, 2000). An average of 0.06 % of the pigs sent to slaughter died after transportation during the years 1991 and 1992 in England (Warris and Brown, 1994) and 0.17 % in pigs marketed in Ontario (Haley et al., 2004).

Origin of the shipment probably reflects characteristics of the pig population related to the farm source. It has been observed in nursery pigs that the origin influences growth performance and survival (Larriestra et al., 2004) and may be used to predict death loss in grower-finisher pigs upon arrival to slaughter (Haley et al., 2004). Origin may also reflect management decisions related to pigs' ability to be transported. Some of the most severe problems that occur during livestock transportation are caused by animals that are not fit for transportation (Grandin, 2001). Considering the results of the model for death rate, origin may play a role only for injuries. One way to reduce the problem of injures is to avoid transporting pigs that may not be well enough to overcome the stress due to the journey.

Mixing sources in the truck may be a plausible explanation for the rate variability among loads. The pig to pig interaction when unfamiliar animals are transported could feasibly induce a higher rate of injuries. Unfortunately, the number of sources was not recorded; therefore that factor could not be evaluated.

The higher injury/death rate observed during quarters 3 and 4 could be explained by ambient temperature. Temperature is a crucial stressor factor that can compromise the welfare of the pigs during transportation (Lambooy, 1988, Hicks et al.,, 1998). In our study, longer trips during "warm quarters" were riskier (see Table 4). The stress due to heat has been characterized as dehydration and weight loss (Hicks et al., 1998, Berry and Lewis, 2001). Warris and Brown (1994) observed an increasing mortality risk in grower-finisher sent to slaughter as the mean temperature went up. There is no previous report suggesting the implication of warm weather on mortality or injuries in weaned pigs under transportation. Our findings suggest that the association would be mostly due to injuries but not for deaths, because the death rate model did not retain such variables.

Distance is not mentioned as a risk factor directly in the literature, but it has been mentioned indirectly thru time of the trip. In our study, trips longer than 639 miles may have lasted at least 10 hours. Since the trips longer than 639 miles were only about 25 % of the total recorded, the impact in the population of that risk excess due to distance would be marginal (Relative Risk = 1.17, 17 % higher).

There are limitations on the dataset, particularly in the range and direction of transport routes. However, we believe that the amount of data involved in the analysis allows us to conclude that distance compromises the death/injury rate. Some injuries are pre-existing conditions. Furthermore, certain characteristics or conditions when pigs are loaded will have implications in the risk of injuries. Outcomes other than injuries such as dehydration and weight loss (Lambooy, 1988; Berry and Lewis, 2001) and their effect on nursery performance were not evaluated. Further research is needed to address those issues under commercial conditions.

Lay interpretation

The mean rate of injuries calculated in this population was only 0.45 pigs dead or injured per 1000 pigs transported, with only .09% dead or euthanized. This increased slightly during quarters 3 and 4, probably reflecting heat stress. The origin of the truckload had a considerable effect on the rate, probably reflecting management decisions on each pig's ability to withstand the stress of transport. There was a consistent pattern of increasing risk according to the trip distance in both, death/injury and dead on arrival. In both cases, a distance longer than 652 miles increased the rate. In conclusion, under the conditions studied, transportation did not pose a high risk for injuries or deaths in the population studied.

Figure 1: Daily high temperatures for one of the recipient sites, Algona, Iowa

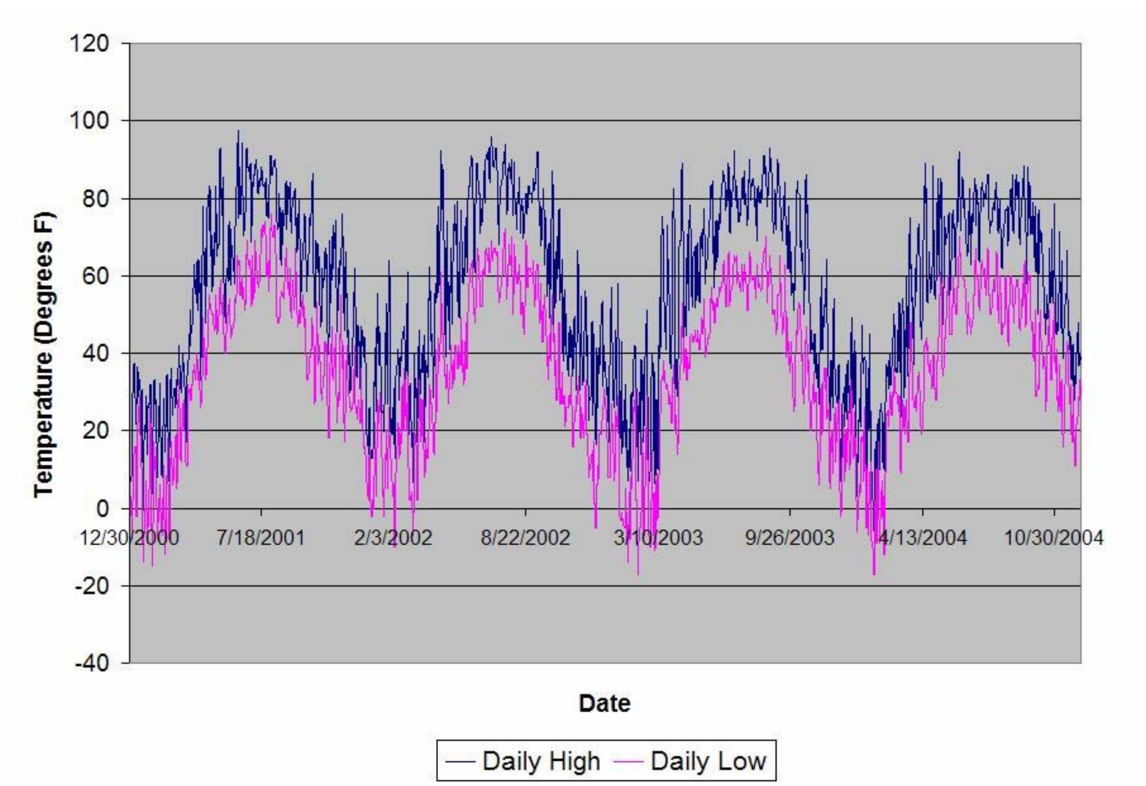

Table 1. Injuries and death records gathered upon the truck arrival.

Conditions	Included in the rate of death and injuries
Dead on arrival [1]	Yes
Downer [2]	Yes
Fractures [3]	Yes
Unthrifty [4]	Yes
Cripple [5]	Yes
Wounds and ruptures [6]	Yes
Humpback – Severe	No
Bad Joints	No
Navel Infection	No
Other conditions	No
Prolapsed rectum	No
Small	No
Swollen joints	No
Scrotal Rupture	No
Thumping	No
Uncastrated	No

[1] Dead on arrival including euthanasia
[2] Incapable of standing up
[3] Broken bones (back, hip, shoulder, etc)
[4] Low response to physical stimulus
[5] Lame or similar conditions
[6] This category included belly ruptures, open wound in area of the body and tail bitten.

Table 2: Mean and 25th, 50th and 75th percentiles for risk factors related to deaths/injury rate.

Variable	N	Mean	25	50	75				
Rate[1]	2079	0.4548	0.125	0.266	0.534				
Death rate	2079	0.09	0.0	0.0	0.0				
Load size[2]	2079	868	500	641	1060				
Distance[3]	2041	499.25	381.74	492.43	638.62				
		Death/injury rate [2]				**Death rate [2]**			
		Mean	**25**	**50**	**75**	**Mean**	**25**	**50**	**75**
Year									
2001	38	0.340	0.111	0.204	0.385	0.02	0	0	0
2002	443	0.408	0.111	0.208	0.444	0.09	0	0	0
2003	1239	0.491	0.139	0.295	0.574	0.09	0	0	0
2004	359	0.398	0.092	0.213	0.498	0.06	0	0	0
Quarter									
1st	560	0.388	0.104	0.221	0.482	0,07	0	0	0
2nd	442	0.475	0.11	0.271	0.568	0.09	0	0	0
3rd	507	0.507	0.148	0.319	0.583	0.11	0	0	0
4th	570	0.459	0.125	0.249	0.500	0.09	0	0	0

[1] cases per 100 pigs loaded
[2] Number of pigs loaded
[3] Geographic distance (miles) between the departure and arrival points (town or city)

Table 3: Number of truckload trips stratified by origin and destination

Source	**N**	**%**	**Destination**	**N**	**%**
Manitoba	784	38.41	Iowa	1152	56.44
Ontario	399	19.55	Minnesota	385	18.86
Saskatchewan	164	8.04	Nebraska	166	8.13
Nebraska	160	7.84	Illinois	78	3.82
Iowa	116	5.68	Ontario	50	2.45
Michigan	88	4.31	Indiana	42	2.06
North Carolina	87	4.26	Quebec	27	1.32
Missouri	67	3.28	Wisconsin	22	1.08
Alberta	31	1.52	Michigan	20	0.98
Oklahoma	30	1.47	South Dakota	18	0.88
Colorado	26	1.27	Missouri	15	0.73
Minnesota	21	1.03	Utah	11	0.54
Kansas	17	0.83	Ohio	10	0.49
Quebec	12	0.59	Pennsylvania	10	0.49
Arkansas	10	0.49	Kansas	9	0.44
South Dakota	8	0.39	Idaho	6	0.29
Illinois	7	0.34	North Carolina	6	0.29
Georgia	6	0.29	Washington	6	0.29
North Dakota	5	0.24	Alberta	3	0.15
Mississippi	1	0.05	Manitoba	2	0.10
Utah	1	0.05	Colorado	1	0.05
Wyoming	1	0.05	New Jersey	1	0.05
			Saskatchewan	1	0.05
Total	2041	100		2041	100

Table 4: Factors associated with the death/injuries rate per 1000 pigs transported (n=2041 trips).

Risk factor	Relative Risk[1]	-95%CI	+95%CI	P-Value
Trip distance (miles)				
> 639	1.17	1.10	1.26	<.0001
> 492 - ≤ 639	0.94	0.89	1.00	0.0470
≤ 492	Base			
Load size (N)				
> Load size > 1060	0.60	0.57	0.64	<.0001
> 640 and < 1060	0.73	0.69	0.77	<.0001
< 640	Base			
Year				
2002	0.63	0.58	0.70	<.0001
2003	0.87	0.81	0.94	0.0002
2004	Base			
Quarter of the year				
1st	0.69	0.64	0.75	<.0001
2nd	0.81	0.76	0.87	<.0001
3rd	0.98	0.93	1.04	0.5481
4th	Base			
Trip Origin				
Oklahoma	1.78	1.48	2.14	<.0001
North Carolina	1.51	1.32	1.72	<.0001
Colorado	1.11	0.92	1.34	0.2604
Minnesota	1.11	0.90	1.36	0.3476
Michigan	1.04	0.90	1.22	0.5802
Nebraska	0.97	0.86	1.11	0.6935
Iowa	0.94	0.82	1.07	0.3585
Missouri	0.89	0.76	1.04	0.1439
Ontario	0.89	0.79	1.00	0.0481
Manitoba	0.73	0.65	0.82	<.0001
Alberta	0.73	0.59	0.89	0.0026
Saskatoon	0.49	0.43	0.57	<.0001
Others	Base			

[1] The relative risk estimates from the Poisson regression model (Proc Genmod, SAS).

Table 5: Factors associated with the death rate per 100 pigs transported (n=2041 trips).

Risk factor	**RR**[1]	**-95%CI**	**+95%CI**	P-value
Dist > 639 miles	1.48	1.05	2.08	0.0235
Dist > 492 - <= 639	1.06	0.72	1.54	0.7784
Baseline <= 492	Base			
> Load size > 1060	1.44	1.02	2.04	0.0395
> 640 and < 1060	1.25	0.86	1.80	0.2379
< 640	Base			

[1]The relative risk estimates from the Poisson regression model (Proc Genmod, SAS).

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