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Factors associated with the incidence of mortality during transport of market hogs

Chris Rademacher[1], Peter Davies[2]
[1]Swine Disease Eradication Center, [2]University of Minnesota; New Fashion Pork, Jackson MN

USDA-FSIS data indicate that the incidence of mortality of market hogs during transport or lairage increased during the 1990's to approximately 3 deaths per 1000 pigs (0.3 %), then declined somewhat to about 2.3 pigs per 1000 in 2002.[1,2] In terms of absolute losses, this incidence appears trivial relative to expected mortality losses during the rearing of growing pigs (15 to 20%, or 150 to 200 pigs per 1000). However, in the context of time at risk, when converted to daily mortality rate (assuming a 12 hour transport period at risk), mortality risk in transported market hogs is comparable to pre-weaning mortality risk of 12% over a 20 day lactation. Furthermore, it is approximately 6 times higher than in a nursery with 4% mortality, and 28 times higher than in a finisher barn with 2% mortality. When expressed in terms of financial losses per pig-day at risk, expected losses per pig-day are much greater during transport to slaughter than in any phase of production (**Table 1**).

It is therefore arguable that focused efforts to reduce deaths in transport have the potential to yield greater return on investment than efforts to reduce mortality in the earlier production phases. Furthermore, understanding of determinants of mortality during transport is also relevant to animal welfare and efforts to improve conditions of animal transport. However, there is negligible published research on determinants of mortality risk during transport and lairage.[2]

We conducted a retrospective analysis of a large database including records of mortalities and non-ambulatory pigs following transport of hogs marketed by New Fashion Pork from November 2002 to February 2005. Here we report selected observations made in the initial univariate analysis of associations between a range of putative explanatory variables and mortality risk in groups of pigs. A multivariate analysis of the data will be reported later.

Materials and methods

Records were obtained from a company database of shipments of market hogs from 11/30/02 to 2/4/05. The data included 7,396 loads (total 1,303,148 hogs) derived from over 1500 groups of hogs placed in 350 finishing or wean-to-finish barns situated on 115 sites. Market loads were trucked by 87 transport providers and delivered to 37 plants. A total of 11,346 market lots were available for analysis, with each lot comprising pigs from a given group (unique ID for group of pigs placed in a barn) transported in a given load (unique ID for each load delivered). In addition to the group and load IDs, records for each lot included the variables shown in **Table 2.**

In addition to the variables recorded in the company database, several additional variables were derived or obtained from other sources (**Table 3**).

For most of the initial descriptive analysis reported here, each of the three outcome variables (DOA, DAP, and SLOWS) have been assessed separately. SLOWS are generally defined as animals that cannot move off the truck and into the plant without some assistance. These outcome data were recorded by staff in the respective slaughter plants without any effort to standardize case definitions or observational methods. This is particularly problematic with SLOWS. DOA and DAP events were combined for some of the further analyses, in order to eliminate possible observer variation in how these events

Table 1: Expected loss per pig-day from mortalities by phase of production.

	Risk per day	Value ($)[A]	Expected loss per pig-day at risk
Pre-weaning mortality 12% (20 days)	0.00637	35	$0.22
Nursery mortality 4% (50 days)	0.000816	50	$0.04
Finishing mortality 2% (112 days)	0.000180	90	$0.02
Transport mortality 0.25% (0.5 days)	0.004994	130	$0.65

[A]Approximate values for illustrative purposes.

Table 2: Description of variables available by lot of pigs transported.

Variable	Explanation
Date and time of loading and unloading	
Time (hours) of transport	Calculated difference between load and unload times
Site and barn of origin	
Sow farm source	Sow farm from where the group was sourced
Date Paylean® added to the feed	
Dose of Paylean® added to the feed	
'Market days'	Number of days until a lot was marketed after the first pigs were marketed from that respective group
Total head loaded in lot	
DOA	Number of pigs recorded as dead on arrival
DAP	Number of pigs recorded as dying at the plant
SLOWS	Number of pigs classified as 'slow' at plant
Trucker name	
Plant name	
Processor name	
Mean live weight	
Mean backfat	

Table 3: Additional variables derived or available for analysis.

Variable	Explanation
Total pigs per load	Sum of pigs in all lots in a load
Groups per load	Number of groups contributing to a load
Unload temperature	Daily maximum for unload date (from station near plant)
Barn type	Autosort, Tunnel, Curtain, Natural tunnel, Power ventilated
Loadout ramp	Categories of loadout facilities
Boar line	5 genotypes
Paylean® to group	Paylean® use by group
Paylean® (Yes/No)	Paylean® use by pigs in a lot
Paylean® days	Duration of Paylean® feeding to pigs in lot

may have been recorded. However, both DOA and DAP data represent crude (i.e. not cause specific) measures of mortality, and it is feasible that the component causes (and risk factors) of DOA may differ from those of DAP. For the univariate analysis, crude risks were calculated using a fixed denominator of the total number of pigs transported - that is, the denominator for DAP was not adjusted for DOA pigs; and the denominator for SLOWS was not adjusted for DOA and DAP. This approximation was considered acceptable given the low incidence of the mortality events. Risk was quantified as the number of events per 1000 pigs transported. It is important to acknowledge the potential importance of confounding in the analysis, and the fact that the observations cannot be considered independent at almost any level of analysis owing to the nature of the enterprise. P-values for the univariate associations are not provided for two reasons. Firstly, due to the very large numbers of animals at risk, statistical significance is essentially inevitable and assessment of effect size is more informative. Secondly, given the nature of the data set (very large data set with confounding and lack of independence among observations), overemphasis on P-values in exploratory univariate analysis of this nature can be potentially misleading.

Results

Of the 1,303,148 hogs shipped, there were 3,935 DOA (3.01 pigs per 1000), 886 DAP (0.68 per 1000) and 5,202 SLOW (3.99 per 1000) events recorded.

The **Figures** display the summary results for selected explanatory variables.

Month of slaughter and ambient temperature

The pattern of DOA risk is consistent with expectations of higher risk associated with transporting market pigs in hot weather. However, this pattern was not reflected in the DAP and SLOW risks, which appear to be highest in the fall months. To further characterize the likely role of hot weather, DOA risk was summarized by daily maximum temperature at the plant location on the unload date (using data available from national or state climatic sources). Risk increased dramatically on days on which the maximum temperature exceeded 80°F. Interestingly,

Figure 1: Crude risks for DOA, DAP and SLOW pigs by month (unload date).

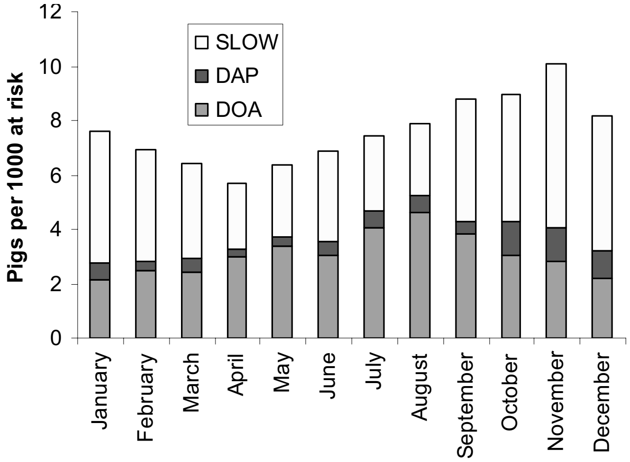


Figure 2: DOA risk (5 degree moving average) by daily maximum temperature at unload date (Note: N refers to the total pigs at risk in each 5 degree window).

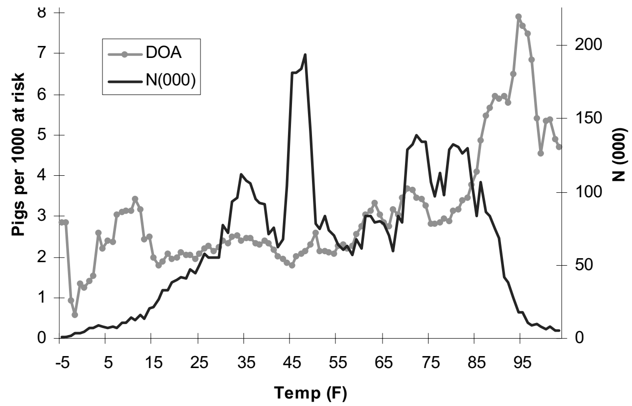


Figure 3: Mortality risk (DOA plus DAP) by calculated time (hours) of transport.

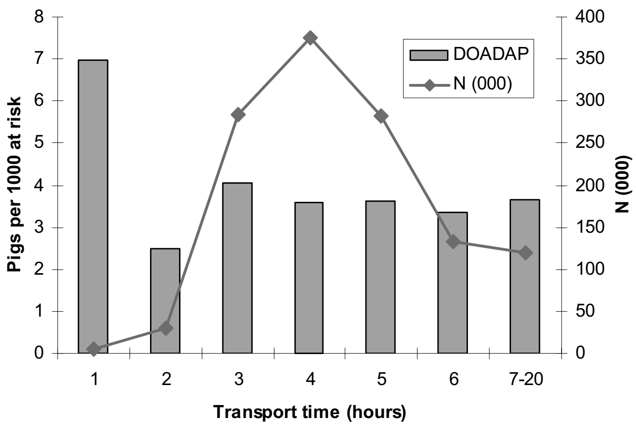


Figure 4: DOA, DAP and SLOW risk by number of hogs in a load (170 to 183).

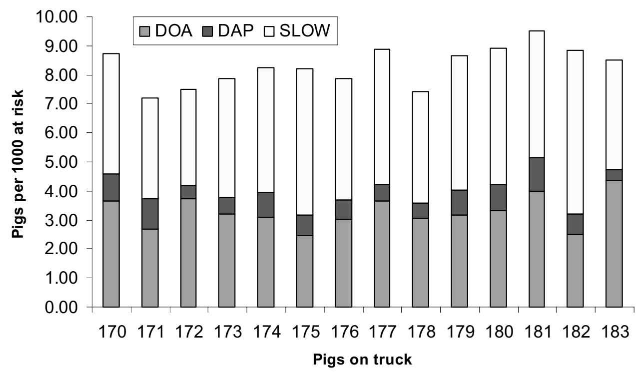


Figure 5: Risk (DOA, DAP) by average weight of hogs in a load (255 to 290) for loads containing single groups (n = 706,588).

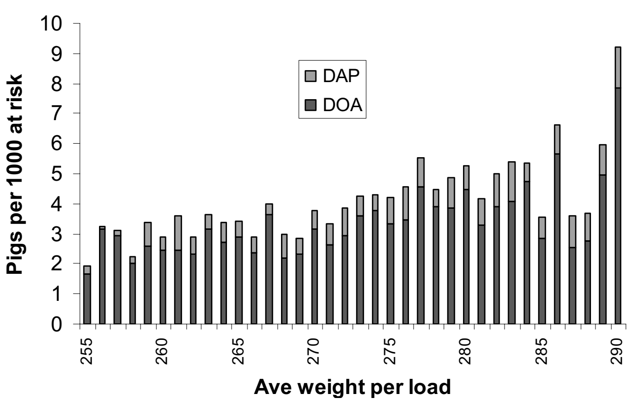


Figure 6: Risk (DOA, DAP) by total load weight (40,000 to 54,000) for loads containing single groups (n = 754,393).

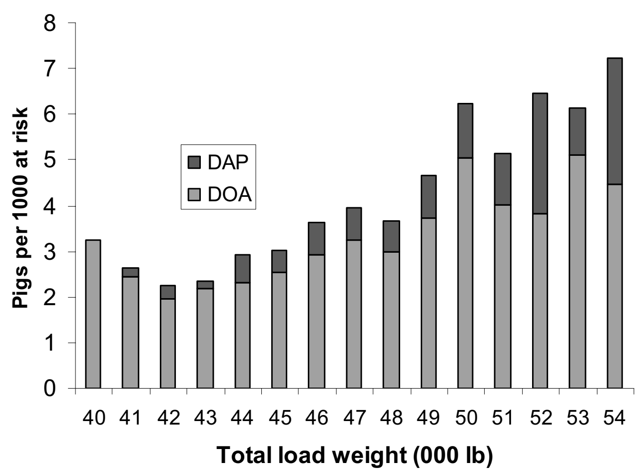


Figure 7: Mortality risk (DOA, DAP) by barn type.

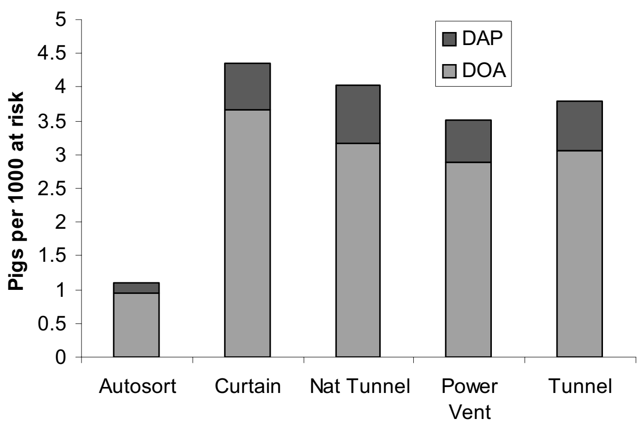
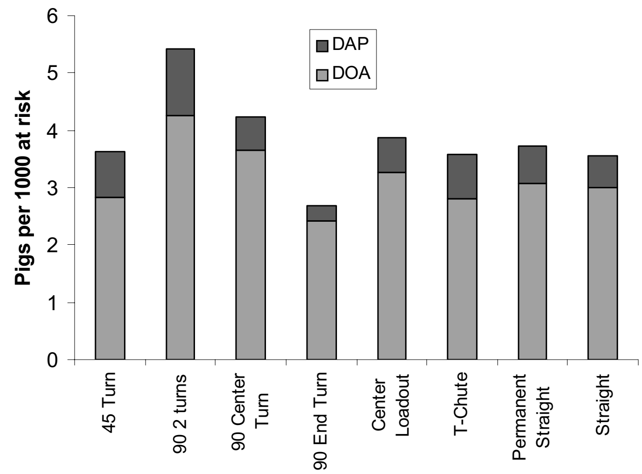


Figure 8: Mortality risk (DOA, DAP) by design of load out facility.



the incidence of neither DAP nor SLOWS exhibited any perceptible trend to increase with temperature. The wider fluctuations at the extremes of temperature are attributed to the relatively small numbers of pigs transported.

Duration of transport and load size

Both loading and unloading times were recorded for 10,981 (96.7%) lots including over 98% of all hogs. The duration of transport (calculated as the difference between load and unload times for each lot) ranged from 1 to 31 hours.

The most striking observation is the very high mortality (almost 7.0 per 1000) among the 4,302 pigs with a recorded transport time of 30 to 90 minutes ("1 hour"). Risk appeared to be lower (2.5 per 1000) for pigs with transport times of 1.5 to 2.5 hours, but duration of transport had minimal influence on mortality risk beyond 3 hours.

The number of groups contributing to a load varied from 1 to 6; however 94% of the pigs marketed were in loads drawn from 1 or 2 groups. DOA risk tended to decline as the numbers of groups in a load increased. The number of hogs in a load varied from 6 to over 240, but over 93% of animals were shipped in loads of between 160 and 200 pigs, and 83% (1,085,568) in loads of 170 to 183 pigs. Within the latter range, minimal variability was seen in the incidence of DOA, DAP and SLOW pigs (**Figure 4**). However, mortality risk tended to increase with average live weight of hogs marketed (**Figure 5**).

The clearest association between load size and mortality risk was evident when total load weight was evaluated. **Figure 6** shows the data for loads comprised of a single group having total live weights in the range from 40,000 to 54,000 lbs. Loads over 48,000 pounds are unintentional (legal weight restrictions) and usually result from errors in estimating the anticipated load weight (**Figure 6**).

Site, barn and loadout facilities

Among sites supplying more than 10,000 head, risk (DOA and DAP) ranged from 0.1 to 9.5 pigs per 1000 (mean 3.65; SD 1.52; CV 0.63). In comparison, among 20 truckers transporting at least 10,000 pigs, the range (0.17 to 5.06 per 1000) was somewhat less (mean 3.52; SD 1.25; CV 0.36). This can be interpreted as suggesting that site related factors may have a greater influence on mortality risk than does variability among transport providers. Barn type appeared to have relatively minor influence on mortalities, apart from a markedly reduced risk observed for pigs from autosort barns (**Figure 7**).

The type of loadout ramp of a barn did not appear to have a marked effect on mortality risk, although risk appeared greatest with chutes including two 90-degree turns (**Figure 8**)

Discussion

Ellis and Ritter (2005) recently reviewed the incidence and nature of transport losses in swine; the physiological alterations observed during animal handling and transportation; and potential risk factors involved.[2] Despite the financial and welfare implications of losses occurring during the transport of market hogs, the subject has attracted little attention from researchers. Better understanding of the key factors influencing losses incurred during this brief time-window at risk can likely enable targeted interventions to improve both welfare and profitability. The low incidence of the outcomes (DOA vs. DAP. vs. SLOW), the diverse nature of loading, transport and lairage experiences, and the potential heterogeneity of outcomes (DOA vs. DAP. vs. SLOW) present obstacles to traditional experimental investigations of the problem. Large databases of transport losses are increasingly available as the industry continues to consolidate. Consequently, there is an opportunity to use observational approaches to explore the possible impact of a range of factors on transport losses. However, problems of bias and confounding are inherent in observational studies, particularly using retrospective data. A multivariate analysis of selected factors is being conducted and should give further insight into which factors may have greatest influence on risk, and more valid estimates of effect sizes. It is also worthy to note that we do not have data available on some factors that are almost certainly important determinants of risk (e.g. stockmanship factors during loading and unloading, including the use of prods; trailer type) and the absence of important causal factors can be a source of bias in analytical models.

The associations described in this univariate analysis should be viewed as hypothesis generating, and therefore require validation from experimental or other observational studies. However, given the size of the database available to us, it is likely that the most conspicuous trends observed (temperature; load size; short transport duration; autosort) will be found to be repeatable. Indeed, the observation of approximately 3-to-4 fold increase in risk of mortality at unloading temperatures above 80oF is biologically plausible and consistent with anecdotal experience, and as such provides some assurance that the analysis of these data can identify influential factors. The apparent decline in risk observed at extremely high temperatures is unlikely to be real, and may be attributable to measurement error (very few pigs transported in the highest temperature extremes) or to confounding factors including possible management adjustments that might be implemented in very hot weather (e.g. numbers of pigs loaded; time of day when loaded).

Two points of interest emerged from the association of transport time and mortality risk. Firstly, time of transport beyond 3 hours appeared to have minimal effect on mortality risk. European authorities have legislated to restrict transport duration to 8 hours for perceived welfare reasons. While mortality and 'slows' are only one index of transport stress and discomfort in animals, the data indicated minimal variation in risk in the range of 3 to 30 hours of transport. In contrast the approximately twofold increase in risk observed in animals transported from 30 to 90 minutes between loading and unloading was striking. This is not entirely unexpected as there are anecdotal reports of high mortality with very short transport distances, and experimental data suggest that a period of about 2 hours after intensive handling is required for physiological parameters in pigs to return to baseline levels.[3,5] Inadequate time to recuperate from the stress of loading may be responsible for the effect observed.

The number of pigs transported per load had little influence on mortality risk. Optimizing transport conditions on an area per animal basis is not simple, and factors such as live weight and temperature need to be considered.[2] Based on our observation that mortality risk was more strongly associated with mean body weight (and even more with total load weight), than with number of pigs in a load, area based standards (e.g. square foot per pig) for animal transport would appear to offer little useful guidance for loading decisions. Hamilton et al (2004) found bodyweight (104kg vs. 128 kg) had minimal influence on blood acid-base status in finishing pigs subject to different handling intensities. Therefore, closer monitoring of total load weight in relation to truck type would appear to be warranted. Possible interactions among factors such as temperature and load weight are likely and will be evaluated in further analyses.

Variability in risk among sites appeared to be greater than among transport providers. Site effects reflect multiple factors including facility, animal, human and environmental influences. Among site related factors available in this study, design of loadout facilities did not appear to have a major effect, although mortality tended to be higher when load outs involved two 90 degree turns. In contrast, mortality risk in lots shipped from autosort barns was markedly lower than for pigs reared in all other barn types. The magnitude of the effect (approximately two-thirds reduction) is difficult to dismiss, and there are several plausible explanatory factors. Unlike pigs loaded from barns without autosort technology, in autosort barns pigs are presorted and do not confront the stresses of sorting and loading in almost immediate succession. Furthermore, in the autosort barns, pigs are sourced from large groups into a loading area. These differences are likely to reduce the distance of movement at the time of loading and the degree of fighting (likely greater when pigs from many small groups are mixed on trucks).[2] Ellis and Ritter (2005) suggested that multiple stressors in loading and transport may have additive effects and that removal of any of them may yield benefits.[2] Also, the presorted pigs have access to water but not feed, and feed restriction may reduce potential for glycogenolysis which is central to the development of lactic acidosis in transported pigs.[4] In that study, the combination of feed withdrawal and reduced handling intensity decreased muscle glycogenolysis.

Perhaps the greatest limitation on retrospective observational studies of transport deaths is the absence of data on handling intensity. Several experimental studies have demonstrated effects of handling intensity on blood chemistry and meat quality variables.[2-6] Under experimental conditions with animals moving at their own pace, minimal effects on acid-base measures was observed, while aggressively handled pigs became acidotic and some became non-ambulatory. At a practical level, the issue of animal handling during transport requires strategies for motivation and education more so than research. At New Fashion Pork, we rank sites (growers) and truckers based on rates of transportation mortality. Sites and truckers in the highest decile of mortality among their respective groups are targeted for education and training, and financial rewards are given annually to the grower and trucker who achieve the lowest incidence. Conversely, those conistently in the lowest decile may be targeted for financial penalties including replacement as contractors.

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