

Associating Risk Factors with Farm Injuries Using Classification Tree

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Abstract

Agriculture is an occupation with risks, especially, when farmers use more machines for farming. Therefore, it is important to associate risk factors with agricultural related injuries, which has implications to make policies for preventing injuries. Lyman, et. al. (1999) and others working have applied multiple logistic regression in agricultural research. However, it is challenging to incorporate appropriate interactions in the logistic regression model. In this paper, the approach of classification tree is used to associate risk factors with farm injuries, which can automatically handle possible interactions. Based on a classification tree, it is also possible to develop different prevention programs for various subgroups given by the tree. We used a data set of 1,051 subjects from Alabama and Mississippi, USA, including African-American farm workers and Caucasian and African-American owners (Source: UAB Injury Center). Condition of farm machinery (Excellent/Good vs. Fair/Poor) first splits the tree. For fair/poor condition of farm machinery, large farms (749 or more acres) give high injury rates (0.28), while for farms with fewer than 749 acres, the estimated injury rate is 0.16 without farm safety training and it is reduced to 0.063 with farm safety training. For excellent/good condition of farm machinery, history of farm injury then splits the tree. Factors that further split the tree include “How Often in A Hurry When Doing Farm Work”, education, primary commodity, wearing seat belt on machinery, race, alcohol consumed per week and farm safety training. Furthermore, classification trees are developed separately for Caucasian and African-American. The graphic displays of the tree are provided.

1. Introduction

Agriculture is considered as a dangerous occupation (National Committee for Injury Prevention and Control, 1989; Bell et al., 1990; Rossignol and Pineault, 1993; Lyman, et. al., 1999), especially when more and more machines are being used for farming (Gerberich et al., 1998). This is certainly the situation in many developing countries.

Therefore, it is important to associate risk factors with agriculture-related injuries, which has policy implications for preventing injuries. In addition, such studies for developed countries may provide useful information for developing country for their current and near future agriculture industry. Several researchers have tried conventional regression methods to address the main question of farm injuries. For example, Lyman, et. al. (1999) used multiple logistic regression and McGwin et al. (2000) utilized the Cox regression for such purpose. However, in general, the association between the predictors and the injury could be very complicated. That is non-linear relationship and complex interactions, which is rather difficult to properly incorporated in these conventional regression models. In this presentation, we apply classification tree to associate risk factors with farm injuries, which can automatically handle possible non-linearity and interactions. Based on a classification tree, it is also possible to develop different prevention programs for various subgroups given by the tree. That is policy implications.

We used a retrospective data set of 1,051 subjects with farm injuries from the states of Alabama and Mississippi, USA, which include injury data on African-American farm workers and Caucasian and African-American owners. Since the data contain a large proportion of African-American farmers, whether ethnic difference is associated with injury, and risk factors for separate ethnic populations is also studied.

2. Materials and Methods

2.1 Study Data

The data set used in this paper is a retrospective data described in details in Lyman, et. al.

(1999) and McGwin et al. (2000). The data were collected from five rural counties in the state of Alabama and four rural counties in the state of Mississippi, United States. Their counties have large African-American populations (50%) so African-American farmers and farm workers are well represented. The study subjects were recruited between January 1994 and June 1996, and were followed until April 1998. The average follow-up duration was 2.5 years. Baseline data were collected from 1,686 active farmers and farm workers, and among them 1384 were completed the follow-up data. For this study, 122 females and 16 Caucasian farm workers were excluded due to small numbers for meaningful representatives. Thus, a total of 1,246 subjects (685 Caucasian owners, 321 African-American owners and 240 African-American workers) are used for this study.

The baseline data include information on demographic (e.g., age, race, education), farm and farming (e.g., commodities, safety training, equipment usage), and behavioral (e.g., risk taking, alcohol assumption), number of hours per week for farm-related work and farm activities (e.g., machinery operation) as well as previous farming-related injuries). During the follow up, injury information was collected. As in some previous studies including the studies done by Lyman, et. al.(1999) and McGwin et al.(2000), the agricultural injury is defined as unintentional physical injury or poisoning which occurred during an agricultural activity and required medical attention or result in at least one-half day of restricted activities. The primary outcome is the occurrence of the agricultural injury during the follow up. This outcome is a dichotomous response variable in the analysis. The risk factors or independent variables are race (white or African-American), age category, education level, history of farm injury (yes or no), comorbid medical

conditions (yes or no), farm owner or worker, full-time farmer (40 or more hours per week on farming), other non-farm job (yes or no), full-time non-farm job (yes or no), farm safety training (yes or no), farm safety training for chemicals (yes or no), milliliters of alcohol consumed per week, behavior for turning off machinery when removing stuck objects, behavior for wearing seat belt, attitude towards farm safety (very careful or not), attention level towards farm safety (very attentive or not), how often tired when doing farm work (often or not often), how often in a hurry when doing farm work (frequently or not), primary commodity farmed, size of farm in acres, use of tractor on farm (yes or no), number of regularly used farm machines, and condition of farm machinery (excellent, good or fair/poor).

2.2 Statistical Methods

In this paper, we use classification and regression tree (CART) (Breiman et. al., 1984) to establish a relationship between the farm injury with risk factors. Since the dependent variable is binary, our data analyses are based on the classification tree. The predictors in a tree method can be a mix of numerical and categorical variables. In general, the tree method is considered as a nonparametric approach, and can easily handle possible interactions among the predictors. Due to this nature, the tree methods are often used in data mining and exploratory data analysis. S-PLUS is used for the classification trees. The minimum size to split a node in the analyses is 100, which seems to be adequate for such a large sample. After the tree is fully grown, deviance against number of terminal nodes is plotted. Based on the reduction in the deviance, pruning the tree can be performed based on the cost-complexity measure. We prune a tree to have about 75%

reduction in deviance. Classification trees were developed for all the data and separately for Caucasian owners and for African-Americans.

3. Results

In the sample, about 55% subjects are Caucasian owners, 25% are African-American owners, and 20% are African-American farm workers. Lyman, et. al. (1999) and McGwin et al. (2000) provide detailed summaries for socio-demographic characters and other characters/risk factors.

For all the subjects, the classification tree actually used condition of farm machinery, history of farm injury, how often in a hurry when doing farm work, primary commodity farmed, size of farm, race, alcohol consumed per week, farm safety training, education, behavior for wearing seat belt, and farm safety training for chemicals in tree construction. Due to missing information, 1,051 observations were used for the tree development. The overall injury rate is 0.105 for these 1,051 subjects. The tree first splits according to the machinery condition. For those with excellent/good machinery condition, the branch then splits according to whether they had history of farm injury. Further, splitting variables are how often in a hurry when doing farm work, primary commodity farmed, size of farm, race, farm safety training for chemicals, education, behavior for wearing seat belt. For those with fair/poor machinery condition, the branch then splits according to the farm size. For smaller farms, the branch splits according to whether they received farm safety training. The fully grown tree has 15 terminal nodes. A plot for deviance against size is obtained as follows.

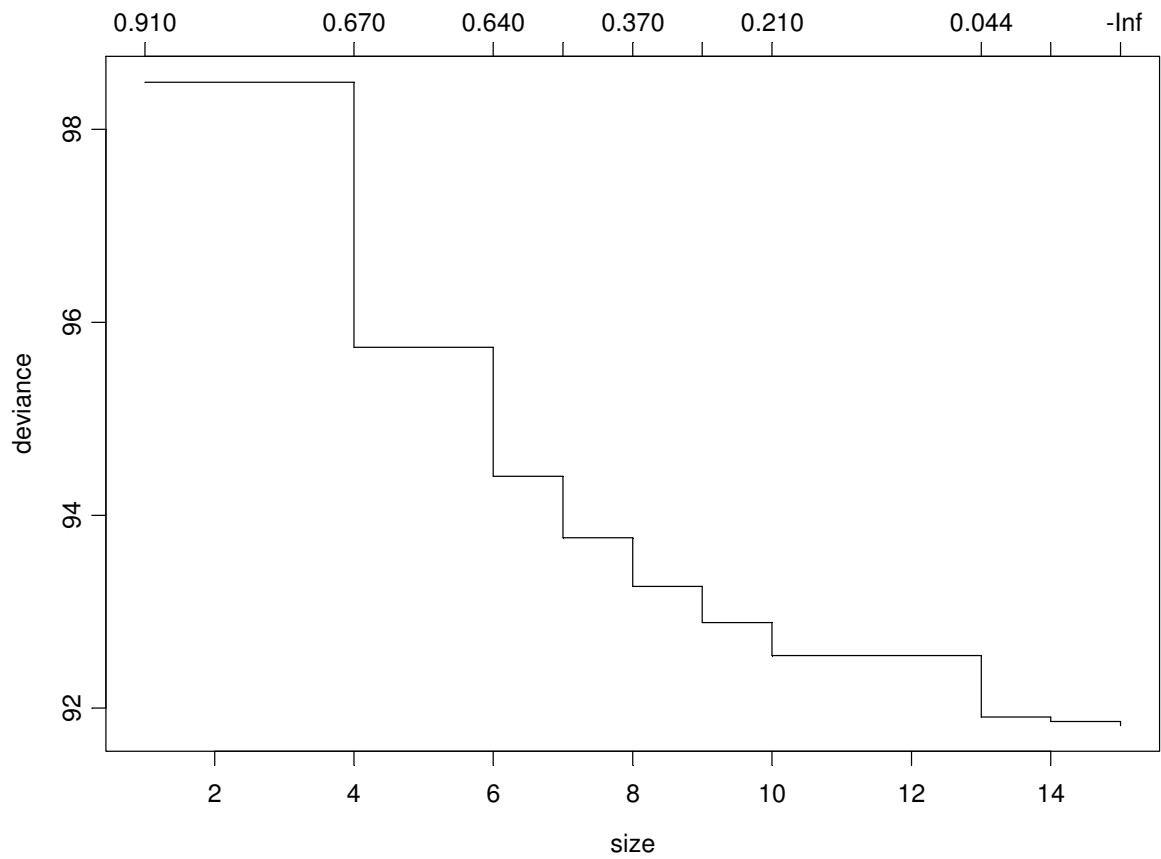


Figure 1: Deviance Against Tree Size Using All the subjects

Based on the reduction on the deviance, the tree is pruned in order to have 10 terminal nodes as described in Table 1.

Table 1: Final Classification for Farm Injury Using All the Subjects

Machine Condition	Excellent/Good						Fair/Poor			
	No			Yes						
Previous Injury	No			Yes						
Frequently in Hurry	No		Yes							
Commodity*	a,b,c,d,g	e,f	a,b,c,f	d,e						
Acres								< 749	≥749	
Education (4-yr College or beyond)					No		Yes			
Seat Belt					Wear	Never				
Safety Training								No	Yes	
n	406	68	89	77	55	86	68	88	64	50
Rate	.039	.132	.067	.195	.127	.233	.074	.159	.063	.280

* a = Aquaculture, b = Field Crop, c = Forestry, d = Livestock, e = Mixed, f = Other, and g = Vegetable.

For African-Americans, the classification tree actually used condition of farm machinery, whether they are full-time farmer, education, or number of regularly used farm

machines. A total of 444 African-Americans farmers and farm workers were in the tree development. The overall injury rate is 0.115, slightly higher than that for all subjects. Again, the tree first splits according to the machinery condition. The fully grown tree has 7 terminal nodes

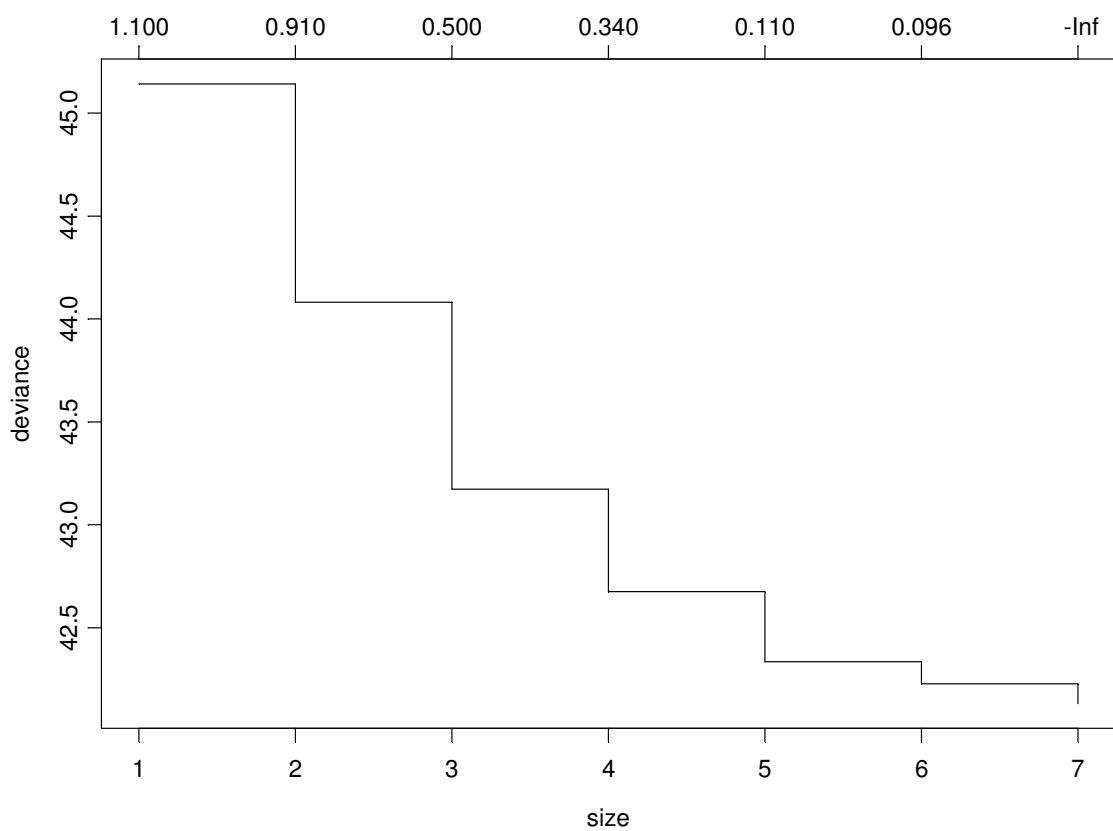


Figure 2: Deviance vs. tree size—African-Americans

Based on the reduction on the deviance, we prune the tree to have 5 terminal nodes as summarized in Table 2.

Table 2: Final Classification for Farm Injury Using all African-Americans

Machine Condition	Excellent/Good			Fair/Poor	
				a,d,e,f	b,c
Commodity*					
Full-Time Farmer	No		Yes		
Education (High School or Beyond)	No	Yes			
N	101	148	85	55	55
Rate	.109	.034	.153	.109	.291

* a = Aquaculture, b = Field Crop, c = Forestry, d = Livestock, e = Mixed, f = Other, and g = Vegetable.

There were 607 farmers included in the tree for Caucasian owners. The overall injury rate is 0.097. The predictors used for the tree are primary commodity farmed, comorbid medical condition, attention level towards farm safety, number of regularly used farm machines, history of farm injury, education, and whether they had other non-farm jobs. The tree first splits according to the commodity, and the fully grown tree has 9 terminal nodes.

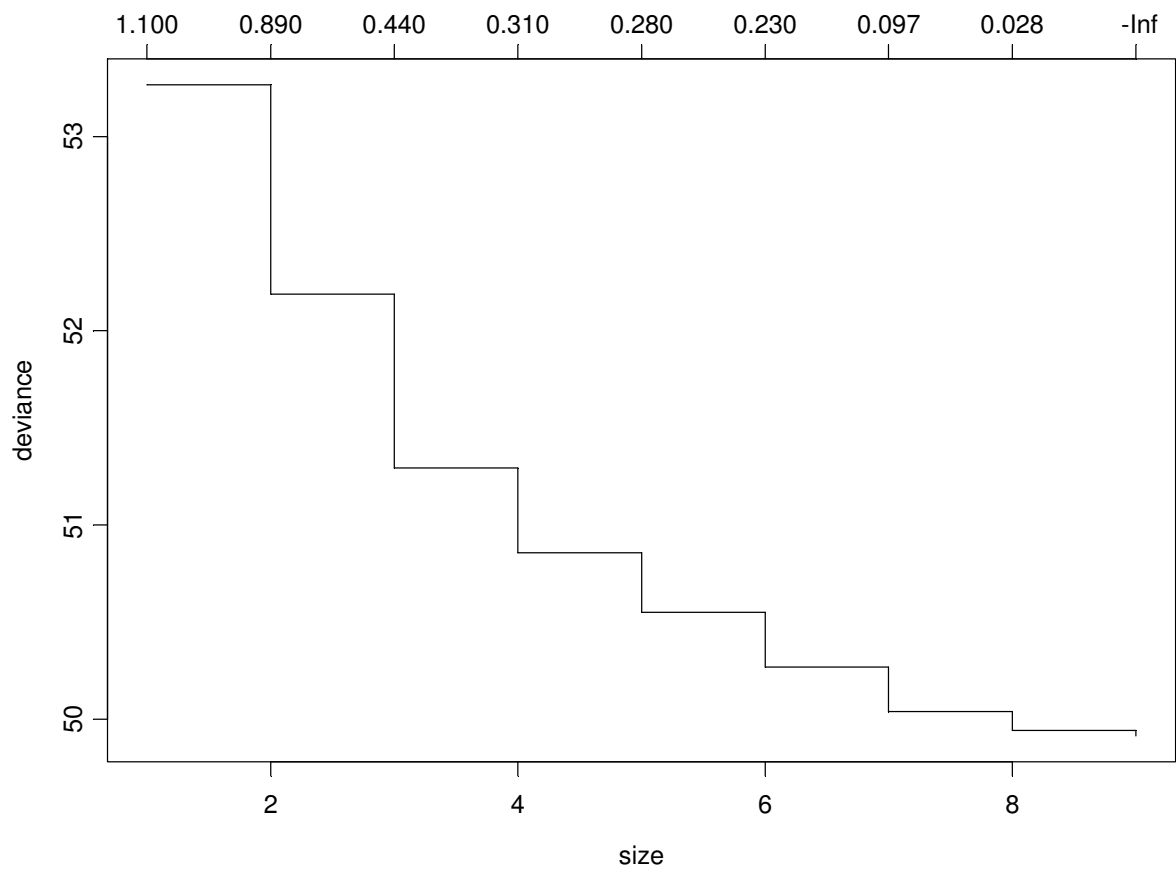


Figure 3: Deviance Against Tree Size Using All Caucasian Owners

Based on the reduction on the deviance, the tree is pruned to have 6 terminal nodes given in Table 3.

Table 3: Final Classification for Farm Injury Using Caucasian Owners

Commodity*	b,c		a,d,e,f,g			
# of Farm Machines	≤ 19	> 19				
Attention Level			Very attentive		Somewhat/Not Attentive	
# of Farm Machines					≤ 13	> 13
Previous Injury			No	Yes		
n	157	50	185	67	89	59
Rate	.013	.120	.070	.149	.225	.136

.149

* a = Aquaculture, b = Field Crop, c = Forestry, d = Livestock, e = Mixed, f = Other, and g = Vegetable.

4. Discussions

The approach of classification tree is used to associate many potential risk factors with farm injury. From the tree for both races, the condition of farm machinery is an important factor related with the farm injury. Without adjusting other factors, the injury rates for fair/poor and excellent/good are 0.158 and 0.092, respectively, which give a risk ratio of 1.71. Among all terminal nodes, large farms (749 or more acres) with fair/poor condition on farm machines were the worst for farm injury, had a rate of 28%, which is

about 2.7 times of the overall rate. For smaller farms with fair/poor condition on farm machines, safety training could greatly reduce the injury rate. With excellent/good condition on farm machinery, those who had history of farm injury were more likely to have new farm injury. College education or wearing seat belt could help to reduce injury. For those without history of farm injury, injury more likely occurred to those who were frequently in a hurry when doing farm work. Further, primary commodity farmed may be related to the chance of injury. Especially, mixed commodity seemed more dangerous, livestock or other commodities may also cause higher injury rate.

For African-Americans, fair/poor condition for farm machinery is still a big risk factor, causing more farm injuries, especially, in field crop and forestry farms. With excellent/good condition on farm machines, full-timer farmer/farm workers had more chance to have injury. Among them, those with better education had less chance to be injured. For Caucasian owners, the machinery condition was not used in the actual tree development. Primary commodity farmed was related to the chance of injury; lower injury rates in field crop and forestry. For field crop and forestry farms, injury is more likely to occur if there were large number (≥ 19) of regularly used farm machines. For the farms with the rest commodities, attention level towards farm safety, number of regularly used farm machines and history of farm injury contributed to the injury. However, for those with lower attention level, smaller number (< 13) of regularly used farm machines was associated with a higher injury rate.

In general, farm commodity, farm size and number of farm machines could be related with the farm injury rate. Maintaining excellent/good condition on farm machines seems very important to prevent farm injuries. Furthermore, good education, good behaviors (e.g., no hurry when doing farm work, wearing seat belt) and safety training can reduce farm injury. These are conditions that can be improved by certain intervention, e.g., by government. Since those with history injury are more likely to be injured again, special attention may be needed for them.

The analyses in this paper used a retrospective data set. Because of lost to follow-up, there may be some bias introduced. In general, the trees method provides less formal statistical inference, and hence the results in this paper are more exploratory in nature. Nevertheless, our results could provide some useful aids for farm injury prevention. The follow-up times of the subjects are not the same, and certainly have impact to the injury. In our trees, we ignored the follow-up time assuming it is pretty much random. Adjusting the follow-up time in classification trees will be a future study topic.

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References

Bell CA, Stout NA, Bender TR, Conroy CS, Crouse WE, Myers JR. 1990. Fatal occupational injuries in the United States, 1980 through 1985. *JAMA* 263:3047-3050.

Breiman L, Friedman JH, Olshen RA, Stone CJ. 1984. *Classification and Regression Trees*. Wadsworth and Brooks/Cole.

Gerberich SG, Gibson RW, French LR, et al. 1998. Machinery-related injuries: Regional Rural Injury Study-I (RRIS-I). *Accid Anal Prev* 30:793-804.

Lyman S, McGwin G Jr, Enochs R, Roseman JM. 1999. History of agricultural injury among farmers in Alabama and Mississippi: Prevalence, characteristics, and associated factors. *Am J Ind Med* 35:499-510.

McGwin G Jr, Enochs R, Roseman JM. 2000. Increased risk of agricultural injury among African farm workers from Alabama and Mississippi. *Am J Epidemiol* 152:640-650.

National Committee for Injury Prevention and Control. 1989. *Injury prevention: Meeting the challenge*. New York: Oxford University Press.

Rossignol M, Pineault M. 1993. Fatal occupational injury rates, 1981 through 1988. *Am J Public Health* 83:1563-1566.