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Assessing Youth Safety Knowledge with the Agricultural Experience Tracker (AET)

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HIGHLIGHTS

- The data generated in this study meet a need for a national sample of youth to examine youth safety knowledge.
- Changing demographics of youth with limited agriculture experience should be considered in the design of safety training and design of agricultural equipment.
- Future research is needed to determine the impact of safety training and at what point students receive this instruction in agricultural education programs.

ABSTRACT. *The purpose of this study was to assess the safety knowledge of youth in high school agricultural education. The target population consisted of youth ages 14 to 18 who were enrolled in school-based agricultural education (SBAE) programs that used the Agricultural Experience Tracker (AET) safety knowledge assessment between May 2019 and June 2020 (N = 1,451). The safety knowledge questions were randomly generated from the curriculum resources of the National Safe Tractor and Machinery Operation Program (NSTMOP). The test consisted of 50 multiple-choice questions, with one point awarded for each correct answer, and covered topics such as safety basics, agricultural hazards, tractors, connecting and using implements with tractors, and materials handling. The majority of students were male (n = 847, 58.4%). The highest proportion of students were enrolled in the 11th grade at the time of the test. Most respondents indicated that they were from a rural area (52.0%). Test scores for the 1,451 students ranged from a minimum of 4% to a maximum of 98%. Within each independent variable, test scores averaged in the low 60s, with the exception of test scores for students in 9th grade, which averaged 56.43%. Research and continuing education are needed to influence the behavior of young workers in agricultural settings.*

Keywords. *Assessment, Education, Safety, Youth.*

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According to the U.S. Bureau of Labor Statistics (BLS, 2018), agriculture is one of the most dangerous industries in the U.S. and experiences a fatal injury rate seven times greater than other industries. Fatalities of youth working in agriculture exceed youth fatalities in all other industries combined (NIOSH, 2014). With more than 27 million youth living, working on, or visiting farms (Hendricks et al., 2018), this population is certainly susceptible to agriculture-related injuries (Hard and Myers, 2006). The high susceptibility of agricultural youth to injuries has been attributed to labor regulation exemptions and other provisions that apply to youth in agriculture. Even more concerning data are noted by the National Children's Center (NCC, 2020), which reported that 60% of household youth who were injured in agriculture were not actively engaged in work-related tasks, thus reiterating the susceptibility to injury due to exposure to an agricultural environment.

With their proximity to agricultural safety hazards, youth need environment-specific training. Students enrolled in school-based agricultural education (SBAE) programs have the opportunity to participate in supervised agricultural experiences (SAEs) (NCAE, 2015) in which they can develop their agricultural safety knowledge and awareness. Ultimately, SBAE allows students to apply classroom and laboratory concepts, such as agricultural safety, as they prepare for future career opportunities (FFA, 2020). Numerous studies have documented the benefits of SAEs (Camp et al., 2000; Lewis et al., 2012; Moules, 2013; Rubenstein and Thorn, 2014). Specifically applicable to safety, SAEs have been shown to provide students the opportunity to explore multiple careers, learn workplace behaviors, and develop and apply occupational skills.

Due to their influential role in SAEs, SBAE teachers are uniquely poised to help reduce agriculture-related youth injuries by disseminating effective safety education curricula. However, SBAE teachers continually express professional development needs in the area of safety education (Lawver et al., 2016; McKim and Saucier, 2011; Saucier et al., 2014; Shultz et al., 2014). Recent efforts to address these needs have been conducted via teacher trainings that focus on integrating hands-on activities into machinery safety curricula (Pate et al., 2019). Additional research has focused on "train the trainer" approaches to increase the safety knowledge and awareness of secondary teachers and subsequent students (Perry et al., 2020). Resulting efforts of this research culminated in recommendations that additional research should focus on the effects of youth background and safety measures within SAEs (Pate et al., 2019; Perry et al., 2020).

There is a need for research examining safety knowledge among agricultural youth, as the availability of data directly from this group is limited. In its recommendations to the U.S. Department of Labor for changes to hazardous orders, NIOSH (2002) noted that "the effectiveness of tractor safety training programs has not been adequately evaluated nationwide" (p. 70). The few studies that have been completed continually demonstrate the need for a much closer and more thorough examination of the effectiveness of tractor safety training for children (Carrabba et al., 2000; Jepsen, 2012; Wilkinson et al., 1993). One such study conducted in Indiana (Carrabba et al., 2000) found that participants who engaged in a 4-H tractor safety program demonstrated a greater level of confidence in operating tractors, and that the program appeared to have a positive influence on the safe operating practices of the participants. However, Carrabba et al. (2000) also found that despite the youths' feelings of confidence, they continued to engage in risky behaviors, such as allowing extra riders. In contrast to the demonstrated challenges of improving youth safety behavior, NIOSH (2002) noted a Wisconsin study (Wilkinson et al., 1993) that found youth who had

completed a training program reported an increase in their use of tractors equipped with rollover protective structures (ROPS).

These few studies demonstrate the need for a much closer and more thorough examination of the effectiveness of tractor safety training for youth. However, a common challenge in evaluating the effectiveness of this safety training is access to a national agricultural youth population. Although admittedly not all-encompassing, one such data source that targets this population and capitalizes on the learning potential of SAEs can be found in the Agricultural Experience Tracker (AET), an integrated online data management and recordkeeping platform that allows educators and students to keep track of their SAEs (AET, 2022). The AET was designed for agricultural education students and teachers to assist in managing the time and financial resources associated with SAEs. The AET has assisted more than 2 million students and teachers nationwide in managing resources inside and outside of the classroom (AET, 2022).

According to the U.S. Department of Labor exemption for student learners, students enrolled agricultural education programs may work in the occupations listed in paragraphs 1 through 6 of the Hazardous Occupations Order in Agriculture (HOOA) under a written agreement that meets certain conditions. One of these conditions is that safety instruction must be given by the school and correlated by the employer with on-the-job training. As part of its recordkeeping process, the AET offers an online assessment system to track students' safety knowledge, as well as other tests for a variety of skills. Within the AET, students in agricultural education programs can complete a tractor and machinery safety knowledge assessment based on the National Safe Tractor and Machinery Operation Program (NSTMOP) curriculum. In this study, data were collected directly from high school agricultural education students who participated in a safety knowledge assessment within the AET, and the collected data were used to assess youth safety knowledge.

Purpose and Objectives

Recognizing the lack of adequate agricultural youth research, the purpose of this study was to assess the safety knowledge of youth in high school agricultural education programs. Specific objectives included:

1. Describe selected demographics of high school agricultural education youth who completed the AET safety knowledge assessment.
2. Describe the tractor and machinery safety knowledge of students in high school agricultural education programs who completed the AET safety knowledge assessment.
3. Determine significant predictors of youth performance on the AET safety knowledge assessment, focusing on student grade level, gender, race, and residence.

Materials and Methods

A human subjects research review was conducted under Utah State University IRB protocol 11426. This study used an existing data set from the AET, and the review determined that the research did not involve human subjects and was not subject to oversight by IRB as defined in 45 CFR 46.102(e) and/or (l). The target population consisted of youth ages 14 to 18 who were enrolled in SBAE programs that used the AET agricultural safety knowledge assessment between May 2019 and June 2020 (N = 1,478). Most of the tests were completed in January 2020 (n = 297, 20.1%), October 2019 (n = 220, 14.9%), and

September 2019 (n = 205, 13.9%). All data were de-identified by the AET and were provided as an Excel file. The data were reviewed and exported as an SPSS file. Only first-attempt test results were used in the data analysis. There were 27 cases that did not meet the inclusion criteria and were removed from the data analysis. Those students were 7th and 8th graders who did not meet the age requirements.

To address objectives 1 and 2, select demographic information was collected through self-reported data. Participants identified their age, grade level, gender, state of residence, race, and residence size. The residence size options were based on National Center for Education Statistics classifications for city (greater than 100,000 population and an urban area), suburb (up to 100,000 population but outside a city), town (10 to 35 miles from an urban area), and rural (outside an urban area and less than 5,000 population). Participants from 39 states completed the safety knowledge assessment.

Selection of Independent Variables

To determine significant predictors of youth performance on the AET safety knowledge assessment, we completed a linear regression model. Grade level, race, formal training, residence, and gender were selected as independent variables to estimate the dependent variable (test score). Justification for the use of grade level was based on an agriculture, food, and natural resources career cluster framework, which established the students' plan of study (Advance CTE, 2021). Students in higher grades (10th, 11th, and 12th) are likely to be enrolled in more advanced skills-based classes in their agricultural education program and therefore should score higher on the AET safety knowledge assessment.

Justification for the use of race was based on the Minority Farm Operator Childhood Agricultural Injury Survey (M-CAIS) report, which suggests a need for prevention strategies for specific subpopulations of the agricultural community, especially for Native American youth because they have significantly higher rates of injury (Goldcamp et al., 2006). There is little data on the number or ability of instructors who use Tractor and Machinery Certification (TMC) resources for underrepresented populations (Jepsen, 2012). Students who are white, male, and from rural areas are likely to be enrolled in agricultural education programs (Lawrence et al., 2013) and should score higher on the AET safety knowledge assessment. As documented by Carrabba et al. (2000) and Wilkinson et al. (1993), as well as the U.S. Department of Labor requirement for youth to receive training, it was hypothesized that receiving formal training should be a significant predictor of test success.

To address objective 2, safety knowledge questions were assigned from the NSTMOP curriculum resources. NSTMOP is a project of the USDA-CSREES Hazardous Occupations Safety Training for Agriculture (HOSTA) program and was developed in response to the need for resources to support the USDA-NIFA Youth Farm Safety Education and Certification Regulation. Students were randomly assessed with 50 questions from a pool of 100 questions. Their test scores were recorded as the percentage answered correctly. The tractor and machinery safety awareness test consisted of multiple-choice questions and covered topics such as safety basics, agricultural hazards, tractors, connecting and using implements with tractors, and materials handling. The curriculum and test items were evaluated by agricultural safety educators and determined to meet content validity standards (Garvey et al., 2008).

Results and Discussion

Demographic data were available for 1,451 eligible students (table 1). Most of the students were male (n = 847, 58.4%). The highest proportion of students were in 11th grade at the time of the test (34.5%). Most students indicated they were from a rural area (52.0%). Many students (n = 998) did not answer the question regarding formal safety training. Of those students who answered the question regarding safety training (n = 453), almost 3/4 of them (frequency = 333, 73.5%) indicated that they had not received formal safety training. The top three states represented in the sample were California (n = 272, 18.7%), Texas (n = 224, 15.4%), and Ohio (n = 194, 13.4%). States not represented were Hawaii, Louisiana, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, Virginia, Washington, Wisconsin, West Virginia, and Wyoming. As shown in table 2, most students were white, non-Hispanic (n = 1,124, 77.6%). Two students chose not to identify their race.

Test scores were recorded as a percentage of the 50 questions answered correctly. For the 1,451 students, the percentage correct ranged from a minimum of 4.0% to a maximum of 98.0%. The mean and median test scores were similar (63.59% and 64.00%, respectively) and implied a normal distribution. However, when graphed, the test scores showed a positive skewed distribution, as shown in figure 1. Test score percentages averaged in the low 60s. Table 3 provides descriptive statistics for the test scores. The top ten questions that the students most often answered incorrectly are shown in table 4.

Student test scores remained consistent across demographic variables, as shown in table 5. The largest difference was within grade level, with 9th graders (n = 131) scoring an average of 58.43% and 11th graders (n = 500) scoring an average of 66.40%. For race, the majority of students were white, non-Hispanic; therefore, the other race categories were

Table 1. Demographic data for students (N = 1,451).

		Frequency	Percentage
Gender	Male	847	58.4
	Female	604	41.6
Grade	9th	131	9.0
	10th	491	33.8
	11th	500	34.5
	12th	329	22.7
Residence	Rural	754	52.0
	Town	432	29.7
	Suburb	167	11.5
	City	98	6.8
Formal safety training[a]	Yes	120	8.3
	No formal training	333	22.9
	Missing or not answered	998	68.8

[a] Students were asked to self-report if they had received formal training by indicating yes or no.

Table 2. Race data for students (N = 1,451).

Race	Frequency	Percentage
White, non-Hispanic	1,124	77.6
Asian	10	0.7
Hispanic	177	12.2
American Indian	16	1.1
Two or more	58	4.0
Black, non-Hispanic	37	2.6
No answer/non-disclosed	24	1.7
Pacific Islander	2	0.1
Native Hawaiian	1	0.1

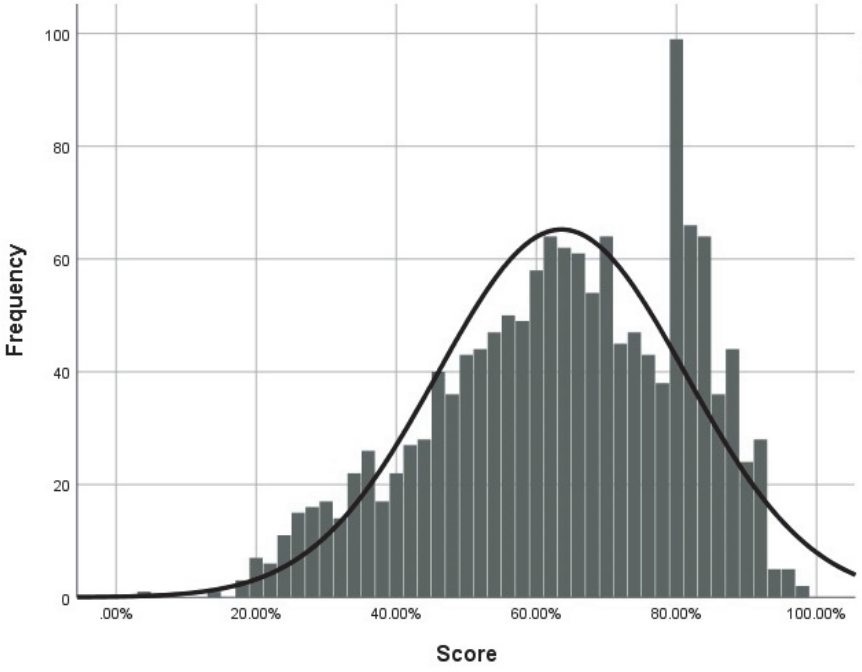

Figure 1. Distribution of student test scores (mean = 63.59%, SD = 17.745%, *N* = 1,451).

collapsed as "all other." As shown in table 5, students identified as white and as "all other" races had similar mean test scores. Males and females also had similar mean test scores. For residence, students from a city had the lowest mean test score (62.22%).

Multiple Linear Regression Model

To determine significant predictors of youth performance on the AET safety knowledge assessment, we completed a multiple linear regression model. Using grade level, race, formal training, residence, and gender as independent variables, the regression model predicted 13% of the variance in test scores (n = 452; R^2 = 0.130). Within the model, grade level, two race categories (Hispanic and Black, non-Hispanic), and one residence category (city) were statistically significant predictors of test scores. When graphed, the standardized residuals showed a positively skewed distribution (fig. 2). Fewer than 5% (1.99%) of the standardized residuals fell outside 1.96, and no standardized residuals fell outside 2.58. Therefore, we proceeded with this model, as recommended by Field (2009). Tables 6 and 7 summarize the regression model and associated coefficients.

Limitations and Conclusions

The purpose of this study was to assess the safety knowledge of youth in high school agricultural education programs by identifying selected demographics, describing the students' knowledge of tractor and machinery safety, and determining significant predictors of student performance on the AET safety knowledge assessment. Several limitations are noted here, and the results of this study should be interpreted with caution.

Table 3. Descriptive statistics for test scores (*N* = 1,453).

	Mean	Median	Mode	SD	Minimum	Maximum
Score	63.59%	64.00%	80.00%	17.74%	4.00%	98.00%

Table 4. Top ten questions most often answered incorrectly.

Question	Frequency	Incorrect (%)[a]
Heavy draft loads (i.e., tillage equipment) should be attached to which of the following: [multiple choice]	1,171	80.8
If you raise your arm vertically overheard (palm to the front) and rotate it in large horizontal circles, what hand signal are you using? [multiple choice]	1,019	70.4
According to the North American Guidelines for Children's Agricultural Tasks (NAGCAT), what is the recommended minimum age for operating a PTO-powered implement? [multiple choice]	995	68.6
Working as a non-family farm employee, youth who are younger than 16 or older can fell trees with a butt diameter up to: [multiple choice]	902	62.0
Nationally, what fraction of all farm work fatalities are tractor-related? [multiple choice]	889	39.1
You should avoid driving an ATV on: [multiple choice]	868	60.9
What percent of tractor-related fatalities are a result of tractor overturns? [multiple choice]	832	42.9
Which of the following are ground-motion controls and should be orange color-coded? [multiple choice]	821	57.1
PTO controls are designed to move rearward or downward to: [multiple choice]	796	55.0
When using wheel-type tractors on silage surfaces, do NOT use with slopes greater than: [multiple choice]	779	53.8

[a] Percentage of students who answered the question incorrectly.

Table 5. Test scores of students within each independent variable.

Variable	Response	Mean	SD	Median
Grade	9 (*n* = 131)	58.43%	18.48%	60.00%
	10 (*n* = 491)	61.53%	18.49%	62.00%
	11 (*n* = 500)	66.40%	17.06%	68.00%
	12 (*n* = 329)	64.46%	16.54%	66.00%
Age	14 (*n* = 74)	57.10%	21.98%	55.00%
	15 (*n* = 362)	61.29%	18.19%	62.00%
	16 (*n* = 501)	64.10%	17.78%	64.00%
	17 (*n* = 434)	65.55%	16.27%	68.00%
	18 (*n* = 80)	66.30%	16.59%	69.00%
Race	White (*n* = 1124)	63.78%	16.85%	66.00%
	All other (*n* = 325)	63.02%	20.56%	62.00%
Gender	Female (*n* = 604)	63.66%	18.23%	64.00%
	Male (*n* = 847)	63.53%	17.40%	66.00%
Residence	Rural (*n* = 754)	63.24%	17.39%	66.00%
	Town (*n* = 432)	64.21%	18.00%	66.00%
	Suburb (*n* = 167)	64.38%	17.98%	64.00%
	City (*n* = 98)	62.22%	19.00%	62.00%

Objective 1: Describe Selected Demographics of High School Agricultural Education Youth who Completed the AET Safety Knowledge Assessment

Generalizations based on the study conclusions should be made with caution. The first limitation of this study is the use of convenience sampling of students who use the AET platform. The results may vary for students who do not use the AET, and it is recommended that researchers investigate if differences exist within this population. This study did not collect data from students representing all 50 states. An additional limitation of the study

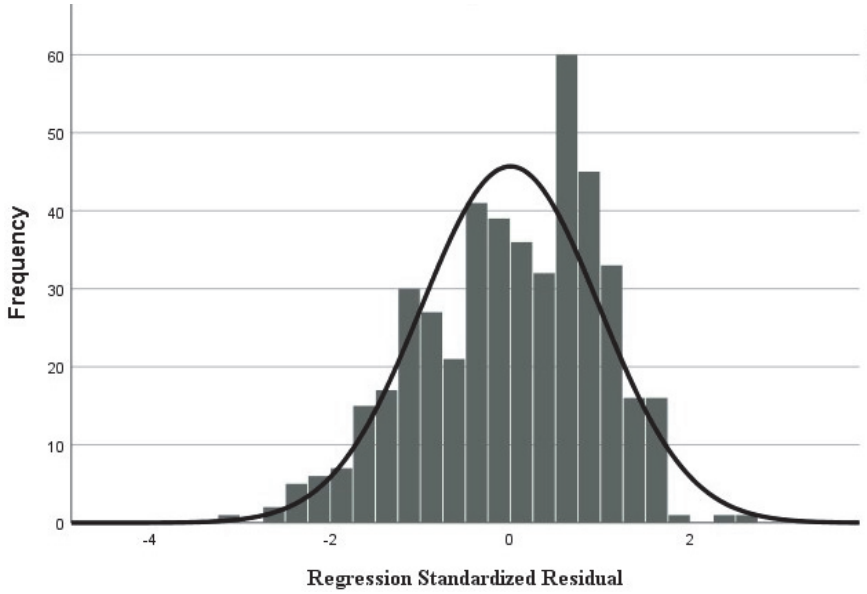

Figure 2. Histogram plot of standardized residuals (mean = -6.73E-16, SD = 0.987, *N* = 452).

Table 6. Summary of regression model to predict test scores (*N* = 452).[a]

R	R^2	Adjusted R^2	F-Value	p-Value
0.361	0.130	0.106	5.473	0.000

[a] Predictors are: (constant), formal training, race, gender, grade, and residence.

Table 7. Regression coefficients in the model.

						95.0% CI	
	B	SE	Beta	t	Sig.	LB	UB
(Constant)	40.191	9.470		4.244	0.000	21.578	58.804
Grade	2.675	0.885	0.137	3.021	0.003	.935	4.414
Race							
Asian	2.653	8.157	0.015	0.325	0.745	-13.378	18.684
Hispanic	-6.641	2.705	-0.115	-2.455	0.014	-11.957	-1.326
American Indian	-8.923	6.677	-0.060	-1.336	0.182	-22.046	4.201
Two or more	-0.277	4.279	-0.003	-0.065	0.948	-8.687	8.134
Black, non-Hispanic	-25.096	4.332	-0.264	-5.793	0.000	-33.611	-16.581
No answer	6.302	5.436	0.052	1.159	0.247	-4.382	16.987
Gender	-1.295	1.531	-0.038	-0.846	0.398	-4.304	1.713
Formal training	2.467	1.754	0.064	1.406	0.160	-.981	5.914
Residence							
Town	0.951	1.790	0.026	0.531	0.596	-2.568	4.470
Suburb	-3.648	2.434	-0.071	-1.498	0.135	-8.432	1.137
City	-9.050	2.926	-0.148	-3.093	0.002	-14.801	-3.299

was the lack of data on specific aspects of the training that the students received. Agricultural youth safety training is a continuous effort to ensure that students have a basic understanding of safety in agricultural settings. More research is recommended to determine the types and formats of training provided to students. Acknowledging these limitations, this study provides an examination of the national scope of students' knowledge of tractor and

machinery safety in SBAE. The results are important to guide policymakers and instructors in improving students' safety knowledge. This study documents that more effort is needed to provide safety training to the variety of youth who are involved in agriculture, specifically students in SBAE. These students engage with production agriculture through their involvement in SAEs, which is an opportunity to apply safety training in the classroom.

Objective 2: Describe the Tractor and Machinery Safety Knowledge of Students in High School Agricultural Education Programs who Completed the AET Safety Knowledge Assessment

The results suggest that SBAE students' knowledge of tractor and machinery safety is limited. The students had an overall mean test score of 63.59% (SD = 17.74%), suggesting that additional safety training is needed. Over half (58%, n = 841) of the students in this study scored lower than the NSTMOP-recommended passing score of 70%. Most of these students (52.3%, n = 440) were 11th and 12th graders. Among 9th and 10th grade students, few (26.2%, n = 221) received the NSTMOP-recommended passing score of 70% or higher. These scores have implications for the inclusion of safety curricula in SBAE programs. A recommendation is to identify SBAE courses in which to integrate safety training, targeting specific grade levels, to ensure that all students receive safety training. Additional efforts should be made to reach diverse populations with tractor and machinery safety training. Fewer females (30%, n = 182) and underrepresented minorities (41.2%, n = 134) scored the NSTMOP-recommended passing score of 70% or higher.

Objective 3: Determine Significant Predictors of Youth Performance on the AET Safety Knowledge Assessment, Focusing on Student Grade Level, Gender, Race, and Residence

A multiple linear regression model was used to determine significant predictors of youth performance on the AET safety knowledge assessment. This model met the assumption for multiple linear regression. Using grade level, race, residence, and gender as independent variables, the regression model was statistically significant and predicted 13% of the variance in test scores ($R^2 = 0.13$). Within the model, grade level, two race categories (Hispanic and Black, non-Hispanic), and one residence category (city) were statistically significant predictors of test scores. Interpretation of the beta values indicated that, as a hypothesis, students in higher grades perform better on the test. A one-unit change in grade level resulted in a corresponding increase of 2.6 percentage points in students' test scores.

A significant finding was that race was a significant predictor of test score. For Hispanic students, test scores were predicted to decrease by 6.6 percentage points. For Black, non-Hispanic students, test scores were predicted to decrease by 25 percentage points. Additionally, students in residences classified as "city" were predicted to score 9.0 percentage points lower than students in the other residence categories. The results suggest that Hispanic students and Black, non-Hispanic students need additional tractor and machinery safety training. These changing demographics might be a factor to consider regarding students' experience and training in agricultural equipment and practices.

The test scores indicated that the students would benefit from directed training or educational programs, as documented by Carrabba et al. (2000) and Wilkinson et al. (1993). Many students in this study did not report receiving formal training, and it was anticipated that these students were familiar with safety concepts as part of their SBAE experiences. Formal training may have included independent study assigned by a teacher, extension agent, or parent. Conversely, informal learning is often characterized by low levels of

planning, organization, learning support, and learning time, as well as limited learning objectives. The NSTMOP curriculum is considered formal training because the curriculum requirements include classroom hours spent on core topics with specific objectives. Vocational teachers may have included parts of the NSTMOP curriculum in their SBAE programs, and it is possible that teachers did not offer a complete course on tractor and machinery safety. In the AET, this question serves a recordkeeping function so that teachers can verify each student before assigning the hands-on driving test upon completion of the knowledge test, as indicated by the grade level. Grade level was a significant predictor of test score, which indicates that students in upper-division classes may receive more safety training as part of their agricultural education curriculum.

Given the model's accounting for 13% of the variance among tractor and machinery test scores, future research is needed to determine the impact of safety training, including when students receive this instruction in agricultural education programs. This is consistent with the recommendation from Carrabba et al. (2000) that additional training and resources are needed. The impact and timing of youth safety training will be important for understanding youth safety knowledge and why the test results fluctuated, especially for Hispanic students and Black, non-Hispanic students. This understanding will help identify specific areas of professional development for agricultural educators and training interventions to reduce the work-related injuries of youth in SAEs. One such provision for teachers to consider integrating into their SAE programming is the National Children's Center model policy for youth in agriculture, which outlines guidelines for hired labor focusing on youth employment, development, and the work environment (NCC, 2020).

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