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Editorial Policy

The primary purpose of the JTM is to publish managerial and policy articles that are relevant to academics, policymakers, and practitioners in the transportation, logistics and supply chain fields. Acceptable articles could include conceptual, theoretical, legal, case, and applied research that contributes to better understanding and management of transportation and logistics. Saying that, our policy requires that articles be of interest to both academics and practitioners, and that they specifically address the managerial or policy implications of the subject matter. Articles that are strictly theoretical in nature, with no direct application to transportation and logistics activities, or to related policy matters, would be inappropriate for the *JTM*. Articles related to any and all types of organizations, and of local to global scope, will be considered for publication.

Acceptable topics for submission include, but are not limited to, broad logistics topics, logistics and transportation related legal issues, carrier management, shipper management of transportation functions, modal and intermodal transportation, international transportation issues, transportation safety, marketing of transportation services, transportation operations, domestic and international transportation policy, transportation economics, customer service, and the changing technology of transportation. Articles from related areas, such as third party logistics, purchasing and materials management, and supply chain management, are acceptable as long as they are related to transportation and logistics activities.

Submissions from practitioners, attorneys or policymakers, co-authoring with academicians, are particularly encouraged in order to increase the interaction between groups. Authors considering the submission of an article to the *JTM* are encouraged to contact the editor for help in determining relevance of the topic and material.

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Publishing Data

Manuscripts. Submit manuscripts to the editor by email attachment at taylorjohn@wayne.edu. Manuscripts should be no longer than 30 double-spaced pages and 7000 words. Guidelines for manuscript submission and publication can be found in the back of this issue.

Subscriptions. The Journal of Transportation Management is published twice yearly. The current annual subscription rate is $50 domestic and $65 international in U.S. currency. Payments are to be sent to Laura Plizka, Delta Nu Alpha, 1720 Manistique Avenue, South Milwaukee WI 53172.

Revised March 15, 2013

From the Editor...

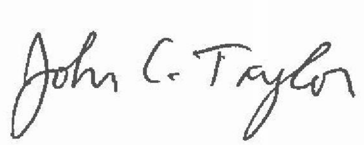
Welcome to the Winter Spring 2020 issue of the Journal of Transportation Management (JTM), being Vol. 30 No 2! Amazing the JTM has hit 30 years and is older than many other SCM journals! So Happy Birthday for JTM and is authors.

The issue starts with an article on trucking industry drug testing and the merits of hair vs. urine tests. The second article examines blockchain and RFID applications in the retail inventory supply chain. The third article is one of two on the airline industry. The third article looks at exogenous factors influencing flight delays. While the fourth article examines the role of size in airline profitability. The issue concludes with an overview of the evolution of the E-Grocery industry chanel.

Our first article explores the advantages and disadvantages of trucking industry drug testing using the current urine sample approach vs. the use of hair samples. Results of their analysis indicates hair samples would offer a lot of advantages. The second article looks at the benefits that could be derived from additional use of blockchain and RFID applications in the retail inventory management space. The third article asks whether size maters in the airline industry. The authors find that cost efficiencies come with every increase in airline size. The fourth article examines the role of various types of delay causes in the total picture of overall delays. They find that non-weather sources of delays under the control of airlines were the primary contributor to overall delays. The last article looks at the e-Grocery channel and how it has evolved. They report on the resurrection of the e-Grocery channel after several years of decline.

At the *Journal*, we are continuing to make a number of changes that will improve the visibility of JTM, and improve its position in the supply chain publishing world. These include registering and updating journal information with several publishing guides, and placing the past and current content on services that provide visibility to Google Scholar. Authors will receive summaries of downloaded articles monthly, and can examine the Digital Commons web site for data on various aspects of the publication and their articles. One year old and beyond issues will be placed into the system.

I look forward to hearing from you our readers with questions, comments and article submissions. The submission guidelines are included at the end of this issue's articles and I encourage both academics and practitioners to consider submitting an article to the Journal. Also included in this issue is a subscription form and I hope you or your library will subscribe.



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DRUG TESTING IN THE U.S. TRUCKING INDUSTRY: HAIR VS. URINE SAMPLES AND THE IMPLICATIONS FOR POLICY AND THE INDUSTRY

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ABSTRACT

Virtually everything we own was transported by truck at some point. Around 3.5 million truck drivers haul almost 71% of U.S. freight. To ensure the safety of our roadways, the U.S. government requires all drivers to pass urinalysis drug screens. However, urinalysis drug screens are easily thwarted and some trucking companies use hair drug screens, a more stringent test. This research examines trucking industry data and finds about 300,000 truck drivers would be removed from their positions if forced to pass a hair drug test. Hair testing opponents argue that the test is biased against ethnic minority groups. Comparing urine and hair pass/fail rates for various ethnic groups, our results indicate ethnic groups are significantly different irrespective of testing procedure. Factors other than testing method seem to underlie ethnic group pass/fail rate differences.

INTRODUCTION

Trucking is a critical component of the US economy (Kemp, Kopp, and Kemp, 2013). The trucking industry is composed of over 3.5 million truck drivers who move 10.5 billion tons annually, equal to almost 71% of all US freight (American Trucking Association, 2020). Many risks confront the industry and managers must manage these issues as part of their daily job functions. Among these risks, safety incidents are perhaps the most critical (Miller and Saldanha, 2016).

Safety incidents involving large trucks have a deleterious effect on health (Zaloshnja and Miler, 2006; Corsi et al., 2014), the operations of carriers, shippers, and receivers (Hendricks and Singhal, 2003), and U.S. transportation system efficiency (Cantor et al., 2006). Increasing insurance rates driven by large legal verdicts have led trucking companies to place an even greater emphasis on shoring up their safety performance (Huff, 2020). Insurance rates were responsible in part for an almost three-fold increase in trucking company bankruptcies during the first half of 2019 as compared to the same period in 2018 (Smith, 2019). Safety is a matter of life and death on the road and also impacts trucking company financial performance (Miller and Saldanha, 2016).

The Federal Motor Carrier Safety Administration uses the Compliance, Safety, and Accountability (CSA) program to measure trucking company safety performance. CSA gathers data from roadside inspections and crash reports and categorizes the data into seven Behavior Analysis and Safety Improvement Categories, which are commonly referred to as BASICs (Federal Motor Carrier Safety Administration, 2020). Kemp, Kopp, and Kemp (2013) recommend trucking companies create a culture of safety within their organization to improve safety performance. Mitra (2016) indicates a positive relationship between safety incidents and violations in the CSA controlled substances/alcohol BASIC. Maintaining a drug-free driver workforce is key to any safety culture (Knipling, 2009) and drug screens are a critical method used to help ensure driver sobriety.

However, evidence exists that the existing urine testing regimen may be less effective than we all hope. Lin et al. (2017) find that urine tests are often invalid. Girotto et al. (2014) find evidence that truck drivers may frequently abuse psychoactive substances and note that these drugs reduce driving competence while also increasing the risk of safety incidents. Mieczkowski (1992) posits that urine tests generally have a 2-3 day lookback period.

This means truck drivers could refrain from drug use for 3 days, pass a scheduled pre-employment urine test, then begin driving and using drugs again. In 1998 Oregon enforcement agencies conducted *unannounced* urine drug screens of commercial truck drivers during roadside and port of entry inspections (Couper et al. 2002). The unannounced nature of these tests negated drivers ability to prepare for the test. In total, enforcement personnel collected 822 urine specimens from commercial truck drivers and found 21% of the samples tested positive for one or more substances including stimulants, cannabinoids, and alcohol. They state (p. 562), "…in spite of comprehensive drug testing in the trucking industry, some tractor-trailer drivers are continuing to take illicit and other drugs with the potential of having a negative effect on their driving ability."

The preceding evidence highlights the possibility that current federally accepted urinalysis is insufficient to deter and catch drivers who may abuse substances that degrade their driving performance. Due to urine testing's insufficiency, and the lack of federal recognition for hair testing, many carriers including Schneider, Knight-Swift Transportation, J.B. Hunt Transport, Werner Enterprises and Maverick USA use more stringent hair drug tests to help ensure driver sobriety (Miller, 2016; Miller, 2017a; Mieczkowski, 2010). The Alliance for Driver Safety and Security (i.e. The Trucking Alliance) recently conducted a study comparing pass/fail rates for urine and hair drug screens (Gallagher, 2019). Using 151,662 paired pre-employment urine and hair drug test results from fifteen (15) different trucking companies, their results indicated that 949 (0.6%) applicants failed the urine test while 12,824 (8.5%) failed or refused the hair test ($\Delta = 7.9\%$). FMCSA classifies refusal to submit to a drug or alcohol screening as a failure (DOT Rule 49 CFR Part 40 §40.191).

The Trucking Alliance extrapolated their results over a population of 3.5 million U.S. truck drivers and claimed that, if their results were generalized across the U.S. driver population, almost 300,000 current drivers would not be on the road if forced to pass a hair test (3,500,000 x 7.9% = 276,500). However, no evidence was presented to justify whether their sample was, in fact, generalizable. Further, some have argued that hair tests are biased against certain ethnic groups based on hair composition (Miller, 2015). Several authors, however, including Mieczkowski (1992; 1993; 2000; 2002; 2010), have argued that the bias claim is spurious.

Despite the importance of drug testing to roadway safety, the supply chain literature is largely silent on the drug testing debate with the exception of Henriksson (1992). Given this gap in the literature, the Trucking Alliance asked the University of Central Arkansas to engage in two studies and independently determine 1) whether their sample is generalizable to the broader U.S. driver population, thereby supporting their claim that hair testing would exclude roughly 275,000 drivers from the workforce and 2) whether hair testing is biased against ethnic groups based on drug test pass/fail rates.

This paper begins with an overview of recent contributions to the motor carrier literature with a focus on safety followed by a history and review of drug testing laws pertaining to transport workers. Next, we describe the method used to address sample generalizability and potential ethnic differences in drug test pass/fail rates coupled with the results of each study. Conclusions are subsequently presented with a discussion highlighting the implications of our research.

LITERATURE REVIEW

Overview of Motor Carrier Research

Research into the motor carrier industry has experienced a recent resurgence. Swartz et al. (2017) surveyed the influence of carriers' safety climate on drivers' job satisfaction and turnover. They find a strong, positive relationship between safety climate and job attitudes, which negatively influences turnover. Miller et al. (2019) examine the impact of Electronic Logging Devices (ELD) on safety performance and offer nuanced results indicating that improvements in Hours of Service (HOS) compliance is dependent upon current technology investments. Mitra (2016) examines the impact of CSA BASIC scores on safety incidents per million miles and finds unsafe driving, fatigued driving, driver fitness, and controlled substances/ alcohol significantly influence crash rates. Guntuka et al. (2019) examine the frequency with which carriers exit the industry and find safety incidents are associated with exit propensity. Miller (2017b) tests the relationship between carrier size and safety performance and finds that continuous vigilance is necessary to encourage drivers to operate safely. He also finds that the relationship between size and safety is not linear: small carriers and large carriers were more likely to improve after being flagged for HOS violations. Miller and Saldanha (2018) examine the size of new entrants to the motor carrier industry as it relates to safety performance. Findings indicate that smaller new entrants are more likely to experience safety deficiencies compared to larger new entrants. Miller, Golicic, and Fugate (2018) examine the safety performance of carriers who rely more upon owner-operators compared to those relying on company drivers to a greater extent. They find that trucking companies using owner-operators exhibit worse safety performance. Tsai, Swartz, and Megahed (2018) examine the role of government in improving highway safety with particular emphasis on investment efficiencies. The government also ensures highway safety by regulating drug testing regimens to which drivers must comply as part of their duties in a safety sensitive position. Despite the increase in motor carrier research, no works of which we are aware address the issue of drug testing or the implications of carriers employing hair testing in lieu of/addition to urinalysis.

Overview of Drug Testing Rules and Research

Drug testing acts as a deterrent to the use of substances that would degrade driving performance (Henriksson, 1992). Urinalysis drug testing for safety sensitive positions came to prominence in the transportation industry following passage of the Omnibus Transportation Employee Testing Act of 1991, which was motivated by a subway train crash involving a driver with a high blood alcohol content (BAC) of 0.21 (Hall, 1995). The Act mandated drug and alcohol testing requirements for all safety sensitive employees serving in the trucking and other transportation industries. Requirements for the trucking industry include (SAMSHA.gov, 2020):

1. Employers must test employees before beginning safety sensitive duties, when reasonable suspicion of substance abuse exists, after accidents, or before allowing an employee to return to work following a violation.
2. Implementation of a random drug testing program.
3. Drug testing must be administered by a certified Department of Health and Human Services laboratory.
4. All drug testing must check for the presence of five classes of drugs: marijuana, cocaine, amphetamines, opioids, and phencyclidine (PCP).
5. All alcohol testing must comply to DOT policies and procedures. Testing must be conducted using DOT approved devices.
6. All tests must be reviewed by a medical review officer (MRO).
7. All employees must receive drug and alcohol awareness training.
8. All supervisors must receive training in substance abuse detection, documentation, and intervention with the training consisting of equal parts drug and alcohol abuse.
9. Employers must refer employees to a substance abuse professional if a substance abuse problem is uncovered.

Among the first literary mentions of the new Omnibus Transportation Employee Testing Act drug testing rules came from the *Labor Law Journal* (1989). Despite its intuitive appeal, the Omnibus Transportation Employee Testing Act was not without controversy. *The Labor Law Journal* (1989) highlights labor union opposition to the Act on the basis of possible invasion of privacy and false positives.

Over time, urine testing has become a generally accepted method to determine compliance with Federal drug/alcohol rules but some trucking companies advocate for the use of hair testing due to its increased rigor. Mieczkowski (1992) posits that urine testing is easily manipulated and generally only has a 2-3 day lookback period. Further, Mieczkowski (1993) argues that hair testing is superior to urinalysis because hair is easily handled, not as prone to degradation, and does not require special storage conditions. Despite these advantages, federal government agencies do not allow trucking companies to utilize hair testing in lieu of urine testing. This requires carriers employing hair testing to also incur urinalysis expenses.

Many of the arguments originally used against urine testing (Labor Law Journal, 1989) are put forth today against hair testing. In a 2015 letter to House leaders, labor groups and some trucking interests decried proposed hair testing regulations claiming the method is unsubstantiated, may yield false positives, and may also be racially biased (Miller, 2015). Some trucking interests agree and also oppose hair testing because they perceive it as another regulatory burden on companies and drivers (Douglas and Swartz, 2016; Williams, Thomas, and Liao-Troth, 2017). Regulatory burdens have been shown to decrease driver job satisfaction and quality of life (Johnson et al., 2010). Even managers who may be amenable to hair testing based on its scientific merit oppose its use because they fear reducing an already insufficient driver pool. Further, while hair testing is a more stringent drug test, it is also more expensive than urine testing. Managers may find it difficult to make the business case justifying the extra safety expenditures (Eroglu, Kurt, and Elwakil, 2016). Miller and Saldanha (2016) caution trucking managers against capturing short-term savings at the expense of safety benefits and posit they should instead view financial performance and safety as complementary goals.

Mieczkowski (1992; 1993; 2000; 2002; 2010) has published numerous works examining drug testing with a specific emphasis on the possibility of racial bias in hair testing. With regard to the role of ethnic differences, Mieczkowski (2000) argues that while race is sociologically and psychologically powerful, it is now commonly accepted as a weak biological differentiator. This would seem to invalidate arguments against hair testing based on biological hair type differences. To wit, Mieczkowski (2010) compares urine and hair test results for the detection of cocaine among Whites and African Americans and finds no racial bias between the tests.

Given the potential benefits of hair testing, the FAST Act legislation of 2015 authorized the Department of Transportation "to use hair testing as an acceptable alternative to urine testing in conducting preemployment testing for the use of a controlled substance; and in conducting random testing for the use of a controlled substance if the operator was subject to hair testing for pre-employment testing." Congress gave the Department of Health and Human Services (DHHS) one year to issue guidelines for hair testing and the Opioid Crisis Response Act of 2018 directed the Substance Abuse and Mental Health Services Administration (SAMHSA) to report to Congress on its progress creating and issuing hair test guidelines (Prevost, 2018). A proposed hair testing rule has now been relayed to the White House Office of Management and Budget for their consideration (Miller, 2019).

METHOD AND RESULTS

This section details the method and results for our two studies. The Trucking Alliance has long advocated for Federal recognition of hair testing. Like-minded members of the trucking industry have joined this effort in order to increase roadway safety and decrease compliance expenditures related to duplicative urinalysis and hair drug testing. University of Central Arkansas researchers were given access to data independently provided by cooperating trucking companies that employ hair testing in addition to urinalysis. Our goals were two-fold. We sought to determine whether 1) The Trucking Alliance sample is generalizable, which would support their claim that roughly 275,000 drivers would be unable to engage in safety sensitive functions if forced to pass a hair test and, 2) whether hair testing has a disparate impact on minority ethnic groups.

Study 1 – Sample Generalizability

Study 1 entailed two steps. First, we determined the sample size required to draw inferences to the U.S.

driver population. Second, we utilized correlation analysis to determine whether the Trucking Alliance sample is representative of the overall U.S. driver population. Researchers requested driver state of licensure information from the fifteen (15) participating trucking companies. Six (6) carriers provided usable data with location information for 56,491 of the 151,622 drivers (37.25%) hired across 2017 and 2018. Drivers are the unit of analysis. Sample driver location information is provided in Table 1.

Researchers then gathered 2018 state-level driver employment data from The U.S. Bureau of Labor Statistics (BLS) Occupational Employment Statistics Query System (Bureau of Labor Statistics, 2020). BLS classifies drivers into three Standard Occupational Classification (SOC) codes. These codes and their BLS descriptions are provided below:

- Light Truck or Delivery Services Drivers (SOC Code 533033): Drive a light vehicle, such as a truck or van, with a capacity of less than 26,000 pounds Gross Vehicle Weight (GVW), primarily to deliver or pick up merchandise or to deliver packages. May load and unload vehicle. Excludes "Couriers and Messengers" (43-5021) and "Driver/Sales Workers" (53-3031).

- Heavy and Tractor-Trailer Truck Drivers (SOC Code 533032): Drive a tractor-trailer combination or a truck with a capacity of at least 26,000 pounds Gross Vehicle Weight (GVW). May be required to unload truck. Requires commercial drivers' license.

- Industrial Truck and Tractor Operators (SOC Code 537051): Operate industrial trucks or tractors equipped to move materials around a warehouse, storage yard, factory, construction site, or similar location. Excludes "Logging Equipment Operators" (45-4022).

State-level BLS data for each SOC code is provided in Table 2:

Researchers utilized correlation analysis to determine whether the Trucking Alliance sample and the national driver population are geographically related. The year 2018 represented the most recent BLS data available. The analysis compares the 2018 Trucking Alliance driver sample (n = 41,922) to the 2018 national BLS data.

The Required Sample Size
A sample of n = 41,922 greatly exceeds that required to make inferences about the national truck driver population. Given a margin of error of 1% and a confidence level of 99%, the sample size required would be 16,641. The formula to obtain this result is provided below:

$n = Z^2 * p(1\text{-}p) / e^2$

where,
- p = .5 (probability of a positive or negative outcome to a hair or urine test);
- e = .01 or 1% (the margin of error or level of tolerable error; sample results should be within 1% of the true population proportion);
- Z = 2.58 (the level of confidence desired; 99% in our sample results).

If p=.5 and e=.01, Z^2 for 99% confidence = 2.58, required sample size (n) = 16,641.

To further clarify, the sample results involved two possibilities: a positive hair or urine test or a negative hair or urine test. Hence, p = the probability of the occurrence of an event in the sample (n) (i.e. a positive or negative outcome of the urine or hair test; because the value of the event is unknown (50-50) before the test is administered, a value of .5 or 50% is utilized to yield the largest possible sample required to produce a representative sample). The numbers produced by the sample size formula indicate that the size of the sample taken exceeds the size of the sample required by over 2.5 times (41,992/16,641 = 2.52). The sample size issue is satisfied by the number of sample units in this analysis.

TABLE 1
TRUCKING ALLIANCE DRIVER LOCATION INFORMATION

CDL State	TA Carriers 2017	TA Carriers 2018	TA Carriers Total
AK	0	1	1
AL	389	441	830
AR	417	655	1,072
AZ	143	1,671	1,814
CA	1,666	4,536	6,202
CO	72	514	586
CT	236	342	578
D.C.	8	10	18
DE	62	116	178
FL	305	1,343	1,648
GA	1,156	3,887	5,043
HI	0	0	0
IA	100	133	233
ID	11	381	392
IL	942	2,259	3,201
IN	347	553	900
KS	78	633	711
KY	260	291	551
LA	255	381	636
MA	108	184	292
MD	288	320	608
ME	8	10	18
MI	302	820	1,122
MN	90	687	777
MO	349	551	900

CDL State	TA Carriers 2017	TA Carriers 2018	TA Carriers Total
MS	307	1,124	1,431
MT	6	5	11
NC	756	1,308	2,064
ND	5	9	14
NE	14	17	31
NH	15	31	46
NJ	384	474	858
NM	47	138	185
NV	54	204	258
NY	307	986	1,293
OH	402	1,616	2,018
OK	232	408	640
OR	61	251	312
PA	999	1,860	2,859
RI	14	26	40
SC	288	936	1,224
SD	7	15	22
TN	322	2,538	2,860
TX	1,783	5,654	7,437
UT	54	1,377	1,431
VA	422	1,282	1,704
VT	4	15	19
WA	206	372	578
WI	203	436	639
WV	84	113	197
WY	1	8	9
TOTAL	14,569	41,922	56,491

TABLE 2
2018 STATE-LEVEL BLS DATA BY SOC CODE

State	Light Truck or Delivery Services Drivers (SOC Code 533033)	Heavy and Tractor-Trailer Truck Drivers (SOC Code 533032)	Industrial Truck and Tractor Operators (SOC Code 537051)	BLS Total
AK	1,840	2,380	450	4,670
AL	14,650	32,170	9,010	55,830
AR	7,080	34,700	7,470	49,250
AZ	15,300	25,450	10,730	51,480
CA	111,100	138,380	62,460	311,940
CO	17,610	22,880	10,400	50,890
CT	11,580	12,560	2,820	26,960
DC	1,340	530	100	1,970
DE	2,620	4,370	2,010	9,000
FL	55,230	87,960	22,640	165,830
GA	27,890	62,500	39,400	129,790
HI	4,830	3,300	830	8,960
IA	9,580	38,470	7,810	55,860
ID	4,520	11,940	2,120	18,580
IL	49,140	70,380	30,080	149,600
IN	18,820	54,560	17,620	91,000
KS	8,400	20,370	5,460	34,230
KY	15,680	24,850	14,040	54,570
LA	15,950	21,070	7,010	44,030
MA	22,800	27,650	5,530	55,980
MD	21,180	23,320	6,280	50,780
ME	4,310	8,830	3,150	16,290
MI	28,860	55,940	20,360	105,160
MN	16,070	34,860	6,450	57,380
MO	16,840	44,470	12,490	73,800
MS	7,990	22,710	8,460	39,160
MT	3,690	6,440	1,080	11,210
NC	27,370	58,110	22,800	108,280
ND	2,060	10,560	1,280	13,900
NE	4,610	26,360	3,880	34,850
NH	4,030	6,870	1,250	12,150
NJ	32,310	48,760	17,990	99,060

State	Light Truck or Delivery Services Drivers (SOC Code 533033)	Heavy and Tractor-Trailer Truck Drivers (SOC Code 533032)	Industrial Truck and Tractor Operators (SOC Code 537051)	BLS Total
NM	4,660	10,970	1,090	16,720
NV	6,680	11,760	3,110	21,550
NY	46,030	62,360	16,010	124,400
OH	39,310	74,090	30,850	144,250
OK	8,730	25,750	7,070	41,550
OR	10,940	23,300	9,120	43,360
PA	37,140	82,330	31,070	150,540
RI	4,080	3,200	760	8,040
SC	13,570	29,620	7,670	50,860
SD	3,130	7,880	1,500	12,510
TN	18,250	63,030	16,720	98,000
TX	65,960	191,490	68,370	325,820
UT	8,190	24,760	4,380	37,330
VA	21,470	42,820	13,550	77,840
VT	2,190	3,440	780	6,410
WA	17,740	31,610	11,260	60,610
WI	15,360	49,760	13,800	78,920
WV	5,130	12,110	2,460	19,700
WY	1,480	6,340	1,070	8,890
Total	915,320	1,800,320	604,100	3,319,740

The Correlation Between Trucking Alliance Drivers and the National Driver Population

Discussion then turns to whether sufficient evidence exists that the distribution by state of Trucking Alliance drivers is representative of the distribution by state of drivers in the national population. SOC Code 533032 (Heavy and Tractor-Trailer Truck Drivers) is the only SOC Code whose members must possess a Commercial Driver's License (CDL) and is the most analogous to drivers in The Trucking Alliance sample. However, all three SOC codes were included in our analysis as well as a summated measure across all three SOC codes (BLS Total).

Results are presented below in Table 3:

Results indicate a significant .880 correlation between the distribution by state of Trucking Alliance drivers and that of drivers in the national population (SOC 533032, $p<0.01$; BLS Total, $p<0.01$). Data visualization graphs are provided below and illustrate these relationships. Regression lines, which minimize the squared distance between the regression line and each data point, are plotted through the data.

These findings indicate a very strong and positive relationship between the BLS data and Trucking Alliance sample.

Conclusions for Study 1

Results indicate significant correlations between The Trucking Alliance sample and BLS data across all three SOC codes individually and the combination of all three SOC codes. Each correlation coefficient was significant at $p<0.01$.

With an $R^2 = 0.786$, Figure 1 indicates that almost 79% of the variation in the number of drivers by state across all three SOC codes can be explained

TABLE 3
CORRELATION ANALYSIS

		Light Truck or Delivery Services Drivers (SOC 533033)	Heavy and Tractor-Trailer Truck Drivers (SOC 533032)	Industrial Truck and Tractor Operators (SOC 537051)	BLS Total
TA Carriers 2018	R	.784*	.880*	.923*	.886*
	p-value	.000	.000	.000	.000
	N	51	51	51	51

*Correlation is significant at the 0.01 level (2-tailed)

by the variation in the number of drivers by state in The Trucking Alliance sample. Figure 2 focuses on SOC Code 533032, the only SOC code requiring a CDL, which is most analogous to drivers in The Trucking Alliance sample. Figure 2 indicates an $R^2 = 0.775$, meaning almost 78% of the variation in the total number of drivers by state for SOC code 533032 can be explained by the variation in the number of drivers by state in the Trucking Alliance sample.

Based on this information, we conclude that 1) The Trucking Alliance sample is large enough to generalize across the national driver population, 2) The Trucking Alliance sample is representative of the national driver population, and 3) The Trucking Alliance urinalysis v. hair test results can be generalized across the national driver population. This supports the notion that roughly 275,000 current drivers would be unable to perform safety sensitive functions if forced to undergo hair testing.

Study 2 – Assessing Hair Testing Ethnic Minority Disparate Impact

Researchers utilized two methods to assess possible disparate impact on minority ethnic groups resulting from the use of hair testing. First, the "Four-Fifths Rule" is defined in the Code of Federal Regulations, Title 29, §1607.4 - Uniform Guidelines on Employee Selection Procedures, Information on Impact as "a selection rate for any race, sex or ethnic group which is less than four-fifths (4/5) (or eighty percent) of the rate for the group with the highest rate will generally be regarded by the Federal enforcement agencies as evidence of adverse impact, while a greater than four-fifths rate will generally not be regarded by Federal enforcement agencies as evidence of adverse impact" (Code of Federal Regulations, 2020). In other words, disparate impact is assumed if any ethnic group does not pass at a rate of at least 80% of the rate of the ethnic group with the highest passing rate.

Second, researchers utilized chi-square (χ^2) difference tests to assess whether significant differences exist between ethnic groups within each test (e.g. whether a significant difference exists between ethnic groups for urine tests and, separately, whether a significant difference exists between ethnic groups for hair tests). Chi-square results would indicate disparate impact if no significant between-group differences exist for urine testing but do exist for hair testing. This would imply that the groups' urine test pass/fail rate is statistically equivalent, but the groups' hair test pass/fail rate is significantly different. Alternatively, chi-square results would indicate equal treatment if significant between-group differences exist for both/neither urine and hair testing. This would imply that the groups pass/fail rates are statistically equivalent/different irrespective of testing procedure.

Researchers were independently provided with paired urine and hair pre-employment drug screen results from three (3) commercial trucking companies for the years 2017-2019. These companies provide a representative sample of drivers, the unit of analysis. Two (2) companies provided results from 2017, three (3) provided

FIGURE 1
SCATTER PLOT: TA CARRIERS 2018 AND BLS TOTAL

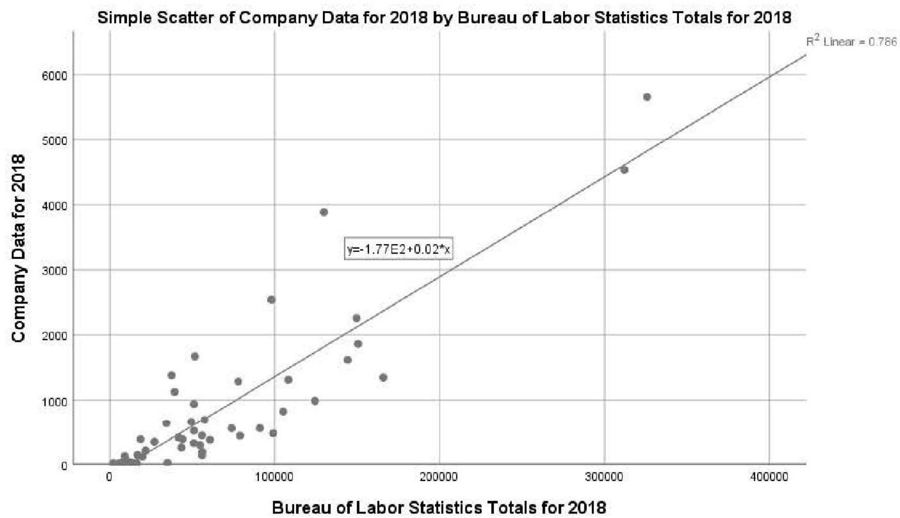
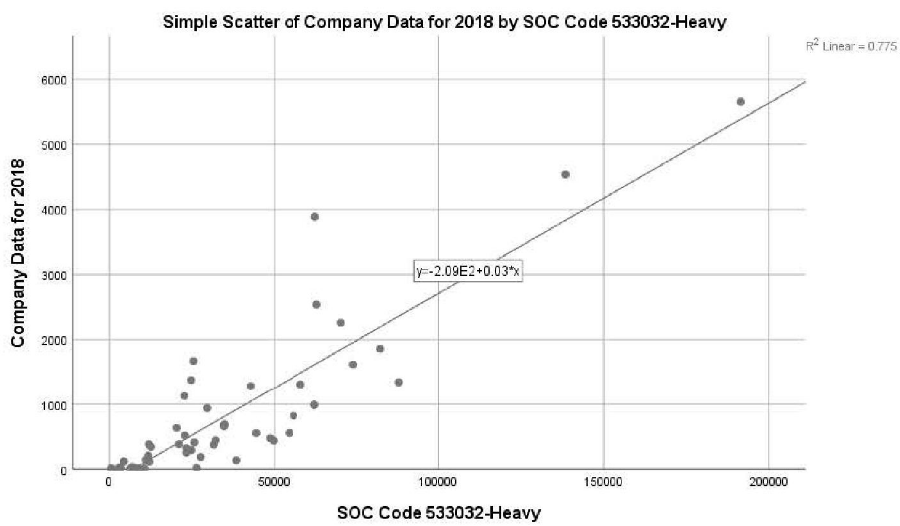


FIGURE 2
SCATTER PLOT: TA CARRIERS 2018 AND SOC CODE 533032



results from 2018, and one (1) provided results from 2019. Aggregated data from 2017-2019 were examined. Sample sizes for each test are as follows:

- 2017-2019 urine test: n = 73,176
- 2017-2019 hair test: n = 72,023

As demonstrated in *study 1*, given a margin of error = 1%, and a confidence level = 99%, a sample size of 16,641 is required to generalize results across the broader U.S. truck driver population. Study 2 sample sizes exceed this threshold and results can be generalized nationally. Results are subsequently presented.

Results: Four-Fifths Rule

Table 4 details 2017-2019 urine test results. Ninety nine percent (99%) of drivers in the Asian ethnic group passed their pre-employment drug screens. To comply with the Four-Fifths Rule, every other ethnic group must pass at a rate equal to 80% of this figure (99% x 80% = 79%). Drivers who chose not to report their ethnic group ("not specified") passed at the lowest rate, which was 98.7% of the ethnic group with the highest passing rate. This exceeds the required Four-Fifths Rule 79% threshold.

Table 5 details 2017-2019 hair test results. Ninety six percent (96%) of drivers in the Asian ethnic group passed their pre-employment drug screens. To comply with the Four-Fifths Rule, every other ethnic group must pass at a rate equal to 80% of this figure (96% x 80% = 77%). Drivers who chose not to report their ethic group ("not specified") passed at the lowest rate, which was 91.7% of the ethnic group with the highest passing rate. This exceeds the required 77% Four-Fifths Rule threshold.

Results: χ^2 Difference Tests: Chi-square results are presented as footnotes below tables 4 and 5. Significant differences across ethnic groups' pass/fail rates were found for urine tests. Significant differences across ethnic groups' pass/fail rates were found for hair tests.

Chi-square results indicate equal treatment if significant between-group differences exist for both urine and hair testing. This indicates the groups pass/fail rates are statistically different for urine

TABLE 4
2017-2019 URINE TEST RESULTS

ETHNIC GROUP	PASSED	FAILED	TOTAL	PERCENT PASSED	PERCENT OF HIGHEST PASSING RATE (ASIAN)
AM. INDIAN	753	6	759	99.2%	99.6%
ASIAN	1802	7	1809	**99.6%**	**100.0%**
BLACK	28632	294	28926	99.0%	99.4%
HAWAII/PACIFIC ISLANDER	276	2	278	99.3%	99.7%
HISPANIC	8191	44	8235	99.5%	99.9%
MULTIPLE	1777	25	1802	98.6%	99.0%
NOT SPECIFIED	8327	144	8471	**98.3%**	**98.7%**
WHITE	22664	232	22896	99.0%	99.4%
TOTAL	72422	754	73176	99.0%	99.4%

*Pearson chi-square = 67.52; p = 0.00; n = 73,176

TABLE 5
2017-2019 HAIR TEST RESULTS

ETHNIC GROUP	PASSED	FAILED	TOTAL	PERCENT PASSED	PERCENT OF HIGHEST PASSING RATE (ASIAN)
AM. INDIAN	709	48	757	93.7%	97.0%
ASIAN	1739	61	1800	**96.6%**	**100.0%**
BLACK	26329	2215	28544	92.2%	95.5%
HAWAII/PACIFIC ISLANDER	258	17	275	93.8%	97.1%
HISPANIC	7699	452	8151	94.5%	97.8%
MULTIPLE	1655	139	1794	92.3%	95.5%
NOT SPECIFIED	7149	925	8074	**88.5%**	**91.7%**
WHITE	21678	950	22628	95.8%	99.2%
TOTAL	67216	4807	72023	93.3%	96.6%

*Pearson chi-square = 624.6; p = 0.000; n = 72,023 testing and are also statistically different for hair testing. Irrespective of testing procedure, ethnic groups' drug test results are significantly different.

Conclusions for Study 2

Utilizing independently provided urine and hair pre-employment drug screen data, University of Central Arkansas researchers were unable to find disparate impacts of hair testing among the ethnic groups. Results for each test in each sample met the required Four-Fifths Rule threshold. Chi-square tests independently examine urine and hair tests. Chi-square results indicate that pass/fail rates are significantly different irrespective of testing method. Given these findings, we find no disparate impact among ethnic groups by testing method.

DISCUSSION AND CONCLUSIONS

Most of us share the road with motor carriers on a daily basis. We all hope that commercial truck drivers are well-trained, well-rested, and drug and alcohol free as they pilot 80,000 pound vehicles traveling within a few feet of our vehicle. To help ensure commercial motor vehicle driver sobriety, the federal government has long maintained strict urinalysis drug testing requirements. Previous research indicates urinalysis may be an insufficient method of ensuring commercial driver sobriety (Couper et al., 2002; Girotto et al., 2014; Lin et al., 2017). Evidence presented by The Trucking Alliance, and verified in this research, supports these findings and urinalysis' insufficiency.

This research was composed of two (2) distinct studies. The first assessed whether the Trucking Alliance was justified in generalizing its sample results over the U.S. driver population. By comparing differences in driver state of licensure information, we demonstrate a high degree of similarity between The Trucking Alliance sample and the national driver pool. This supports the notion that around 275,000 drivers would not be able to hold a safety sensitive occupation if they were forced to pass a hair drug test. The second study addressed concerns over potential disparate impacts posed by the use of hair drug testing. Consistent with the arguments of Mieczkowski (2010), we were unable to find racially disparate impacts. Factors other than testing method seem to underly ethnic groups' pass/fail rate differences.

This work lends itself to several theoretical and managerial implications. First, our work sheds light on the importance of drug testing as an important area of supply chain inquiry. The supply chain literature is largely silent on the drug testing debate with the exception of Henriksson (1992). Future investigations may wish to examine trucking company drug testing best practices, such as when drivers are most likely to test positive or the relationship between the number of positive random drug screens and safety performance. Such research would be quite interesting. On one hand, higher random drug screen failure rates may indicate a more effective drug testing program and, therefore, fewer safety incidents. However, if random failure rates increase, driver recruitment and selection problems clearly exist. Second, managers should consider employing hair testing in addition to urinalysis. While this would increase the cost of doing business, any added cost would be more than offset if several safety incidents (and their associated liability) were prevented.

No trucking industry safety manager wants to get the call that their driver has been involved in a reportable safety event. Hair testing is a powerful tool that can help prevent safety incidents or lessen potential liability when they occur. Managers should ask themselves, "How many of our drivers could be included in the 275,000 who would be unable to drive if forced to pass a more stringent drug test?" While this question presupposes that these 275,000, left on the road, would lead to a number of additional deaths, this is a first order impact that, while accurate, may not tell the whole story. There is also a 2nd order impact. The trucking industry has to replace these 275,000 drivers with more qualified, sober employees if it wishes to improve roadway safety. Additional research is needed to better understand the impact of taking these 275,000 drivers off the road and how the trucking industry can improve driver recruitment and retention.

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