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RESEARCH ARTICLE

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Fatal injuries associated with rear step riding among municipal solid waste collection workers (United States, 1984–2020)

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Abstract

Background: United States solid waste workers suffer a high fatal injury rate due to their frequent exposures to refuse-vehicle-related hazards. The Occupational Safety and Health Administration (OSHA) allows workers to ride on the rear steps of a garbage truck (exterior riding) if employers abide by American National Standard Z245.1 (ANSI Z245.1). The State of California (CA) has banned exterior riding since 1984, and the City of New York (NYC) has implemented its own initiatives to prevent exterior riding deaths.

Methods: Fatal exterior riding incidents were identified from two online databases. Variables relating to deceased workers, employers, and injury circumstances were analyzed.

Results: The study identified 181 exterior riding deaths from 604 refuse-vehicle-related fatal incidents (deaths either directly caused by a refuse vehicle or one in which the victim was performing a refuse-vehicle-related task) in the United States (1984–2020). A total of 50 (27.6%) of the exterior riding deaths had no ANSI Z245.1 violations. Risk factors other than those addressed by ANSI Z245.1 contributed to these worker deaths.

Conclusions: Exterior riding deaths identified by this study were all preventable. Temporary workers and workers in the public sector may be at higher risk for exterior riding deaths. Both CA and NYC had taken measures to prohibit the practice of exterior riding, and both had lower numbers of exterior riding deaths. ANSI Z245.1 and current OSHA enforcement policy do not address the inherent dangers of falling off a moving heavy vehicle while standing on a small and elevated platform, and are not effective in preventing fatal exterior riding incidents.

KEYWORDS

ANSI Z245.1, exterior riding, fatal injuries, garbage truck, rear step riding, refuse vehicle collection

Institution at which the work was performed: Bureau of Occupational Health and Injury Prevention, New York State Department of Health.

Disclaimer: The contents of the article are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention, or the Department of Health and Human Services.

1 | INTRODUCTION

Refuse collection remains one of the most dangerous occupations in the United States (U.S.) with a fatal injury rate of 27.9 per 100,000 full time equivalent employees.[1] Based on this rate, refuse collectors are 7.8 times more likely to be killed in work-related incidents than an average U.S. worker. The most significant hazards to which refuse collectors are exposed are vehicle related. Not only can vehicular traffic on public roadways endanger the safety of these workers, but the refuse vehicles (aka garbage trucks) they drive, ride, and operate can put them in harm's way.

A common practice among collection workers is rear step riding (aka exterior riding or riding outside the cab). Refuse collectors can often be seen perched on the rear steps as their garbage trucks travel at varying speeds through bustling metropolitan city streets, quiet suburban neighborhoods, and hilly and winding rural country roads in all seasons and weather conditions. Currently, the Occupational Safety and Health Administration (OSHA) does not have a specific standard addressing the hazards associated with refuse collection vehicles. OSHA allows rear step riding if companies abide by American National Standard Z245.1 "Mobile Wastes and Recyclable Materials Collection, Transportation, and Compaction Equipment" (ANSI Z245.1).[2] ANSI Z245.1 specifies that workers can only ride on the rear steps when the vehicle is moving forward and traveling at or under 10 miles per hour and no further than 0.2 miles in distance. The standard requires that workers ride only on steps specifically designated for riding, mount or dismount only when vehicles are completely stopped, and ride facing the side of the vehicle with both hands on the handhold. OSHA uses its General Duty Clause to cite employers for failing to follow ANSI Z245.1.[3] At the state level, California (CA) is the only state that has regulation prohibiting rear step riding.[4] New York City (NYC) has taken initiatives to prevent rear step riding among both private and public waste collection workers.[5]

The National Institute for Occupational Safety and Health (NIOSH) issued its first warning against the danger of rear step riding in 1997.[6] Since then, U.S. waste collectors have continued the practice and have suffered deadly consequences.[7–9] To the authors' knowledge, there have been neither readily available data, nor published studies that answer questions like these: (1) How many U.S. solid waste workers are killed in exterior riding incidents every year? (2) What are the direct causes and contributing factors, and who is at higher risk? (3) Are ANSI Z245.1 and OSHA enforcement policies effective in preventing exterior riding deaths?

This study intended to seek answers to the above questions as the first step towards understanding the causes and prevention measures of these types of fatal injuries. The researchers of this study hope that the findings can be utilized by the solid waste industry to develop best practices, by employers to implement proactive prevention measures, by researchers to conduct more in-depth studies, and by policy makers to assess and evaluate the effectiveness of the current safety regulations on the practice of rear step riding.

2 | METHODS

This study focused on fatal incidents that occurred during local collection and transportation of municipal solid waste (MSW) since exterior riding-related deaths are most likely to occur during these operations. MSW consists of everyday items or materials that are disposed of by homes and businesses.[10] For a case to be included in the study, it had to meet one of two criteria: (1) The death had to be directly caused by a "refuse vehicle" regardless of the victim's task at the time of the fatal incident; or (2) The victim had to be performing a "refuse vehicle-related task" at the time of his or her death regardless of whether the fatal injury was caused by a refuse vehicle. A "refuse vehicle" was defined as a vehicle that was used for performing "refuse vehicle-related tasks." A "refuse vehicle-related task" was a task that was associated with loading, unloading, operating, driving, troubleshooting, maintaining, or repairing a refuse vehicle. Fatal incidents that occurred at or en route to company depots (company home sites), collection sites, transfer stations, and landfills were within the scope of the study.[1]

The OSHA Fatality and Catastrophe Investigation Summaries (FCIS) was used as the primary data source, and the NIOSH and State Fatality Assessment and Control Evaluation (FACE) Investigation Reports database and the internet were used as supplementary data sources.[11,12] OSHA investigates all work-related fatalities that occur in the United States except for the ones involving nonemployees or public sector workers (unless the public sector is covered by an OSHA-approved State Plan).[13] The FCIS database, which is searchable by pre-set keywords, contains OSHA inspection records dating back to 1984. Each fatality summary provides a brief incident narrative along with basic information about the employer, and the deceased worker. The keyword "garbage truck" was used for initial case identification.

NIOSH and collaborating states investigate select occupational fatalities through the FACE program by collecting case information, identifying root causes and contributing factors, and proposing prevention measures. The FACE database currently contains over 2800 fatality investigation reports with the earliest investigation conducted in 1982. The FACE database was searched by the industry "Waste Management & Remediation Services" to identify pertinent cases. Internet searches via Google Search using phrases such as "garbage truck worker killed" or "waste collector killed" yielded additional cases and case information. Images of Google Earth were utilized to determine the types of incident locations.[14] The Civil Service Employees Association (CSEA) provided information on fatalities involving CSEA members who were employed by municipal sanitation departments in NY.[2]

The research team read through each source file to extract data and eliminate duplicate cases. The fatal injury incident types were categorized by following the Census for Fatal Occupational Injury (CFOI)'s coding guidelines.[15] The fatal transportation incidents were further divided into two categories: exterior riding and nonriding. For a case to be classified as an exterior riding death, its source documents must have clear indication that the decedent was riding outside the cab on a moving refuse vehicle. The nonriding category included the remaining fatal incidents in which the victims did not

ride outside the cab. Variables associated with decedents, employers, and incident circumstances were identified, categorized, and standardized. Statistical tests, using Chi-square (11 variables) or Fisher's Exact test (4 variables) were performed. Any variables with more than 20% missing variables were excluded from tests of significance. Geospatial analyses were performed using ArcMap Version 10.8.1.

3 | RESULTS

The study identified a total of 604 refuse vehicle related worker deaths in the United States between 1984 and 2020.[3,4,5] Of these deceased workers, 398 (68.9%) were killed in transportation incidents including 181 who were killed in exterior riding incidents (Figure 1). Contact injuries resulted in 170 (28.1%) worker deaths. Workers were also killed by heat exhaustion (13, 2.2%), falls (7, 1.2%), electrocution (5, 0.8%), fire and explosion (6, 1.0%), inhalation of toxic chemicals (3, 0.5%), and miscellaneous injuries (2, 0.3%).

3.1 | Victim demographic and occupational information

The demographic and occupational information of all 604 victims is summarized in Table 1 by major fatal injury incident types: transportation incidents which include exterior riding and nonriding categories, contact injuries, and other injuries. Race, age, and length of employment are not included in the table: These variables are excluded from statistical analysis due to high missing values (>85%).

Victims were predominantly male and full-time employed workers. Temporary workers made up approximately 4.0% of the total victim population. Most workers were employed in waste collection (391, 64.7%) and waste treatment and disposal (165, 27.3%) businesses.[6] The rest were employed in material recycling, recyclable material wholesale, equipment repair, temporary staffing, composting, and freight trucking businesses.[7] Refuse collectors made up the biggest occupational group followed by refuse vehicle drivers. Victims also worked as mechanics, maintenance technicians and laborers. The majority of the companies were privately-owned and nonunion, and company employment ranged from below 10 employees to greater than 1000.[8]

When comparing the characteristics of victims in the exterior riding group with the nonriding group, the following are observed:

(1) Almost all the victims in the exterior riding group were refuse collectors, while the nonriding group also had drivers and laborers in addition to refuse collectors.
(2) The exterior riding group had a higher percentage of temporary workers (6.1%) than the nonriding group (3.1%). The study found that of the 12 workers who were killed in the first week of their employment, six (50%) were temporary workers, and three of the six were killed in exterior riding incidents in the first 2 days on the job.
(3) The exterior riding group had a higher percentage of workers who were employed in the public sector, and the nonriding group had a higher percentage of private sector workers (although neither of the percentage differences was statistically significant).
(4) Workers with or without union representation in the exterior riding and nonriding groups experienced essentially the same percentages of deaths.

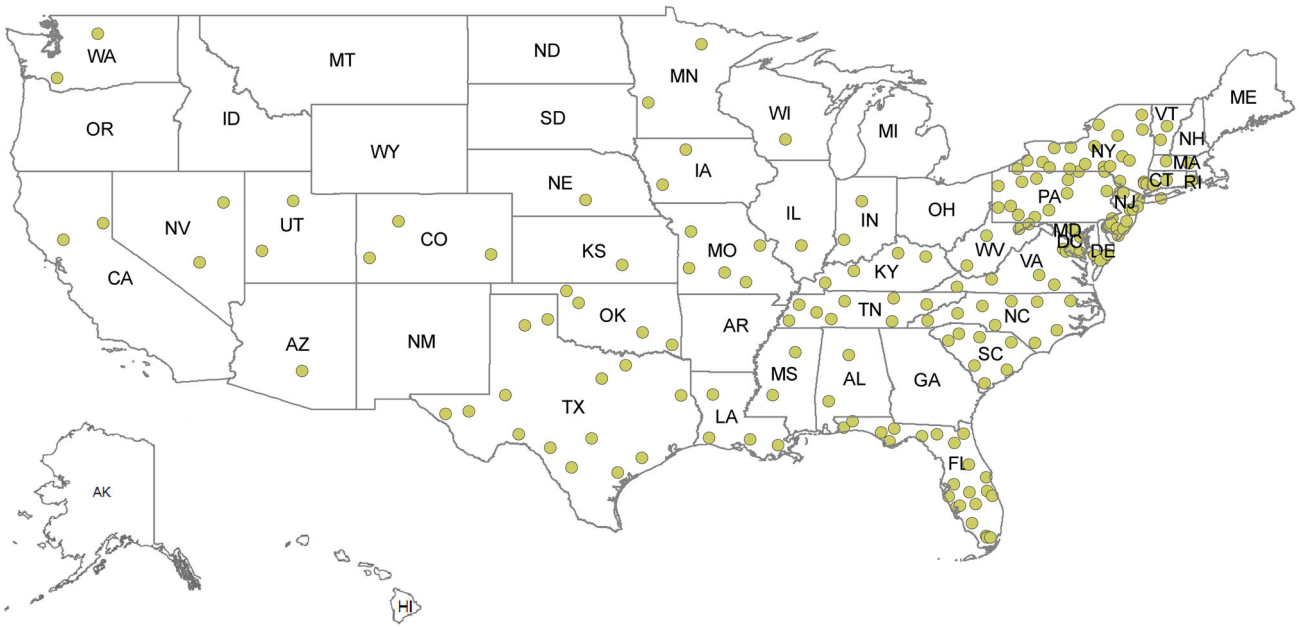

FIGURE 1 Location of worker deaths associated with exterior riding, United States, 1984–2020 (*N* = 181). **1 dot = 1 death. **Three exterior riding deaths occurred in Puerto Rico are not represented on this map.*

TABLE 1 Victim demographic and occupational characteristics, U.S., 1984–2020 (*N* = 604).

Demographic and occupational characteristics	Transportation incident deaths				Contact injury deaths	%	Other injury deaths[d]	%	Total deaths	%
	Exterior riding	%[a]	Nonriding	%[b]						
Sex										
Male	180	99.4	215	99.1	167	98.2	36	100.0	598	99.0
Female	1	0.6	2	0.9	3	1.8	0	0.0	6	1.0
Employment status										
Full time regular employees	167	92.3	210	96.8	166	97.6	32	88.9	575	95.2
Temporary workers	11	6.1	7	3.2	2	1.2	4	11.1	24	4.0
Other[g]	3	1.7	0	0.0	2	1.2	0	0.0	5	0.8
Job title										
Refuse collector	178	98.3	158	72.8	85	50.0	23	63.9	444	73.5
Refuse vehicle driver	1	0.6	40	18.4	54	31.8	8	22.2	103	17.1
Laborer	0	0.0	14	6.5	2	1.2	0	0.0	16	2.6
Mechanics	0	0.0	3	1.4	29	17.1	5	13.9	37	6.1
Misc.	2	1.1	2	0.9	0	0.0	0	0.0	4	0.7
Business ownership										
Private	133	73.5	170	78.3	153	90.0	34	94.4	490	81.1
Public	48	26.5	47	21.7	17	10.0	2	5.6	114	18.9
Business union status										
Union	36	19.9	40	18.4	33	19.4	8	22.2	117	19.4
Nonunion	143	79.0	170	78.3	134	78.8	28	77.8	475	78.6
Unknown	2	1.1	7	3.2	3	1.8	0	0.0	12	2.0
Total	181	100.0	217	100.0	170	100.0	36	100.0	604	100.0

[a]Percentage of total exterior riding deaths (*N* = 181).
[b]Percentage of total nonriding deaths (*N* = 217).
[c]Percentage of total contact injury deaths (*N* = 170).
[d]This category includes deaths due to heat exhaustion, fall, electrocution, fire and explosion, and toxic chemical exposure.
[e]Percentage of total other injury deaths (*N* = 36).
[f]Percentage of total worker deaths (*N* = 604).
[g]This category includes self-employed, part-time, or nonemployees.

3.2 | Fatal transportation incidents and characteristics of exterior riding deaths

On average, approximately 11 workers died from transportation incidents every year, and five of them were killed while riding outside the cab (U.S., 1984–2020).[9] Exterior riding incidents were the leading cause of death for 12 of the 37 years covered by the study.[9] Seven states (NY, FL, CA, PA, TX, NJ, and MD) accounted for approximately half of the total worker deaths and 54.7% of the total exterior riding deaths in the country (Table 4).

Over 80% of the exterior riding victims (149) died in noncollision incidents (Table 2). They were either killed by the fall or being struck or run over. Most victims fell or jumped from the vehicles they were riding by their vehicles following the fall. Collision incidents killed the remaining 32 victims. These workers were killed when the vehicles they were riding collided with other moving vehicles or stationary objects such as buildings, trees, utility poles, lamp posts, or parked vehicles.

Victims' own refuse vehicles (vehicles driven by victims' own crew) were involved in 171 or 94.5% of the exterior riding incidents, while 85 or 47% of the exterior riders were killed by backing refuse vehicles. These vehicles either ran over the victims after they fell off the garbage trucks or crushed the workers who were on the riding steps against stationary objects. Compared to the exterior riding group, 69 or 31.8% of the worker deaths in the nonriding group were caused by back-over incidents. Vehicles backing up posed a statistically significant higher fatal injury risk for the workers in the exterior riding group ($p < 0.0001$).

TABLE 2 Transportation incidents ($N = 398$) including exterior riding deaths ($N = 181$) and nonriding deaths ($N = 217$), U.S., 1984–2020.

Injury characteristics	Total exterior riding deaths (%)[a]	Exterior riding deaths—vehicle backing up only (%)[b]	Total nonriding deaths (%)[c]	Nonriding deaths—vehicle backing up only (%)[d]	Total transportation deaths
Incident type					
Collision (with)					
Stationary object	23 (12.7)	14 (16.5)	9 (4.1)	1 (1.4)	32
Moving vehicles	9 (5.0)	0 (0.0)	7 (3.2)	0 (0.0)	16
Other	0 (0.0)	0 (0.0)	1 (0.5)	1 (100.0)	1
Noncollision					
Fall or jump then struck by	94 (51.9)	69 (81.2)	8 (3.7)	0 (0.0)	102
Fall or jump	53 (29.3)	2 (2.4)	1 (0.5)	0 (0.0)	54
Single vehicle incident[e]	1 (0.6)	0 (0.0)	16 (7.4)	1 (1.4)	17
Unspecified	1 (0.6)	0 (0.0)	2 (0.9)	0 (0.0)	3
Pedestrian incident	0 (0.0)	0 (0.0)	173 (79.7)	66 (95.7)	173
Primary injury causing agent					
"Own" refuse vehicle[f]	171 (94.5)	85 (100.0)	93 (42.9)	42 (60.9)	264
"Other" refuse vehicle	1 (0.6)	0 (0.0)	37 (17.1)	20 (29.0)	38
Motor vehicle driven by public	8 (4.4)	0 (0.0)	76 (35.0)	0 (0.0)	84
Mobile equipment	0 (0.0)	0 (0.0)	11 (5.1)	7 (10.1)	11
Unknown	1 (0.6)	0 (0.0)	0 (0.0)	0 (0.0)	1
Incident location					
Collection route	179 (98.9)	83 (97.7)	143 (65.9)	37 (53.6)	322
Landfill	1 (0.6)	1 (1.2)	27 (12.4)	17 (24.6)	28
Company depots	1 (0.6)	1 (1.2)	23 (10.6)	10 (14.5)	24
En route to destination	0 (0.0)	0 (0.0)	16 (7.4)	0 (0.0)	16
Transfer station	0 (0.0)	0 (0.0)	7 (3.2)	5 (7.2)	7
Unknown	0 (0.0)	0 (0.0)	1 (0.5)	0 (0.0)	1
Total	181 (100)	(85)	217 (100)	(69)	398

[a]Percentage of total exterior riding deaths ($N = 181$).
[b]Percentage of exterior riding deaths caused by a backing vehicle ($N = 85$).
[c]Percentage of total nonriding deaths ($N = 217$).
[d]Percentage of nonriding deaths caused by a backing vehicle ($N = 69$).
[e]Vehicle overturn or run-off-road were included in this category.
[f]Refuse vehicle operated by the victim's crew.

Pedestrian incidents (173, 79.7%) were the leading cause of death among nonriding victims: In these incidents, workers-on-foot were struck and killed by moving vehicles. The nonriding deaths were caused by victims' own refuse vehicles (93), vehicles driven by other workers (37), motor vehicles driven by the public (76), and mobile equipment such as bulldozers, landfill compactors, and frontend loaders (11). While the exterior riding deaths primarily occurred on collection routes, nonriding deaths also occurred at landfills, transfer stations, and company depots, and enroute to these destinations.

3.2.1 | Fatal exterior riding deaths: ANSI Z245.1 violations and OSHA citations

Of the 181 fatal exterior riding incidents, 130 (71.8%) had one or more ANSI Z245.1 violations and 50 (27.6%) had no ANSI violations (Table 3). OSHA issued citations in 122 or 67.4% of the exterior riding fatalities, while 53 (29.3%) worker deaths resulted in no OSHA citations. More than half (29, 54.7%) of the incidents that received no OSHA citations had one or more ANSI violations including vehicle backing up.[10] Seven types of ANSI violations were identified among

TABLE 3 ANSI Z245.1 violations and OSHA citations counts for fatal exterior riding incidents, U.S., 1984–2020.

ANSI Z245.1 violations	No OSHA citations	%[a]	With OSHA citations	%[b]	OSHA citation unknown	%[c]	Total exterior riding deaths	%[d]
Yes[e]	29	54.7	97	79.5	4	66.7	130	71.8
No[f]	24	45.3	24	19.7	2	33.3	50	27.6
Unknown	0	0.0	1	0.8	0	0.0	1	0.6
Total	53	100.0	122	100	6	100	181	100

Abbreviation: OSHA, Occupational Safety and Health Administration.

[a]Percentage of cases without OSHA citations ($N = 53$).

[b]Percentage of cases with OSHA citations ($N = 122$).

[c]Percentage of cases with unknown OSHA citations ($N = 6$).

[d]Percentage of total exterior riding deaths ($N = 181$).

[e]These fatal incidents had one to three ANSI violations.

[f]These fatal incidents received citations such as missing records.

TABLE 4 Exterior riding and nonriding deaths among seven states with the highest total worker deaths, U.S., 1984–2020.

			Transportation incident deaths			
State	Total deaths	%[a]	Exterior riding	%[b]	Nonriding	%[c]
NY[d]	75	12.4	24	13.3	21	9.7
FL	56	9.3	23	12.7	16	7.4
CA[e]	38	6.3	2	1.1	13	6.0
PA	38	6.3	15	8.3	13	6.0
TX	35	5.8	14	7.7	7	3.2
NJ	31	5.1	11	6.1	14	6.5
MD	28	4.6	10	5.5	13	6.0

[a]Percentage of total deaths (604).

[b]Percentage of total exterior riding deaths (181).

[c]Percentage of total nonriding deaths (217).

[d]Seventeen of the 75 worker deaths in NY including two exterior riding deaths occurred in NYC.

[e]With two deaths, CA is ranked 18th in total exterior riding deaths and had fewer cases than KY, OK, LA, or CO.

the 130 exterior riding deaths.[11] The most frequently occurring violation was garbage truck backing up while riding, followed by not riding on designated riding steps. The workers were riding on the hopper sill, jump seat, loading step, rear bumper, running board, or trash container attached to a front-loading truck. The third most frequently occurring violation was getting on or off the trucks while the trucks were in motion. "Improper riding positions" was the fourth most frequently occurring violation. ANSI Z245.1 requires that workers ride facing the side of the vehicle with both hands on the handhold. OSHA documented that workers lost their balance and fell off their trucks while they were eating, drinking, urinating, reaching to grab recyclables in the hopper, walking on hopper rim, or moving across the back of the truck. Other ANSI violations included speeding, damaged or modified riding steps, and traveling more than 0.2 miles with riders on steps.

3.2.2 | Exterior riding deaths without ANSI Z245.1 violations

OSHA incident narratives did not document any type of ANSI Z245.1 violation for 50 or 27.6% of the 181 fatal exterior riding incidents Table 3. However, the OSHA compliance officers (CO) who investigated these cases indicated the following risk factors (other than the ones addressed by ANSI Z245.1) had contributed to some of these worker deaths:

(1) Proximity to stationary objects: The riders were crushed between their garbage trucks and stationary objects. In one case, the driver "steered left to clear a telephone pole and then steered right to line up for the next pick up, the rear of the truck contacted the telephone pole and crushed the rider."
(2) Garbage trucks driving on wet, slippery, or rough roads caused riders to fall. One CO documented that "the garbage truck went over two consecutive dips in the road at an intersection and the employee fell off the truck and hit his head on the concrete road surface. The employee was hospitalized with a head injury and died later."
(3) Sudden movement of the garbage trucks due to driver maneuvering: Riders fell off the steps when their trucks "made a sharp turn" or stopped abruptly.
(4) Collision with other vehicles and slippery truck surfaces also contributed to some of these fatal incidents.

It should be noted that of the 50 cases without ANSI violations, 24 (48%) had no clearly identifiable risk factors. Typical narratives describing these incidents included: Riders "fell from the garbage truck while the truck was headed to the next pick-up," employee "lost his grip and fell to the pavement," or worker "fell backward off the riding step of the truck, struck his head on the pavement." These cases indicate the inherent risk of falling off a moving heavy vehicle while standing on a small, elevated platform and hanging onto the handhold.

3.3 | Other significant findings

3.3.1 | Fatal pedestrian incidents

Pedestrian incidents ($N = 173$) were the leading cause of deaths among nonriding victims and accounted for 43.5% of transportation related deaths and 28.6% of the total worker deaths. The following characteristics were noted by the study:

(1) Of the 173 pedestrian incident victims, 67 (38.7%) were struck by refuse vehicles and mobile equipment that was backing up in both roadway and nonroadway events.
(2) Twenty pedestrian incidents (11.6%) occurred at company depots. The victims were struck while they were walking through company yards, and 9 or 45% of the refuse vehicles or mobile equipment involved were backing up.
(3) Vehicles driven by the public were responsible for 70 or 40.5% of fatal pedestrian incidents. Among these incidents, 31 victims (44.3%) were killed when the vehicles struck stopped garbage trucks from behind and crushed the workers against their garbage trucks.

3.3.2 | Contact injuries caused by "runaway" refuse vehicle

Of the 170 contact injury incidents, 47 (27.6%) involved "runaway" or rolling refuse vehicles. A "runaway" vehicle was defined as a parked vehicle that started rolling on its own without a driver. The following types of vehicles were involved: front loading, side loading, and rear loading trucks, roll off trucks, dump trucks, box trucks, recycling trucks, and tractor trailers. The leading cause of "runaway" vehicle incidents was failure to set brakes followed by brake failure. Besides these two primary causes, the study identified additional contributing factors. In 10 incidents, the parked vehicles started rolling when the operators revved engines to engage the compactor or dumping mechanisms. Inclined road surfaces also contributed to the vehicles' failure to remain stationary. More than one-third of the victims (17) attempted to regain control of the "runaway" vehicles by trying to get back on them. These victims were either run over by the vehicles when they fell or slipped or crushed by the vehicles against other objects.

4 | DISCUSSION

4.1 | Temporary and public sector workers' risk for exterior riding deaths

A higher percentage of temporary workers were killed in exterior riding incidents than in nonriding incidents, including three killed on the first 2 days on the job. Lack of experience and inadequate training may have contributed to these deaths. Often temporary workers are sent to work with regular collection crews without receiving adequate training. For a worker who is not familiar with the collection routes, traffic conditions, and the crew's work routines and communication procedures, his or her injury risk is likely to be higher than a worker who is experienced and well trained. The current labor shortage faced by the solid waste industry might prompt more companies to resort to employment agencies for needed laborers.[16] Therefore, temporary workers' injury risk is likely to increase as more are hired to meet industry demands.

Public sector workers are at increased risk for exterior riding incidents due to multiple factors. One of the risk factors is the degree of automation of the refuse vehicles, which directly correlates with the number of collectors exposed to traffic hazards. An automated side loading truck can be operated by one driver and allows the driver to load the waste by maneuvering a loading arm from inside the cab. In comparison, a conventional rear loading truck often needs two to three crew members to load at curb side, increasing worker injury risks significantly. Automation in the solid waste industry has mainly been driven by the demand for higher efficiency and lower collection cost.[17] While there are no published data available to compare the automation levels among different employment sectors, one can reasonably speculate that public sector employers might not increase automation as easily as private companies due to constraints of labor contracts. Therefore, public sector workers might have higher injury risks due to lower levels of refuse vehicle automation.

The "on-task" system adopted by some solid waste companies might have also encouraged workers to ride the step, although there are no data available to measure how widespread the system is within the public and private sectors. With the "on-task" system, workers are paid for a full shift when the daily assigned collection route is finished. Under this system, workers are rewarded with shorter working days by adopting a rapid work pace. One can expect that a worker might be more likely to ride the step than to walk or ride inside the cab for convenience and time saving. A FACE investigation documented that one municipal sanitation department with 430 employees had two fatal exterior riding incidents within 4 years.[18] The unionized collection employees worked under the "on-task" system. In between the two fatal incidents, the department documented 50 recordable injuries associated with step riding including both fall and contact injuries.

4.2 | The impacts of ANSI Z245.1, CA regulation and NYC initiatives

ANSI Z245.1 prohibits waste collectors from riding on the rear steps when refuse vehicles are backing up. According to this study, refuse vehicle backing is the most frequently occurring ANSI violation. The size and configuration of a garbage truck make it difficult to back up, especially on a narrow street. In some cases, the collection crews routinely backed their refuse vehicles while riding on rear steps even though the companies had policies against garbage truck backing and the employees knew and understood the policies.[18] Due to the nature of the work, direct supervision and constant monitoring of crews on their collection routes is difficult, and the responsibility for following step riding

safety rules often lay on sanitation crew members themselves. As long as workers are allowed to ride outside the cab, worker deaths due to vehicle backing will likely continue to occur.

The study found that one out of every four exterior riding incidents had no ANSI violations. A riding step could be as small as eight inches deep and 27.5 inches wide, and it could be mounted as high as 24 inches above the ground.[2] ANSI Z245.1 is unable to address the inherent dangers of falling off a moving vehicle from the small and elevated platform as well as riding outside the cab without the protection of the vehicle. During a collision, a worker who rides inside the driver's cab wearing a seatbelt has a much better chance of survival than a worker who rides on a riding step. Rough and uneven roads, wet and slippery truck surfaces, and sudden turning, acceleration, or deceleration of the garbage trucks can all increase the riders' risk of falling.

Both NYC and CA have taken measures to prohibit exterior riding, and both had low numbers of exterior riding deaths. The NYC Business Integrity Commission (BIC) regulates the private waste industry by enforcing the NYC Trade Waste Law (TWL). The private waste industry consisting of over 1850 private companies and 6500 refuse hauling vehicles collects waste from all commercial establishments in NYC. The TWL was amended to clearly state that "under no circumstances shall an individual ride on or cling to the outside of a trade waste vehicle while the vehicle is operating on a roadway."[19] BIC conducts regular "truck stops" (inspections) and issues citations for violations of the TWL and written warnings for unsafe practices. NYC has had only two exterior riding deaths involving private sector waste collection workers between 1984 and 2020 (Table 4). Although the low number of exterior riding deaths could not be directly attributed to the impact of the TWL amendment which only became effective in 2021, BIC believes that the agency's enforcement practices and active involvement in NYC traffic safety programs such as "Vision Zero" have served as a deterrent for unsafe behaviors, such as rear step riding.[20]

The New York City Sanitation Department (DSNY) provides residential waste service. DSNY employs approximately 7800 uniformed sanitation workers who operate over 2000 collection vehicles traveling thousands of lane-miles of city streets and collecting 24 million pounds of trash, recycling, and compostable material everyday.[21,22] The TWL does not apply to DSNY employees. Recognizing the danger associated with rear step riding, DSNY took a two-pronged proactive approach to eliminate the serious injury risk: DSNY removed the riding steps from all existing garbage trucks in 2007 and since then has gradually replaced old garbage trucks with new ones without the riding steps. Remarkably, DSNY has had zero exterior riding incidents since 1984.

California Code of Regulations (CCR) 4355 on refuse "compaction equipment" became effective in 1980.[23] CCR 4355 states that "No employee shall be positioned in the path of the moving vehicle, standing on front or rear steps or on side steps, or in any other location where he cannot be seen by the vehicle operator and is subject to being struck by the vehicle or being thrown off the vehicle." In responding to a single fatal incident that occurred in 2007 in which a worker was killed after falling off a trash container that was attached to the forks of a front-loading truck, CA amended the rule by adding specific locations or attachments, to which workers are prohibited to ride. As the most populous state with the highest number of refuse collectors,[24,25] CA had significant lower total worker deaths than NY and FL (Table 4). Unlike the other six states that also had the highest number of exterior riding deaths, CA had statistically significant lower exterior riding deaths ($p = 0.047$). With two deaths, CA is ranked 18th in total exterior riding deaths behind states with much smaller populations, such as KY, OK, LA, and CO.

4.3 | Other hazards: Hazards posed by motor vehicles driven by the public and "runaway" refuse vehicles

Motor vehicles driven by the public were responsible for approximately 40% of all pedestrian incidents. The highest number of refuse collectors were killed by motor vehicles driven by the public striking stopped garbage trucks from behind. According to witness statements documented by OSHA investigators, some of the drivers involved never slowed down before the collisions even though the stopped collection vehicles had warning lights flashing, and the crews wore reflective safety clothing. These incidents occurred mainly due to lack of attention by drivers. To manage and control public roadway traffic hazards that threaten collection worker safety, public motorist education, collection worker safety training, enactment and enforcement of traffic laws that protect collection workers should all be part of the prevention approach.

Refuse vehicles that are parked can start moving on their own without a driver, causing serious injuries including deaths. To our knowledge, the hazard of a "runaway" refuse vehicles had never been specifically addressed by the industry before this study. To prevent drivers leaving the cab without engaging parking brakes, employers may consider retrofitting existing vehicles or purchasing new ones with interlock systems or other engineering controls which can automatically apply the brakes when the operator leaves the seat, when the cab door is open, or when the engine is shut down.[26,27] It is alarming that over a third of the victims were killed while trying to re-enter the moving vehicles to stop them. Employers should provide training to ensure that workers do not attempt to stop a moving vehicle from outside the cab and use wheel chocks to prevent a runaway vehicle when necessary. In some cases, the parked garbage trucks started rolling when the operators revved the engines to engage the trucks' compacting or dumping mechanisms. The solid waste industry and refuse vehicle manufacturers should further investigate the causes of these "runaway" refuse vehicles and implement effective prevention measures.

4.4 | Limitations of the study

The findings of this study are subjected to the following limitations:

1. The study population may not represent all fatal injuries that met the case inclusion criteria within the study period since OSHA does not investigate fatal incidents involving nonemployees or

public sector workers (unless the public sector is covered by an OSHA-approved State Plan).
2. Google Search likely missed the pertinent cases that occurred in earlier years before the internet era.
3. The study was unable to verify the validity and accuracy of the cases and case information identified from the internet obtained through Google Search.
4. The missing information on victim age and race, employment time, company size, and types of refuse vehicles hindered our ability to fully assess worker injury risks associated with these variables.

5 | CONCLUSIONS

Refuse vehicle-related fatal injuries identified by this study were all preventable. Fatal exterior riding incidents take a heavy toll on this study population. Approximately 45.5% of the waste collectors killed in the transportation incidents were riding outside the refuse vehicles at the time of their deaths, and exterior riding incidents were the leading cause of death for 12 of the 37 years covered by this study. ANSI Z245.1 and current OSHA enforcement policy do not address the inherent dangers of falling off a moving heavy vehicle while standing on a small, elevated platform and hanging onto the handhold. The study found that CA and NYC had taken measures to prohibit the practice of exterior riding, and both had lower numbers of exterior riding deaths. Regulatory agencies and leading industry groups should assess whether there is a need to revise the current regulations and policies on rear step riding and take appropriate steps to mitigate worker injury risk. More studies should be conducted to assess waste collectors' risk of fatal exterior riding incidents associated with age, race, employment time, company size, as well as refuse vehicle types.

AUTHOR CONTRIBUTIONS

Julia Zhu: designed the study, determined variables for risk analysis, and drafted the manuscript. **Alicia Fletcher and Nehel Verma**: contributed to the data tabulation, statistical analysis, and finalization of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

DATA AVAILABILITY STATEMENT

These data were derived from the following resources available in the public domain: - Fatality Inspection Data, https://www.osha.gov/fatalities. - NIOSH FACE and State FACE Reports, https://www.cdc.gov/niosh/face/default.html.

ETHICS STATEMENT

The study was conducted under the Fatality Assessment and Control Evaluation (FACE) program which was exempted by the New York State Department of Health Institutional Review Board.

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ENDNOTES

[1] Fatal incidents associated with long-haul transportation of MSW or handling of hazardous or liquid wastes were excluded from this study.

[2] CSEA is a labor union representing employees in state and local governments in NY.

[3] The sources of these worker deaths are: FCIS (579), internet (14), FACE (10), and CSEA (1).

[4] Vehicle type is not a standard entry on FCIS. The following refuse vehicle types were identified through reviewing the incident narratives: Front-loading, side-loading, and rear-loading compaction vehicles, roll-off vehicles, box trucks, dump trucks, flatbed trucks, tractor trailers with walking floors, and collection vehicles with dual controls.

[5] For the majority of the variables analyzed in this study, the findings were not significant at the 0.05 level unless otherwise indicated.

[6] The North American Industry Classification System (NAICS) code for waste collection, treatment and disposal industries is 562. NAICS code for municipal solid waste management programs is 924.

[7] Victim employment by industry types is not shown in the Table.

[8] Company employment (not shown in Table I) was excluded from statistical analysis due to high missing values and difficulty verifying the numbers.

[9] Info not shown in the Table.

[10] The reasons for OSHA not issuing citations for the cases with documented ANSI violations were not available.

[11] Info not shown in the Table.

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