RESEARCH ARTICLE



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Examining injury trends in parcel delivery drivers in the United States: Challenges and opportunities

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Abstract

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Introduction: Growth of e-commerce has caused a vast increase in parcel delivery, which raises concern for safety of drivers and other road users as more deliveries take place. **Methods:** This project analyzes injury/illness and fatality trends among workers with delivery-related NAICS codes using three major sources of occupational hazard data in the United States: the Survey of Occupational Illnesses and Injuries, the Census of Fatal Occupational Injuries, and the Industrial Tracking Application. Descriptive statistics were employed to illustrate trends over time as well as to highlight opportunities for improved data collection and dissemination.

Results: The number of injuries to drivers has risen sharply over the past decade. Some of this increase appears due to growth of this industry, but increasing overall rates suggest the industry is becoming more hazardous. While nonfatal injuries were typically caused by continuous workplace exposures (e.g., repetitive strain, contact with object/equipment), fatalities were almost exclusively caused by transportation incidents. Additionally, crucial aspects of these trends are difficult or impossible to analyze given the current data landscape.

Conclusions: Observed trends reinforce earlier calls for additional scrutiny of working conditions that threaten drivers. Injuries caused by transportation incidents are likely more severe than others and highlight the danger the transportation system poses to drivers and others. Current data collection and dissemination processes offer room to improve in terms of understanding how to prevent future injuries.

KEYWORDS

crashes, occupational hazards, parcel delivery, safety, surveillance

1 | INTRODUCTION AND BACKGROUND

Parcel delivery drivers are an essential link in our modern goods delivery system, the importance of which is emphasized as online shopping continues to grow. As they complete delivery routes, drivers encounter several hazards that endanger health and safety, including intense, repeated strain on their musculoskeletal systems, long work hours, delivery schedules that demand a rapid pace of work, wide variations in weather and daylight, psychological stress, and crucially, risk of motor vehicle crashes or injury from motor

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vehicles as they enter and exit their own vehicles to make deliveries. Despite this sector's increasing importance, however, an understanding of how these circumstances affect their propensity for occupational injury and fatality remains underdeveloped. A better understanding of safety within this industry-particularly in terms of change over time-is crucial, as the landscape of parcel delivery continues to exhibit rapid growth.

As a matter of introduction, we first discuss the propensity for injury and multifaceted injury risks encountered by drivers. We then address some factors that make injury prevention somewhat complex, before describing how the rise of e-commerce has compounded these. We then illustrate how this landscape leaves key gaps in our understanding of current trends before describing our recommendations that address these gaps.

1.1 | Injury propensity among delivery drivers

Research has consistently demonstrated that Couriers and Messengers the industry category to which parcel delivery drivers belong—are among the highest ranked in terms of occupational injury risk. Notably, Bonauto et al.¹ used Washington State Workers' Compensation data from 1999 to 2003 to construct a "Prevention Index" that ranked industries based on the claim count and claim incidence rate, identifying sectors most in need of health prevention and research resources. Couriers ranked third out of 274 sectors. Nearly a decade later, Couriers and Messengers continued to outpace nearly all other transportation subsectors in terms of injury rates,² with the highest risk for time loss workers' compensation claims.³ As of 2021, BLS data shows "Couriers and express delivery services" have the 7th highest nonfatal occupational illness and injury rate and 13th highest rate of cases resulting in days away from work.^{4,5} Thus, the need both for research into and policy that addresses safety among the courier industry is long established but remains underdeveloped.

1.2 | Multifaceted injury risks and mechanisms

Evidence suggests that some of the increased injury propensity stems from the diversity and (sometimes) unpredictability of hazards and repetitive strains encountered by delivery personnel. While studies have found that motor vehicle crashes are a primary safety concern of delivery personnel, most injuries tend to result from other causes. A survey of 321 light/short-haul drivers in Australia found that among those injured in the previous year (n = 121), the events most commonly leading to injury were manual handling activities, such as lifting items (55.4%) and slips, trips and falls (28.9%), especially slipping or falling from a vehicle (19.0%).⁶ Only a very small proportion suffered injury due to a work-related vehicle collision (1.7%). This is in contrast with the 69% of drivers (n = 264) who expressed road/driving problems as a top safety concern. Similarly, a survey of US truck drivers in Washington state found that assignments other than long haul trucking had higher likelihood of injury, possibly because of more frequent stopping, loading/unloading, and other manual tasks.⁷

Indeed, much of the work of delivery drivers (parcel and otherwise) takes place outside the delivery vehicle, meaning that the conditions they encounter as they make deliveries contribute substantially to injury risk. A study using national datasets in Finland, where all compensated occupational injuries are maintained in a central database, found that over 90% of delivery driver injuries took place outside the vehicle.⁸ Most injuries took place either in public areas (30.7% of injury events) or areas used for storage, loading, and unloading (27.4%). In other words, most injuries happened while performing delivery or maintenance-related duties, rather than driving. The multifaceted nature of contributing hazards, taking place in a variety of environments, with different owners, and with sometimes ill-defined understanding of factors that combine to cause injuries, led the authors to conclude "... that the social context and human work is in many ways neglected in current stakeholder management processes in delivery transportation, and the role of corporate social responsibility is blurred to the actors in the field of road transportation."8 (p. 474)

Through interviews with 64 drivers in Sweden, another study identified several key working condition categories that contributed to injury propensity: (1) Goods and equipment factors (e.g., Defective equipment, Unsafe construction of equipment, Lack of proper equipment, Unsafe placement of goods, Excess stowage, Unsuitable packaging), (2) Loading/unloading area factors (e.g., Crowding/disorder, Unsafe surface), (3) Loading and unloading tasks (e.g., Manual lifting, Unloading heavy loads alone, Unsafe handling of goods, Involved in others' unloading), (4) Organization factors (e.g., Imbalance between resources and demands), and (5) Inattention/distraction.⁹ Unsurprisingly, negative psychological safety climate—a metric of how workers perceive the safety of their work environment—is associated with higher rates of injury among commercial drivers.⁷

It is worth noting that the above studies, which draw on samples from the United States, Australia, and Europe, are therefore drawn from contexts that likely differ across these continents. While many of the injury risks and mechanisms likely persist across these contexts, the figures from this international work emphasize the utility of further exploration of this area in a US context.

1.3 | Prevention complexity

Solutions that address these issues elude simple formulation. Drivers operate in a variety of contexts, including location, weather, job nature, route, schedule, and workload, which makes each job and each day different and challenging, requiring adaptation. Injuries can result from a single risk factor, but often are the result of multiple factors combining, for example fatigue combined with pressure to rush or a cluttered work area.^{7,9} Furthermore, in addition to their delivery responsibilities, drivers are often responsible for maintenance if something breaks, sorting other problems, and filling in other procedural gaps. Much of their work takes place in areas not directly under company supervision/control, including public spaces or client properties, where the company has less control over safety.

Firms may not have direct control over these areas, but their procedures, pressures, and culture affect safety. For example, pressure to rush exacerbates potential safety hazards. Moreover, some companies have exhibited cultures of skipping steps, like verifying a load was secured, to save time/beat traffic.⁹ In this way, employee safety and employee safety-related behaviors are strongly related to organizational context. Moreover, companies oversee equipment provision and maintenance. Injuries from faulty or inadequate equipment are therefore also addressable at the organizational level. Understanding how hazards, injuries, and fatalities are affecting parcel delivery drivers over time is crucial to devising solutions, especially as e-commerce drastically reshapes the environment and nature of the parcel delivery workforce.

1.4 | A changing safety landscape: E-commerce and the "Last Mile"

The impact of e-commerce on the last-mile parcel delivery industry is difficult to overstate, with the COVID-19 pandemic serving only to accelerate this impact. Figure 1 shows the number of packages delivered in the United States each year between 2014 and 2021. The influence of the COVID-19 pandemic on online shopping is evident, with 14.7 billion small parcels delivered in 2019, jumping to 20.2 billion parcels in 2020. Even as pandemic-related restrictions have relaxed, analysts suggest the uptake of e-commerce will persist.¹⁰ The continued uptick in volume in 2021 corroborates this view.

Increases in volume have been accompanied by major changes in parcel delivery. Historically, parcel delivery companies typically carried high value and high priority items, accompanied by accordingly profitable shipping rates. The emergence of services like Amazon, however, have introduced and accustomed customers to ubiquitous availability of even basic, inexpensive items, shipped very quickly for very low rates.¹³ This expectation creates pressure to keep operating costs, including labor costs, as low as possible while maintaining a high rate of speed in operations, including in completion of delivery routes, potentially resulting in higher rates of injury.¹⁴



FIGURE 1 US parcel delivery volume (2014–2021). *Source*: Pitney Bowes Parcel Shipping Index.^{11,12}

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Provision of space for delivery vehicles to park while drivers make deliveries has long been an issue in urban freight planning, especially in dense cities.¹⁵⁻¹⁸ Even before the pandemic-induced e-commerce boom, commercial vehicles engaging in short-term stops, like delivering a parcel, had been observed to resort to parking in unauthorized spaces when no other spaces were available, up to 65% of the time in certain areas of Seattle.¹⁹ As urban parcel delivery continues to grow, there is reason for safety concern as the capacity of extant infrastructure to safely accommodate increased volume using traditional means, that is, large parcel trucks or vans, is in question. Moreover, while motor crashes account for a relatively low proportion of overall injuries to delivery drivers, evidence suggests that freight crashes are accounting for an increasing proportion of overall crashes over time.²⁰ Crashes are of particular concern given their propensity to cause severe injury or death both to drivers and other road users, even if they account for a smaller overall proportion of injuries.²¹

Finally, recent research, using content analysis of conversations between drivers on online forums, suggests that drivers are cognizant of these problems, concerned for their safety, and that they take steps to mitigate unsafe situations when possible.²² Drivers reported that practices like unauthorized parking are typically a last resort and are sometimes—perhaps counterintuitively—used to avoid situations they consider unsafe. For example, some drivers reported parking on the wrong side of the street to avoid having to walk across traffic to deliver a package. Moreover, drivers shared concerns that they or their delivery vehicles may be struck by another vehicle while parked to make a delivery.

1.5 | Study objectives

In short, Couriers and Messengers represent a class of employees in a historically dangerous profession that is undergoing rapid changes which may compound existing risks while introducing new ones. It is therefore imperative to understand the injury and fatality trends affecting this employment sector as well as to identify potential shortcomings in the data landscape that informs these trends. To that end, this paper examines major sources of occupational hazard data in the United States. The first sources consist of occupational surveillance data maintained by the Bureau of Labor Statistics, including the Survey of Occupational Injuries and Illnesses (SOII), which tracks injuries and illnesses, and the Census of Fatal Occupational Injuries (CFOI), which tracks occupational fatalities. We also analyze data from the Injury Tracking Application (ITA), maintained by the Occupational Safety and Health Administration (OSHA). Using these data sources, we establish recent trends in nonfatal injuries and fatalities among this industrial subsector, overall and by employer and injury type, while also identifying potential shortcomings in the currently available data and opportunities for improvement.

Specifically, we address the following two key questions:

1. Given available data, what are the trends in courier/delivery driver fatal and nonfatal injuries—overall, by employer type, and by cause of injury?

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2. What shortcomings exist in the three datasets (and what should change) to track fatal and nonfatal injury trends in this rapidly growing sector?

2 | MATERIALS AND METHODS

This study analyzed three national data sets collected by two federal agencies to triangulate insights on occupational injury and death trends over time—overall, by employer, and by injury cause. We present analysis by employer as a proxy for company culture, which literature suggests exhibits substantial influence on safety. Injury cause is included to better understand the nature of safety hazards as this industry expands. We briefly discuss each of these data sources, as well as our reasons for intentionally selecting these sources for analyses. Finally, we outline our analytic approach. An overview of the data sources used is shown in Table 1.

2.1 | SOII and CFOI

The SOII is an establishment-based survey conducted annually by the Bureau of Labor Statistics to estimate counts and incidence rates of nonfatal workplace injuries and illnesses.²³ It is fielded through a stratified sampling design based on industry, ownership, establishment size, and state.²⁴ While the SOII uses the same recordkeeping rules—and therefore data fields—as OSHA,²⁵ the universe of establishments that can be selected for participation in the SOII is more extensive than those required to maintain reporting for OSHA. Apart from the self-employed, small farms, railroad, and mining industries, every private establishment in the United States with at least one employee is eligible to participate in the SOII are notified before the year for which they must keep records for submission to BLS and are given instructions for recording and reporting of injuries and illnesses during the year for which they are required to report.

The CFOI is a counterpart to the SOII, also maintained by the BLS, that records workplace fatalities resulting from injury.²⁶ Fatalities from illness are not included, given the complications in identifying time of exposure, latency period, and onset of illness, and linking these specifically to the workplace. Nevertheless, the CFOI incorporates all deaths that occur in a reference year, including if the injury that caused the fatality took place in a prior year, though usually 95% of fatalities take place in the same year as the causal injury. The CFOI is conducted in partnership between federal and state governments, and collects multiple sources of federal, state, and independent documentation (e.g., death certificate, coroner report, police report) of fatalities both to verify cases and to establish that they were the result of a workplace incident.²⁶

For the SOII and CFOI, we considered cases between the years 2011 and 2020, since substantial changes in sampling and calculation methodology beginning in 2011 resulted in a series break with prior years, making direct comparisons inadvisable.²³ We used the BLS

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ata source	Maintaining organization	Key variables	Sample/population	Availability
urvey of Occupational Injuries and Illnesses (SOII)	Bureau of Labor Statistics (BLS)	 Injury/illness cases resulting in DAFW Rates of DAFW injury/illness cases per 10,000 FTE Characteristics of injured person Injury characteristics (e.g., type, cause) 	 Sampled from all private establishments in United States with at least one employee (except self-employed, small farms, railroad, and mining industries) Stratified by industry, ownership, establishment size, and state Weighted to represent population of US private industry 	Restricted, summary figures and precompiled crosstabs available
ensus of Fatal Occupational Injuries (CFOI)	Bureau of Labor Statistics (BLS)	 Fatality cases resulting from workplace injury Fatality rates per 10,000 FTE Characteristics of deceased person Fatality characteristics (e.g., nature of injury, cause of injury) 	 Census of all verifiable workplace fatalities in United States each year Cases verified by triangulating multiple information sources (e.g., death certificate, coroner report, police report) 	Restricted, summary figures and precompiled crosstabs available
ıjury Tracking Application (ITA)	Occupational Safety and Health Administration (OSHA)	 Injury/illness cases resulting in DAFW Fatality cases resulting from workplace injury Company/establishment characteristics (e.g., firm, establishment location, # of employees) 	• Census of injuries, illnesses, and fatalities for private US establishments that a) have more than 249 employees and/or b) have between 20 and 249 employees and are designated as having high rates of OII	Publicly available

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Injury, Illness, and Fatality (IIF) database to retrieve aggregate figures and detailed crosstabs, since access to the full data set is restricted. While the SOII and CFOI databases switched to biennial reporting and will not publish results for 2021 until late 2023, these sources published some overall, aggregate estimates for 2021 in the form of summary tables, from which we included results where possible.²⁷ Since the study period coincides with the mass adoption of e-commerce, this period is especially relevant for analyses.

2.2 | OSHA ITA

Through its Injury Tracking Application, OSHA collects establishmentspecific injury, illness, and fatality data at the summary level (Form 300A) for US establishments that meet specific criteria. The target universe for this reporting includes: (a) establishments with greater than 249 employees, and (b) establishments with between 20 and 249 employees that are in industries designated as having high rates of occupational illness and injury (OII) (e.g., Utilities, Construction, Manufacturing).^{24,25} The North American Industry Classification System (NAICS) code that includes parcel delivery drivers falls under the latter category. While the ITA data is therefore restricted in scope compared to the SOII, it is a census of establishments in its target universe, collecting data from all establishments meeting the above criteria in a given year.²⁴ For the ITA, we include data for years 2016 to 2021, as this period represents all data available since OSHA began its Electronic Data Collection Initiative (EDCI) through which these data are collected and published.

2.3 | Selection of occupational injury-related data sources

We focus on these three data sources for a few key reasons. First, though the target universes are somewhat different, both sources use the same job classification system, allowing for comparison of trends and therefore a degree of triangulation between the two sources. It is estimated that 86.7% of recordable cases in the SOII are captured in the OSHA target universe, or 65% when national weighting is applied to the SOII.²⁴ This overlap in cases comes despite an unweighted overlap in establishments estimated at 39.6%. Likely, this is an indication that most employees, and therefore injury cases, are at larger firms that fall in the OSHA universe. For this paper's specific subsector, that is, parcel delivery drivers, this overlap may be much more substantial, since a small number of large firms account for the bulk of parcel delivery (Amazon Logistics, UPS, FedEx, and USPS account for approximately 99% of the market).¹² In addition, each of these sources provides crucial information that the other does not. The SOII and CFOI provide information both about the demographics of the injured party as well as the circumstances surrounding the incident, both of which are not in the ITA. In contrast, the ITA provides information about the injuries at specific companies and their constituent establishments, which is not available from the SOII/CFOI.

2.4 | Analytic approach

Our analysis proceeded in three parts. First, we compared the number of nonfatal injury/illness cases, the incidence rates of nonfatal injury/illness per 10,000 full-time equivalent (FTE) employees, and the number of fatalities over time for parcel delivery personnel in these data sources.¹ The incidence rates are defined as the number of cases reported per equivalent of 10,000 full-time employees working 40 h per week, 50 weeks per year.²³ This figure is calculated by multiplying the sum of the reported characteristic (i.e., DAFW cases) by 200,000, and dividing that result by the sum of the total number of hours worked. We used this formula to calculate equivalent rates for comparison from the ITA. For the SOII overview. since the results are from a weighted sample, we also calculated 95% confidence intervals (CIs) for these figures. As per the BLS Handbook of Methods, this was accomplished by obtaining the relative standard error (RSE) for each data point from the appropriate SOII summary sheet, dividing this number by 100 to obtain the standard error, and multiplying the result by 1.96 to determine the confidence error.²³

Parcel delivery personnel injuries and fatalities were examined using NAICS code 492XXX, "Couriers and Messengers," which includes last-mile delivery companies including UPS, FedEx, Amazon, and Amazon-affiliated contractors, among others.² (This code is a combination of codes 492110 and 492210). Next, we use data from the ITA to stratify these nonfatal injury/illness and fatality counts and rates by the major employers that serve this industry.

Finally, we used data from the SOII and CFOI to examine the major injury type or mechanism categories that contribute to nonfatal injuries and fatalities over time. Throughout the analysis, we focused on cases resulting in days away from work (DAFW), both because these cases are likely linked to substantial injuries and because only DAFW cases are available in the IIF database from which the SOII and CFOI data were sourced. All data are publicly available; therefore, this is considered not human subjects research (NHSR) and was designated as such by the appropriate IRB. All analyses were completed using version 4.1.1 of the R programming language. Tables containing all numbers used to generate the presented figures are available in the Supporting Information: Appendix.

3 | RESULTS

3.1 | Number of DAFW cases over time

The first trend of note is that injuries to Couriers and Messengers ("CM" hereon) appear to be on the rise. Panel A of Figure 2 below shows a comparison of the number of injuries and illnesses observed per year between 2011 and 2021, including 95% Cls for the estimates from the SOII.

In the earliest presented data point from the SOII, for year 2011, there were 9930 (95% CI = 8976.3, 10883.7) CM injuries/illnesses resulting in days away from work. Apart from the period between 2012 and 2013, in which there was a slight dip from 11,620



FIGURE 2 Comparison of DAFW cases (Panel A), case rates (Panel B), and fatalities (Panel C) in BLS SOII and OSHA ITA. BLS, Bureau of Labor Statistics, SOII, Survey of Occupational Injuries and Illnesses.

(95% CI = 9911.9, 13328.1) to 10,010 (95% CI = 9146.7, 10873.3), and 2015–2016, in which the number stayed roughly the same, from 13,080 (95% CI = 11875.1, 14284.9) to 13,070 (95% CI = 19897, 22383), the number of CM DAFW cases grew in every year, with particularly precipitous growth taking place after 2016. By 2020, the number of CM DAFW cases had reached 21,140 (95% CI = 19897, 22383) before increasing sharply to 27,400 (95% CI = 25735.2, 29064.8) in 2021.

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This trend is largely corroborated by data from OSHA, for which available records begin in 2016. Despite differences in the establishments comprising each data set, the trends shown through these years are similar in both sources, with the counts in the ITA falling within or close to within the 95% Cls for most of the SOII estimates. Between 2016, in which there were 10,748 reported DAFW cases, and 2020, in which there were 19,794, the number of DAFW cases nearly doubled. Between 2020 and 2021, this figure increased sharply to 30,109, mirroring the precipitous spike in the SOII, for which the upper bound of the 95% CI was 29,065 in the same year.

3.2 | Rate of DAFW cases per 10,000 FTE employees over time

The increase in injuries/illnesses came at a time of major growth in the shipping industry, with more workers needing to work more hours to accommodate the ever-increasing parcel volume shown in Figure 1. It is therefore crucial to examine the rates at which these cases are taking place, which are presented in panel B of Figure 2 as the number of DAFW cases per 10,000 full-time equivalent employees. Here, a marked difference emerges between the SOII and the ITA.

In terms of the rate of DAFW injury/illness, the ITA consistently shows higher rates than the SOII, with its figures falling above the upper CI limit of the SOII estimates in every year except 2018. Especially notable is that from 2019 to 2020, the SOII showed a sharp decrease in the rate of DAFW cases (from 325.5 (95% CI = 300.6, 350.4) to 289.8 (95% CI = 272.8, 306.8)) while the ITA showed a marked increase (from 375.5 to 393.6). Additionally, consistent with the jump in counts, the ITA also shows a major spike in rate of DAFW cases between 2020 and 2021, from 393.6 DAFW cases per 10,000 to 436.1 cases per 10,000. Though smaller in absolute terms, the SOII also showed an increase in this period, going from 289.8 (95% CI = 272.8, 306.8) to 310.0 (95% CI = 292.4, 327.6) DAFW cases per 10,000.

3.3 | Workplace fatalities over time

The OSHA ITA also tracks workplace fatalities, which we compare with the CFOI figures in panel C of Figure 2. The comparatively small number of fatalities show no clear trend, though the line from the SOII shows an overall increase over the past decade, from 15 in 2011 to 34 in 2020. The number of fatalities recorded by the ITA has also risen in recent years, from its second lowest observed figure of 14 in 2019 to 29 in 2021, eclipsing its previous high of 28 in 2017.

3.4 | Differences by company

Data collected in the ITA allows for comparison between major private parcel shipping carriers in terms of injuries/illnesses and fatalities. These figures are shown for years 2016–2021 (i.e., every year currently available) in panel A of Figure 3. SOII/CFOI do not provide these data.

DAFW cases have consistently risen between 2016 and 2021 across all companies. UPS is the consistent leader across the displayed categories but is behind FedEx when their Ground and Express divisions are combined. For example, in the most recently reported year of 2021, UPS had 9715 DAFW cases, compared to 5383 at FedEx Express, and 6954 at FedEx Ground, but is behind their combined total of 12,337. Meanwhile, the "Other" category consistently has the smallest number of cases, peaking at 2492 in 2021. UPS consistently has the lowest rate of injury/illness, apart from the "Other" category in 2017 and 2019. For example, in 2021, UPS had a rate of 316.5 DAFW cases per 10,000 FTE, while FedEx's Express and Ground divisions had 587.5 and 619.0, respectively. Curiously, the case rate for "Other" nearly doubled between 2019 and 2020, moving from 233.7 to 412.0, and remaining high at 412.8 in 2021. Finally, the fatality numbers are much smaller than those for injuries/illnesses.

3.5 | Causes of injury and fatality

In addition to overall numbers and rates, the SOII/CFOI capture several pieces of information about the circumstances leading up to

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injury/illness and fatality cases. The major cause categories for incidents recorded between 2011 and 2020 are displayed in Figure 4. Data for 2021 are not yet available at the time of this writing. The OSHA ITA does not currently capture case level data.

In general, all leading causes of injury/illness are trending upwards, paralleling the general trends seen in Figure 2. Across all years, "Overexertion and bodily reaction" leads in DAFW cases, consistently accounting for nearly twice the number of DAFW cases as the next two leading causes, which are "Falls, Slips, and Trips" and "Contact with object, equipment." In the most recent available year of 2020, for example, there were 8930 cases of "Overexertion and bodily reaction," while there were 5120 from "Falls, Slips, and Trips," and 4010 from "Contact with object, equipment." Each of these causes has seen a substantial increases in cases over the past decade, with "Overexertion and bodily reaction" increasing from 4700 cases in 2011 to 8,930 cases in 2020, a 90% increase, while "Falls, Slips, and Trips" increased from 2510 to 5120 (104% increase) and "Contact with object, equipment" increased from 1640 to 4010 (145% increase) over the same period. Transportation incidents account for a comparatively small share of injuries, but have nonetheless been generally on the rise, increasing substantially from 670 cases in 2011 to 1520 cases in 2019 (127%). These cases saw a precipitous decline in 2020, falling to 1010, possibly relating to a general decline in automotive traffic during the worst of the pandemic. Looking at the rates of injury/illness per 10,000 FTE employees, the numbers remain relatively consistent over time across all causes, with some spikes and troughs but no definitive upward or downward trends over the 10-year period.

Turning to fatalities, the analysis reveals the critical insight that while transportation incidents account for a relatively small proportion of DAFW cases, they are by far the leading cause of death. While the modal number of fatalities from other major recorded causes is 0, there were over 20 fatalities in every year except for 2011, and over 35 recorded fatalities in 2017 and 2019. It is difficult to establish trends with these numbers, but the downtick from 36 fatalities in 2019 to 27 in 2020 could likewise be related to decreased pandemic traffic.

4 | DISCUSSION

4.1 | Injury and fatality trends among parcel delivery personnel

In terms of major injury/illness and fatality patterns, we revealed a few broad insights. First, the number of injuries/illnesses sustained by Couriers and Messengers has been continuously on the rise over the past decade. As indicated by the rate of injury/illness per FTE employees, a substantial component of this increase has been the growth of this industry, with more employees working more hours to deliver more packages. Nevertheless, injury/illness rates have crept upward. This trend is especially pronounced in the subset of industries tracked by the ITA. Since the number of recorded cases is so similar in



FIGURE 3 Comparison of DAFW cases (Panel A), case rates (Panel B), and fatalities (Panel C) by company. Amazon, Inc. is not included to avoid because their ITA entries primarily represent warehouse workers, and not parcel delivery personnel. See Section 4 for more detail. ITA, Injury Tracking Application.

absolute terms across the two data sources, the vast gulf in injury rates between them—which is particularly pronounced after 2018—is related to the recorded number of hours worked in each data set for the selected NAICS codes—the denominator for these rates. It is possible that the ITA-based denominator better indicates parcel delivery work, since the SOII sample includes more, smaller firms that are not performing parcel delivery, but this is not completely clear from these data. If so, this trend is worrisome, as it shows increasingly higher rates of driver injury/illnesses year over year since 2016. Evidence of increasing danger in the course of performing these jobs reinforces earlier calls for additional scrutiny of working conditions that continue to threaten workers, for example.^{1,28}

It is more difficult to establish a trend for fatalities, given the relatively small number compared to DAFW cases, but our analysis reveals there are nonetheless a substantial number of fatalities each year. The fatality numbers recorded in the ITA are consistently lower than in the SOII, which makes sense given that the ITA collects information only for its target establishments, whereas the CFOI is a Census of all workplace fatalities in a given year.^{24,26} As with DAFW cases, ITA figures may more accurately reflect parcel delivery drivers, given their typical employment by larger firms. It is nevertheless hard to generalize from these numbers, and future scrutiny of case-level data of fatalities in this industry is warranted.

We noted substantial increases in injuries/illnesses across multiple causes, though these trends were substantially flattened when considered as rates per 10,000 FTE. This flattening compared with the absolute numbers is likely indicative of an increasing number of employees, consistent with growth of the parcel delivery industry.



FIGURE 4 Comparison of DAFW cases (Panel A), case rates (Panel B), and fatalities (Panel C) by cause.

Nevertheless, this flattening is consistent with the overall rates shown from SOII data—but not from ITA data—a gulf that merits further investigation.

The significance of these fatalities is highlighted when considering common causes of injury/illness and fatality. While the far greater number of injuries are caused by continuous workplace exposures to things like repetitive strain and equipment, fatalities were almost exclusively caused by transportation incidents. The lethal potential of these incidents likely explains why they have long been a primary concern of drivers, despite occurring less frequently than other injury-causing events.⁶ This overwhelmingly singular cause of fatalities could further imply that the injuries caused by transportation incidents tend to be more severe and potentially debilitating than those from more frequent causes, and highlights the danger the nation's transportation system continues to pose to many of its users, including those carrying urban freight.²⁰

Finally, our analysis of differences between common US parcel carriers reveals stark disparities. FedEx has the most overall DAFW cases when accounting for both its Express and Ground divisions, a remarkable figure considering UPS's market share in terms of parcel volume is substantially higher than FedEx across both divisions, accounting for 24% of US volume compared to FedEx's 19%.¹² Some have chalked potential differences up to factors like unionization (positive effect) and motivations to keep deliveries as fast and cheap as possible (negative effect).^{29,30} Nevertheless, these hypotheses merit further empirical investigation.

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Moreover, despite handling comparable volumes to other shipping services, it is difficult or impossible to track injury/illness and fatality data across Amazon's delivery network. Amazon delivers most of their packages through their Delivery Service Partners (DSP), which are nominally independent logistics companies, capped at a maximum of 100 employees and 40 vehicles each.³¹ This practice entails that most, if not all, of the employees delivering Amazon packages are technically not Amazon employees, and fall into the "Other" category in Figure 3.³ A recent report suggests that only around 10% of Amazon's Delivery Service Partners (DSP) are accounted for in OSHA's ITA data.¹⁴ This difficulty in tracking is one of several revelations in the above analysis that points to a need for reevaluation of data collection processes.

4.2 | Occupational hazard surveillance in the United States and limitations

Occupational Hazard surveillance in the United States is a fractured enterprise, as described in a recent report: "There is no single, comprehensive OSH surveillance system in the United States, but rather an evolving set of systems using a variety of data sources that meet different surveillance objectives, each with strengths and weaknesses."³² Across this landscape of systems, agencies constantly engage with obstacles to comprehensive surveillance, including limited resources, barriers to sharing information between key actors (e.g., agencies, different levels of government, health care facilities, employers, employees), data collection processes that have not kept up with the changing nature of employment, and a historical priority on understanding health outcomes as opposed to hazards and exposures that can lead to these outcomes and more readily inform upstream prevention.^{32,33}

While increased recent attention to these issues is a positive step, the current data landscape nevertheless inhibited our ability to generate a full picture of driver occupational hazards and outcomes. First, in part due to limited resources, both data sources employed here rely on employers to track and report their own injury data. This practice almost certainly leads to underreporting, perhaps in some part due to employers' desire to minimize their perception as dangerous places to work, but likely in larger part because the degree to which different firms are set up to accomplish this tracking and reporting varies widely.³⁴ This issue is compounded by a litany of other factors that lead to underreporting of injuries. Because of this reality, the figures we presented are almost certainly underestimates.

Moreover, in part to mitigate potential reluctance by companies to share their injury data, access to SOII data is (by law) heavily restricted, with information about for example, specific companies, unavailable to the public, with SOII data overall legally unable to serve as the basis for drafting regulations.²⁵ This emphasis on confidentiality is therefore a double-edged sword: It may assuage company concerns about reporting their data, but it also prevents important insights that might be revealed by scrutinizing companies. Because of restrictions on the actual SOII data set, only certain precomputed crosstabulations are available from the Injuries, Illnesses, and Fatalities (IIF) database. Moreover, since granular data about demographics and injury circumstances are only collected for DAFW cases, only such cases are available for query in the IIF database.

4.2.1 | Specific difficulties in understanding occupational hazards among parcel delivery personnel

These limitations also constrained the picture we were able to generate of parcel delivery driver injuries/illnesses and fatalities. Given that the SOII figures come from the IIF database, we were not able to exclude nonparcel delivery establishments that are none-theless classified as 492110 or 492210 from of our SOII figures. We therefore did not exclude them from our ITA analysis, both to ensure valid comparison and because this would be logistically difficult. It is in principle possible to refine data in such a way using the ITA, by verifying, on an establishment-by-establishment basis, which are involved specifically in parcel delivery, which could provide the basis for additional future work.¹⁴

These difficulties are compounded by the way some companies have engineered and classified components of their delivery networks. For instance, while most of Amazon's last mile deliveries take place using Amazon-branded vehicles and personnel, these enterprises are all technically owned and run by small companies contracted exclusively through and controlled by Amazon.^{13,35} Because these companies are legally independent, not named in a way that indicates their affiliation with Amazon, are capped at 100 employees (often substantially smaller), and are not clearly or consistently classified into a particular NAICS code, they are exceptionally difficult to track, with most of them seemingly not appearing in the ITA,¹⁴ and presumably therefore not in the SOII, either. This issue is further complicated by other problems of classification, for example, a good deal of Amazon's warehousing and logistics operations were reclassified into NAICS code 492110 as of 2021, meaning that, counterintuitively, most employees classified under "Amazon, Inc." under the NAICS code for Couriers and Messengers are neither couriers nor messengers, nor are they parcel delivery personnel (and therefore were excluded from our companyspecific ITA analysis).

Beyond these classification problems, the emergence of individual contract work and "gig" economy labor has made inroads into parcel delivery. Increases in contract work, "gig" work, and other arrangements that represent evolutions in what work can look like since most surveillance systems were designed, make tracking difficult.³² A main example, Amazon's "Flex" service, contracts with individual drivers who are assigned a block of packages, load their own private cars, and deliver parcels on Amazon's behalf.³⁶ This service joins others like PostMates, through which couriers deliver a variety of products directly to a customer's home, sometimes as fast as the same day.³⁷ These delivery personnel are likely entirely missing from both the SOII/CFOI and the ITA.

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Several of the shortcomings we encountered in attempting to use national surveillance data to understand occupational hazards faced by parcel delivery drivers are well understood in the general case.³² We echo a suggestion from the National Academies' report on Occupational Hazard surveillance systems of a "system of systems" approach, which would "... strengthen the ongoing coordination and data sharing across federal agencies, between federal and state agencies, across state agencies (e.g., labor and health), and with employers and workers to result in the maximum possible engagement of all"32 (p. 5). Such an approach, leveraging better communication, coordination, and technology, would make better use of existing resources and reduce duplication of effort across agencies. Moreover, refocusing data collection procedures to include continuous (as opposed to annual) monitoring, a focus on hazards that increase risk of occupational injury, capturing chronic conditions, and layering these practices atop traditional strengths in monitoring health outcomes could serve as a foundation for better future policy. Additionally, reducing burden of reporting from resting solely on companies to sharing across affiliated entities may enhance reliability of reporting.

Moreover, recent scholarship has increasingly called for systems approaches to understand complex causal chains in occupational injury.^{38,39} As described in our introduction, the causal chains in delivery driver injuries can be multifaceted, and are products of many combined factors, including company culture, pressures, and procedures. While our results showing differences in injuries/illnesses and fatalities across companies corroborates these factors, the data landscape nonetheless makes it difficult or impossible to parse the complex chains and interrelations between systems that increase or reduce injury risk. Better data collection, dissemination, and access procedures could help inform a rapidly evolving situation in the last mile, where the curb is becoming a more dangerous place. Existing work describes the disjointed policies involved in allocating curb space for delivery⁴⁰ and documents the difficulties drivers are experiencing in navigating this landscape.²² In turn, partnerships between agencies charged with supporting occupational health, urban planning professionals, municipalities, and private shipping companies could help to coordinate multifaceted solutions that improve safety, delivery operations, and quality of life where these systems interact with the places people live.

Future work may consider combining occupational safety data with other data sources to better understand the details leading up to incidents of special interest. For example, it may be possible to link restricted data from the CFOI to crash data from systems like the National Highway Traffic Safety Administration's (NHTSA) Fatality Analysis Reporting System (FARS) to scrutinize details about fatal crashes involving delivery personnel.

5 | CONCLUSIONS

This study shows that as e-commerce has continued to generate demand for parcel shipping, the number of injuries experienced by parcel delivery personnel has increased dramatically. While a substantial portion of this increase is explained by the growth of the industry, as shown through rates of injury/illness per 10,000 FTE employees, we nonetheless find a worrying trend of increased injury and illness, particularly shown using data from OSHA's ITA. We also find that while transportation incidents are relatively infrequent compared to other injury causes, they are almost the sole cause of fatalities, which further implies that injuries sustained from these incidents may be more severe. Through this analysis, however, we find many shortcomings and limitations in using our selected data sources, which represent the main avenues for tracking occupational illness, injury, and fatality in the United States. We therefore recommend several avenues for improvement and further investigation.

AUTHOR CONTRIBUTIONS

Evan lacobucci: Conceptualization; methodology; investigation; formal analysis; data curation; writing-original draft; writing-review & editing. **Noreen C. McDonald**: Conceptualization; funding acquisition; project administration; writing-review & editing. **Rebecca B. Naumann**: Conceptualization; writing-review & editing. **Kristen L. Kucera**: Conceptualization; writing-review & editing.

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CONFLICTS OF INTEREST STATEMENT

The authors declare that there are 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

The data that support the findings of this study are available from the Injuries, Illnesses and Fatalities database at https://www.bls.gov/iif/ and from the Industrial Tracking Application at https://www.osha.gov/Establishment-Specific-Injury-and-Illness-Data.

INSTITUTION AND ETHICS APPROVAL AND INFORMED CONSENT

Work was performed at the University of North Carolina, Chapel Hill, was submitted for IRB approval there, and designated as Not Human Subjects Research (NHSR).

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ENDNOTES

¹ We also performed data checks to detect any data entry or similar errors in the ITA data set that could have influenced our result. We discovered that one regional (i.e., not national) last-mile delivery company had mistakenly entered their company-wide numbers for number of employees and total hours worked for years 2016–2019. We divided these figures by the total number of that company's Y-OF

establishments reported in each year and replaced the original figures with that result, which ensured that the denominators of the analyses performed in this paper are correct. Since we did not perform any analyses which split this company's results into different categories, this method of correction does not skew any of our presented results.

- ² The United States Postal Service is a government entity and not part of the reporting for these NAICS codes. The current analysis is limited to private companies.
- ³ "Amazon, Inc." appears in 2021 because the company reclassified some of its logistics operations (e.g., sortation centers, delivery stations, and air hubs), which had previously been categorized as General Warehouse and Storage (NAICS Code 493110) as Couriers and Messengers (NAICS Code 492110)¹⁴. Thus, most injuries and fatalities related to Amazon's parcel delivery operations fall into the "Other" category, which may capture only a subset of this activity.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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