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Sociology & Social Policy, 2025, 2(3), 181-190
https://www.hillpublisher.com/Journals/ssp/
ISSN Online: 3066-5698

Behind the High Efficiency Cost: A Study on the Impact Mechanism of Occupational Injuries for Food Delivery Riders

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How to cite this paper: Boyu Zhang. (2025). Behind the High Efficiency Cost: A Study on the Impact Mechanism of Occupational Injuries for Food Delivery Riders. *Sociology & Social Policy*, 2(3), 181-190.
DOI: 10.26855/ssp.2025.12.007

Received: October 16, 2025
Accepted: November 25, 2025
Published: December 22, 2025

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Abstract

With the development of the food delivery industry, the problem of occupational injuries to delivery riders has become increasingly prominent. Most existing studies focus on macro labor rights and interests, while insufficient exploration of the micro mechanisms of occupational injuries. This study conducted a questionnaire survey among 146 Chinese food delivery riders and analyzed them using an ordered Logit model. It was found that the complexity of the task and strict delivery time limits significantly increased the frequency of injuries. Further analysis indicates that the gap between working hours and income expectations is a key mediating factor among them. At the same time, a rider's risk perception has a dual function: a moderate level of alertness enhances safety, but excessive anxiety is more likely to lead to mistakes. This study provides micro-evidence for understanding the occupational safety risks under platform employment and puts forward specific suggestions for the platform to optimize order management and ensure the safety of riders.

Keywords

Food delivery riders; Occupational injuries; Platform control; Risk perception; Income expectation gap

1. Introduction

The development of the digital platform economy has influenced the urban labor force structure, and food delivery riders have become a form of flexible employment in China. According to data from QuestMobile Research Institute (Quest, 2025), the number of food delivery riders across the country has exceeded 14 million. This group plays a certain role in supporting urban operation and absorbing employment, but the accidents and injuries they face have also drawn attention. Under the combined effect of pursuing delivery efficiency and platform algorithm management, riders often fall into the working predicament of "high cost and high efficiency". Occupational injuries not only affect the personal health of riders, but also pose challenges to governance links such as labor protection, traffic safety and social security (Zhu, 2021).

Existing studies have explored the working conditions of riders from various perspectives, including employment quality, labor rights and interests, and digital management systems, etc. (Sun & Chen, 2021) However, most of the existing achievements focus on institutional analysis at the macro level, while empirical research on the formation mechanism of occupational injuries is relatively lacking. International academic research on long working hours

and occupational health (Dembe & Banks, 2005), as well as emerging domestic discussions on algorithmic management and labor instability, all suggest that the interaction among work intensity, time pressure and management control may be the key to understanding injury risk. However, there is still a lack of systematic quantitative tests on how these factors jointly affect the frequency of injury. Furthermore, the mediating role of working hours, income expectation gap and risk perception among them, especially in the context of China's express delivery industry, still awaits in-depth exploration.

To make up for the above deficiencies, this study adopts a microscopic quantitative method to investigate the influencing mechanism of occupational injuries among Chinese food delivery riders. Based on first-hand survey data and an ordered Logit regression model, this paper analyzes the relationship among the complexity of distribution tasks, platform control and injury frequency, and examines the mediating roles of working hours, income expectation gap and risk perception. The research, by integrating structural and psychological dimensions, aims to provide empirical references for the study of occupational risks in the platform economy and offer suggestions for platform governance and labor protection policies.

2. Literature Review and Theoretical Framework

2.1 Occupational Risks and Platform Work

The development of China's platform economy has gradually drawn the attention of the academic community to the working conditions of food delivery riders. Since food delivery workers were included in the Chinese occupational classification Catalogue in 2020, this group has been regarded as a representative case in the study of flexible employment and digital labor. Previous studies have pointed out that riders generally face high labor intensity, long working hours and more traffic safety risks. Zhu pointed out that the majority of riders have not yet been included in the traditional work-related injury insurance system; Li et al. (Li & Luo, 2024) analyzed how the insufficiency of institutional guarantees and mental health support deepened the vulnerability of this group.

Empirical research shows that long working hours increase the risk of occupational injuries. Dembe et al. found based on data from the United States that extending working hours would increase the probability of workplace accidents. Wagstaff and Lie's research shows (Wagstaff & Lie, 2011) that working overtime for more than 8 hours significantly increases the risk of fatigue and injury. In the context of China, Chen et al. (Chen & Huang, 2022) also observed a similar phenomenon: the work intensity and duration of couriers have a negative impact on their safety and health. These studies suggest that the efficiency improvement of digital distribution platforms is often accompanied by a reduction in working hours and an increase in workload, which in turn brings about certain labor costs.

Although the number of related studies has gradually increased, most of the achievements still focus on discussions at the macro policy or institutional level, lacking systematic analysis of the micro mechanisms of occupational injury formation (Tian & Zheng, 2022). How platform structure, working environment and behavioral factors jointly affect the occurrence of injuries has not been fully explored. In addition, the intra-group differences brought about by factors such as gender, city type and contract arrangement have also received less attention. To make up for the above deficiencies, it is necessary to adopt a more integrated empirical research method to analyze the structural characteristics of the platform in connection with the actual behavior and risk perception of riders.

2.2 Platform Control and Algorithmic Management

With the development of the digital platform economy, algorithmic management has gradually become a feature of the new type of labor relations. The platform no longer relies on direct supervision but instead achieves order allocation, mobile tracking and real-time performance evaluation through a data-driven system. Sun and Chen pointed out that the platform transforms time into a management tool and implements what is called "time arbitrage" by constantly shortening the delivery time limit. Tu et al. further proposed that algorithmic rules and incentive systems have formed a new form of labor control, in which gamified mechanisms such as points, badges and rewards not only motivate riders but also impose constraints on them. Wei et al. 's research indicates that such mechanisms may initially enhance rider engagement, but when the incentives are excessive, they may eventually lead to fatigue and risky behavior.

The research also found that platform control affected riders' autonomy in terms of time and space. Although riders are nominally free to choose their working hours, algorithmic evaluations and customer ratings directly link

performance to income, thereby limiting actual flexibility. Zheng et al. pointed out that this system forms a dependency relationship between riders and the platform, and riders often have to passively extend their working hours to maintain a stable order flow. From this perspective, the "flexibility" emphasized by the platform may mask a certain degree of digital compulsion. Tu et al. found that riders driven by income pressure are more likely to work overtime and neglect rest mechanisms, while riders who focus on long-term stability are more likely to adhere to safety regulations. These studies collectively indicate that there is a structural contradiction in platform labor: incentive mechanisms aimed at maintaining productivity may also simultaneously increase occupational risks.

2.3 Theoretical Perspective: The Mechanism of Occupational Injuries

Based on the self-depletion theory and the resource conservation theory, this study regards occupational injuries as the result of the combined effects of algorithmic control, task complexity and psychological adaptation. According to the self-depletion theory, when an individual is under continuous stress and fatigue, their self-regulation ability may weaken, making them more prone to impulsive or risky behaviors. In the working environment of the platform, when riders face complex tasks such as long-distance delivery, overlapping orders and uncertain traffic conditions, they will constantly consume physical and cognitive resources. Under strict algorithmic time constraints, these pressures are further manifested as extended working hours and decision fatigue, thereby creating conditions prone to accidents (Zheng & Feng, 2022).

The resource conservation theory further explains that if continuous efforts are not fully restored, it may lead to the gradual depletion of personal resources, making individuals more sensitive to resource loss. When a rider's actual income does not meet expectations, an income expectation gap will arise, which may lead to compensatory actions, such as accepting more orders or violating traffic rules, to make up for the perceived income loss. Sun and Chen's research indicates that the compression of time by platforms has intensified the work pace and further strengthened this economic psychological pressure. Risk perception plays a dual role in this process: moderate risk awareness helps promote cautious behavior, but persistent anxiety and uncertainty may also interfere with attention and increase the possibility of operational errors.

In conclusion, the occupational injuries faced by food delivery riders are not random or purely technical incidents, but rather the result of the interaction between digital management systems and the psychological factors of riders' behaviors. The theoretical framework constructed in this paper integrates platform control and task complexity at the structural level, working hours and risky behaviors at the behavioral level, as well as income expectation gap and risk perception at the psychological level. This framework provides a foundation for subsequent empirical analysis. Next, based on the original survey data from Chinese riders, the ordered Logit model and mediating effect test will be used to verify these relationships.

3. Research Methods and Variable Selection

3.1 Data Sources

The data of this study is derived from an online questionnaire survey conducted through the Wenjuanxing platform in August 2025. A pre-survey was conducted before the formal investigation to refine the questionnaire design and ensure the quality of the data. Based on the literature review, the questionnaire clarified the core characteristics of food delivery riders and their relationship with the research variables, and optimized the project logic and expression specificity according to the previous feedback.

During the formal investigation stage, food delivery riders were randomly recruited from multiple cities in China through the tag sample service of the Wenjuanxing platform (with a sample library size of 6.2 million). The questionnaire is conducted through online self-filling and covers five parts: (1) demographic information, (2) working conditions, (3) delivery task scenarios, (4) platform control mechanisms, and (5) occupational injury experiences. During the collection process, the system automatically marks questionnaires with contradictory responses or logical anomalies, which are then manually verified and screened. A total of 146 valid questionnaires were ultimately retained.

3.2 Variable Settings

We classify variables into dependent, core explanatory, and control variables. Measurement and coding are as follows.

3.2.1 Dependent Variable: Occupational Injury

Occupational injury is measured by the frequency of work-related injuries in the past year. Respondents answered: "Approximately how many times have you been injured while delivering food?" with options 0, 1, 2–3, and 4 or more. We construct an ordered categorical variable where higher values indicate higher injury frequency and assign: 0 = never, 1 = once, 2 = two to three times, 3 = four or more times.

3.2.2 Core Explanatory Variables

We focus on two clusters: delivery operation context and platform control.

(1) Delivery operation context

Four constructs were measured with multiple items, each on a 4-point Likert scale (1 = never, 2 = occasionally, 3 = frequently, 4 = almost every day); the higher scores indicate greater exposure/frequency.

Weather conditions (4 items): rainy day, snowy day, high temperature (≥35 °C), low temperature (<5 °C).

Road conditions (4 items): highway/urban expressway, mixed lanes (non-motorized/motor traffic), densely populated commercial areas, poor night lighting.

Risky riding violations (3 items): running red lights, wrong-way riding, speeding (capturing violations induced by time pressure).

Task complexity (4 items): long one-way distance; simultaneous multi-order delivery (route planning required); long pickup waiting time; heavy/special orders (e.g., carrying upstairs, purchasing cigarettes, taking out trash).

In subsequent regressions, we apply principal component analysis (PCA) to these scenario variables and extract a composite factor score that condenses the common information reflecting task complexity for use as a single variable.

(2) Platform control

Delivery time constraint is measured by riders' subjective evaluation of the reasonableness of platform-set latest delivery times on a 5-point Likert scale (1 = very unreasonable, 5 = very reasonable). Lower scores imply tighter time pressure and stronger perceived constraints.

Incentive engagement captures whether platform incentives (e.g., completion bonuses) increase work pressure. We code 1 = pressure felt due to incentives, 0 = not affected. This reflects the extent to which incentive policies shape riders' behavior and psychological stress.

3.2.3 Control Variables

Following Tu et al. and Zheng et al., we control for individual and job characteristics to mitigate confounding: gender (male = 1, female = 0), age, marital status (married = 1, otherwise = 0), children (have children = 1, none = 0), years of education (converted from highest attainment), self-rated health (1 = very unhealthy, 5 = very healthy), full-time status (full-time = 1, part-time = 0), monthly delivery volume (banded categories; higher values indicate more orders), delivery income level (e.g., "< ¥5,000" = 1 … "¥12,000–14,999" = 6), city type (first-tier; provincial capital/new first-tier; others—entered as dummies), delivery method (station/team—reference; crowdsourced; single merchant—entered as dummies), and contract type (formal labor contract—reference; outsourcing/cooperation agreement; no agreement—entered as dummies). This design isolates the effects of context and platform control on injury frequency from demographic and job-structure influences.

3.3 Descriptive Statistics

3.3.1 Demographics

According to Table 1, among the 146 surveyed riders, 74.66% were male and 25.34% were female. This gender ratio is close to the female proportion (24.3%) stated in the QuestMobile research report. The average age of the riders is approximately 30 years old, with more than half of them aged between 30 and 40. The proportion of married riders is 86.30%, while those with children only account for 23.97%, reflecting that the majority of married riders have not yet given birth. The average educational duration for riders is 12.90 years, equivalent to a high school diploma. The average self-assessed health level is 4.08 (with a value range of 1 to 5), and the overall health condition is good. This group's characteristics are basically consistent with the labor force structure described in the research by Wang Chunxuan and Wang Xing, which is mainly composed of middle-aged and young men with average educational attainment (Wang & Wang, 2024).

3.3.2 Working Conditions

Full-time riders comprise 92.47% (part-time 7.53%). Over 70% deliver ≥1,000 orders per month (≈ 30/day). Income is positively correlated with workload: Only 18.49% of the riders in the sample have a monthly income of less than 7,000 yuan, while over 70% have a monthly income of 7,000 yuan or more. This distribution feature is consistent with the conclusion of Wang Zhaoping and Li Zhuhui's research that "order volume is the main factor affecting riders' income". The proportion of riders with higher incomes in the sample is relatively large, which also reflects that full-time riders usually undertake a greater workload.

3.3.3 Job Scenarios and Risk Behaviors

Riders commonly face adverse environments: over half frequently deliver in rain, high heat, or low temperatures; nearly 70% often ride on mixed or congested roads—echoing literature on weather/congestion risks (Wei & Ling, 2022). Simultaneous multi-order delivery is prevalent (80.82%), and 40.41% often encounter long pickup waits or additional tasks, indicating high task complexity. Risky behaviors are non-negligible: speeding (35.62%), wrong-way riding (8.22%), and running red lights (5.48%), reflecting time-limit pressure and incentive-driven overwork highlighted in prior studies.

3.3.4 Occupational Injury Experience

In our sample, 95.21% report edat least one injury, 60.27% reported 2–3 injuries, and 19.86% reported 4+. This notably exceeds typical estimates for general occupations and corroborates the association between overtime and accident frequency documented by Wagstaff and Lie. The high injury frequency provides a robust dependent variable for the econometric analysis.

Table 1. Selected Descriptive Statistics (N = 146)

Dimension	Indicator	Value
Gender	Male / Female	74.66% / 25.34%
Marital / Children	Married / Have children	86.30% / 23.97%
Education (years)	Mean	12.91
Self-rated health (1–5)	Mean	4.08
Full-time	Share	92.47%
Monthly orders	<500 / 500–999 / 1000–1499 / 1500–1999	4.11% / 21.92% / 54.11% / 19.86%
Monthly income	<¥5k / 5–6.9k / 7–8.9k / 9–9.9k / 10–11.9k / 12–14.9k	6.84% / 12.33% / 34.25% / 21.23% / 19.18% / 6.16%
City type	First-tier / Provincial or New First-tier / Others	43.84% / 17.12% / 39.04%
Delivery method	Station/team / Crowdsourced / Single merchant	54.11% / 43.84% / 2.05%
Contract type	Formal / Outsourcing / None	29.45% / 49.32% / 21.23%
Injury frequency	0 / 1 / 2–3 / ≥4	4.79% / 15.07% / 60.27% / 19.86%
Scenario (freq.)	Rain / Hot / Low temp / Mixed road / Crowded	50.68% / 70.55% / 56.16% / 65.07% / 70.55%
Risky behavior	Speeding / Wrong-way / Red-light running	35.62% / 8.22% / 5.48%
Incentive pressure	“Incentives bring pressure” (=1)	67.81%

3.4 Research Methods and Econometric Models

The dependent variable (number of injuries) is ordered (0, 1, 2–3, 4+). Therefore, we employ an ordered Logit model, taking injury frequency as the response and controlling for individual/job characteristics, platform control, and delivery context factors. This framework evaluates how each explanatory variable affects the cumulative log-odds of falling into higher injury categories.

We adhere to this annotation method to fully present the model structure.

(1) Latent-variable formulation

$$y^* = \alpha + X\beta + \mathrm{E}\gamma + \mathrm{P}\delta + \varepsilon$$

where y^*denotes the latent propensity to be injured; X is the vector of control variables; E captures delivery operation scenario factors; P represents platform control; and ε follows a standard logistic distribution.

(2) Threshold mapping to observed ordered outcome

$$y = j \quad \Leftrightarrow \quad \mu_j < y^* \leq \mu_{j+1}, \quad j = 0,1,\ldots,J$$

(3) Cumulative logit representation

$$\log \frac{Pr(y \leq j \mid \mathrm{X})}{Pr(y > j \mid \mathrm{X})} = \mu_{j+1} - (\alpha + X\beta + \mathrm{E}\gamma + \mathrm{P}\delta)$$

This specification exactly matches your equations and variable partitioning, with thresholds $\{\mu_j\}$ estimated alongside coefficients.

4. Empirical Results

4.1 Benchmark Regression Results

To investigate the determinants of riders' occupational injuries, an ordered Logit model was employed with stepwise inclusion of variable groups. The results of three benchmark models are presented in Table 2.

Gender and health status exhibit consistent and significant effects on injury frequency. Male riders report significantly higher injury frequencies than female riders (coefficients between 1.070 and 1.170, $p < 0.05$). Conversely, self-rated health has a negative association with injury frequency (–0.839, $p < 0.01$), although its significance disappears once job-related and behavioral variables are introduced, suggesting that part of its effect is mediated by work intensity and behavioral factors.

Income level are another robust predictor. Monthly distribution of income is positively and significantly associated with injury frequency across all model specifications (0.669–0.735, $p < 0.01$), indicating that higher earnings are achieved at the cost of greater exposure to risk. Neither the number of orders delivered nor full-time status showed significant effects, implying that workload alone does not determine injury likelihood.

Regarding delivery operation scenarios, the complexity of delivery tasks consistently exerts a strong positive effect (Model 3: 0.909, $p < 0.01$). Dangerous cycling behaviour also raises injury frequency (0.416, $p < 0.05$), though its significance vanishes after controlling for platform factors, suggesting that time pressure and platform management partly account for risky behaviour. Environmental factors such as weather and road conditions remain insignificant.

Table 2. Benchmark and Robustness Regression Results (Key Significant Variables Only)

Variable	Model (2)	Model (3)	Robustness (Low-risk)	Robustness (High-risk)
Male (vs. female)	1.059**	1.170**	–	–
Monthly distribution income	0.622***	0.735***	–	–
Dangerous cycling behaviour	0.416**	n.s.	–	–
Task complexity	1.004***	0.909***	7.572***	1.164***
Single-merchant delivery	–3.049**	–2.868*	–	–
No contract (vs. formal)	1.465**	1.507**	–	–
Delivery time constraint (lenient = high)	–	–0.657*	–2.007***	–2.007***

Notes: n.s. = not significant. Robustness tests use a generalized ordered Logit with recoded injury categories. Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

The type of labor relationship and the delivery method have a statistically significant impact on the safety of riders. The injury rate of riders who did not sign a contract agreement was significantly higher than that of those who signed a contract (coefficient 1.465-1.507, $p < 0.05/0.01$), while the injury rate of riders engaged in the dedicated delivery service of a single merchant was significantly lower than that of riders without a contract (coefficient

-3.049 - -2.868, $p < 0.05/0.1$). In contrast, the differences between formal contracts and outsourcing contracts are not statistically significant. Furthermore, a more lenient delivery time limit was negatively correlated with the frequency of injury (coefficient -0.657, $p < 0.1$), while incentive stress did not show a direct increasing effect on the risk of injury. Overall, these results indicate that occupational injuries are jointly influenced by the complexity of the task, the degree of contract protection, and the platform's time management mechanism, rather than being determined solely by external conditions.

The robustness analysis re-encoded the injury frequency into three ordered categories: "low", "medium", and "high", and the analysis results supported the stability of the aforementioned conclusion. The coefficients of task complexity were 7.572 and 1.164 respectively ($p < 0.01$), and the coefficient of delivery time constraint was -2.007 ($p < 0.01$). These findings further indicate that operational complexity and delivery time management have a statistically significant impact on the occupational safety of riders.

4.2 Mechanism Analysis

To explore the intrinsic mechanism of occupational injury risk, this study employed ordered Logit and OLS models to examine three mediating pathways - working hours, income expectation gap, and risk perception (the results are shown in Table 3).

Table 3. Mechanism and Heterogeneity Analysis (Significant Effects Only)

Mechanism / Interaction	Coefficient	Significance
Mechanisms		
Task complexity → Working hours	0.468	$p < 0.1$
Task complexity → Income expectation gap	–0.674	$p < 0.01$
Monthly income → Income expectation gap	0.606	$p < 0.01$
Time constraint (lenient) → Income expectation gap	0.959	$p < 0.05$
Task complexity → Risk perception	0.129	$p < 0.1$
Gender heterogeneity		
Male × Road conditions	0.954	$p < 0.01$
Male × Time constraint	–1.896	$p < 0.05$
Male × Incentive engagement	–2.872	$p < 0.05$
City-type heterogeneity		
Road conditions × New-tier cities	1.579	$p < 0.01$
Road conditions × Other cities	0.700	$p < 0.1$
Incentive engagement × Other cities	3.439	$p < 0.05$

Notes: Only statistically significant relationships are reported.

Firstly, in terms of the time burden path, the increase in task complexity will prolong the average daily working time of riders (coefficient 0.468, $p < 0.1$). The extension of working hours may increase the probability of fatigue and operational errors, thereby partially explaining the positive correlation between task complexity and injury frequency.

Secondly, in terms of economic paths, the complexity of tasks significantly widened the income expectation gap among riders (coefficient -0.674, $p < 0.01$), reflecting its negative impact on income satisfaction. To bridge the gap between actual income and expectations, some riders may increase their income by taking on more orders or engaging in dangerous behaviors such as speeding, thereby raising the risk of injury. Meanwhile, a higher actual income will also widen the expected gap (coefficient 0.606, $p < 0.01$), while a more lenient delivery time limit helps to

narrow this gap (coefficient 0.959, $p < 0.05$), indicating that a reasonable time arrangement may indirectly reduce the risk of injury by alleviating economic pressure.

Thirdly, in terms of psychological pathways, task complexity enhances riders' risk perception (coefficient 0.129, $p < 0.1$), and risk perception is negatively correlated with time constraints (coefficient -0.200, $p < 0.1$). Moderate risk perception can help enhance cautious behavior, but excessive anxiety may also interfere with operations, reflecting the dual role of risk perception in this.

In conclusion, the formation of occupational injuries is not only related to physical exposure, but is also jointly influenced by time pressure, economic motivation and psychological perception caused by the platform labor system.

4.3 Heterogeneity Analysis

Further analysis examined the group differences in the impact of gender and city type on occupational injuries. The interaction effect shows that male riders have a higher risk of injury in bad road conditions (coefficient 0.954, $p < 0.01$), while female riders are more sensitive to delivery time pressure (coefficient -1.896, $p < 0.05$). In addition, male riders showed a relatively lower risk of injury when facing incentive pressure (coefficient -2.872, $p < 0.05$).

City-level analysis indicates that riders in non-first-tier cities face a higher risk of injury under unfavorable road conditions, with this being particularly evident in new first-tier cities (coefficient 1.579, $p < 0.01$) and small cities (coefficient 0.700, $p < 0.1$). This phenomenon may be related to local transportation infrastructure and law enforcement efforts. Meanwhile, in medium and small cities, the impact of incentive pressure on injury risk is more prominent (coefficient 3.439, $p < 0.05$), which may reflect that riders in these areas have a relatively high dependence on platform income.

Overall, gender differences and urban infrastructure conditions have influenced the extent and direction of the impact of platform control and work intensity on occupational injuries. All model results consistently indicate that occupational injuries to riders are mainly related to the complexity of delivery tasks, platform time regulations, and the degree of contract protection, rather than being mainly determined by demographic or environmental factors. Mediation analysis further identified that working hours, income expectation gap and risk perception are important paths connecting task characteristics with injury risk. These findings reveal the formation mechanism of occupational risks in the platform economy from both institutional arrangements and behavioral responses.

5. Conclusions and Recommendations

5.1 Research Conclusions and Contributions

Based on the above empirical analysis, this study explores the formation mechanism of occupational injuries among food delivery riders.

Firstly, the research results show that there is a significant association between task complexity, dangerous riding behaviors and platform control mechanisms and the risk of rider injury. High-complexity orders (such as long-distance delivery, multiple orders stacked or special customer requirements) increase the frequency of injuries by adding operational load and psychological pressure. Meanwhile, dangerous cycling behaviors such as speeding, running red lights, and driving against traffic also significantly increase the risk of accidents, which is consistent with Shi et al. 's conclusion that illegal cycling is the main source of traffic accidents in the express delivery industry. In contrast, the influence of general environmental factors such as weather and road conditions is not significant. The time limits set by the platform and the algorithmic incentive system still have significant impacts. Similar to the research by Wei et al., this study found that gamified incentives, while enhancing engagement, may also lead to an increase in workload, reflecting that the impact of platform management on security has different directions.

Secondly, the analysis reveals that there are differences among different individuals and their employment characteristics. Male riders have a higher risk of injury than female riders, which may be related to their tendency towards risky behaviors and workload. Riders who have not signed formal contracts have a higher risk of injury than those protected by contracts, demonstrating the protective effect of formal labor agreements. Shi et al. also pointed out that in the absence of institutional protection, riders often rely on personal accident insurance as an alternative. In contrast, riders engaged in single-merchant or dedicated delivery services have a relatively lower injury rate due to their fixed routes and standardized tasks. These differences indicate that both individual characteristics and labor relations can affect the level of risk exposure and need to be given attention in safety governance.

Thirdly, mechanism analysis indicates that task complexity indirectly affects injury risk through the following three paths:

(1) Time constraint - Complex tasks usually prolong working hours and intensify fatigue. This finding is consistent with the research conclusion of Zheng Qi et al., that is, long working hours increase the possibility of accidents.

(2) Income expectation gap - Complex tasks often result in actual income being lower than expected. Some riders may thus extend their working hours or violate traffic rules to make up for the income gap. This phenomenon echoes the research of Tu et al., which also pointed out that riders might bypass the prescribed rest mechanism by taking orders across platforms.

(3) Risk Perception - Moderate risk perception can help promote prudent behavior, but excessive anxiety may also trigger tension and operational errors. Overall, the above-mentioned mechanisms together form a series path that links task complexity with security risks.

Fourth, heterogeneity analysis shows that some groups are at a relatively high risk. Male riders have a higher risk of injury in bad road conditions, which may be related to their degree of work exposure or risk tendency. Riders in provincial cities and small cities have a relatively higher risk of injury due to relatively insufficient infrastructure and greater incentive pressure. Furthermore, riders who have not signed contracts have a higher proportion of injuries when the roads are congested or time is tight, reflecting the importance of organizational guarantees.

Finally, the robustness test supports the stability of the above relationship. The generalized ordered Logit model is used to re-estimate the injury risk into three levels: low, medium and high. The key variable directions remain consistent: the task complexity coefficient remains positive, and the time constraint coefficient remains negative. Overall, this study provides theoretical and empirical references for understanding the occupational injury mechanism of riders by incorporating individual risk behaviors and platform management into a unified analytical framework. The research has expanded the relevant discussions on labor risks in the platform economy, provided new empirical evidence for the self-depletion theory and the resource conservation theory, and identified high-risk groups and policy intervention factors related to rider safety.

5.2 Policy Implications and Practical Recommendations

Building on these findings, several strategies are proposed to mitigate riders' occupational injury risks.

(1) Optimize task-allocation algorithms to lower task complexity.

Platforms should refine dispatch systems to prevent excessive order stacking and unreasonable routing. Limiting simultaneous multi-order assignments and prioritizing geographical rationality can reduce cognitive and physical load, decreasing accident incidence at its source.

(2) Adjust delivery-time settings to ease time pressure.

Time limits should account for delivery distance, traffic, and weather, granting riders flexible margins. Avoiding artificially stringent deadlines can break the cycle in which "time pressure induces risky behavior," thereby improving overall safety.

(3) Strengthen safety training and behavioral regulation.

Platforms should provide routine online and offline safety programs and reward compliance. A balanced system of incentives and sanctions—penalizing dangerous riding while rewarding safe conduct—can cultivate long-term safety awareness and responsible driving habits.

(4) Enhance employment protection for contract-free riders.

Platforms and regulators should extend basic accident or commercial insurance coverage to all riders and encourage formal cooperation agreements that clarify their rights and responsibilities. Institutional protection—combined with access to training and protective equipment—can reduce both perceived insecurity and the incentive to take excessive risks.

In summary, comprehensive intervention—including algorithm optimization, realistic time management, safety education, and institutional protection—can substantially reduce occupational risks for food-delivery workers. Ensuring their safety is not only a matter of corporate social responsibility but also a prerequisite for the sustainable and equitable development of the platform economy.

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