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Traffic crash risk among on-demand food delivery riders in Danang city, Vietnam: Key contributing factors☆

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ABSTRACT

The rise of on-demand food delivery services, operating on gig economy models, has gained popularity worldwide. However, this surge has led to a concerning increase in road traffic crashes involving delivery riders. From this, an urgent need has emerged for a comprehensive study to explore the complex traffic safety issues that this vulnerable group faces daily. Therefore, this study aims to provide in-depth insights into the unsafe riding practices of food delivery riders and to identify effective countermeasures to mitigate the risks they commonly encounter. To address this need, the study has proposed a theoretical framework based on the job demands-resources (JD-R) model. In addition, two constructs, including safety compliance and intention to violate traffic rules, are incorporated into the JD-R model to examine their impact on negative safety outcomes. A survey was conducted in Danang city, Vietnam, gathering responses from 419 delivery riders. Partial Least Squares Structural Equation Modeling was employed to analyze the relationships among the constructs in the developed model. The results highlight the significance of all job aspects as predictors of safety compliance and intentions to violate traffic rules. Furthermore, the study's findings reveal that safety compliance serves as a mediator between job demands and job resources, influencing negative safety outcomes. Based on these research findings, platform firms can strategically consider implementing tailored solutions to enhance traffic safety, discourage participation in unsafe riding practices, and promote sustainable travel behavior patterns among delivery riders.

1. Introduction

Food delivery riding, a key component of the gig economy, involves short-term contractual arrangements between delivery persons and clients for picking up and transporting food from restaurants. Facilitated through mobile applications, this industry has witnessed unprecedented growth, particularly during the COVID-19 pandemic when the demand for home delivery services surged worldwide (Lin, 2021). Technological advancements and the widespread use of the internet have made freelance jobs like food delivery increasingly popular and accessible. Today, food delivery is not only a multi-million dollar industry but also a growing employment sector, providing numerous opportunities for a diverse contract workforce to operate independently and on their own terms. However, food delivery riders hired by platform firms often face several challenges, including working conditions, a lack of safety regulations, and job insecurity, all of which significantly influence their riding behaviors and safety (Nguyen-Phuoc et al., 2022). For instance, in China, over 50 % of food delivery riders surveyed confirmed their involvement in at least one traffic collision in 2022, underscoring the precarious nature of their working conditions (Zhou et al., 2023). Consequently, the assurance of traffic safety during the execution of work at platform companies remains questionable.

Unsafe riding practices (e.g., red light running, phone use while riding, or speeding) significantly contribute to serious crashes among

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food delivery riders. In this regard, previous research has investigated the determinants of risky riding behavior among delivery riders (Shen et al., 2020; Shin et al., 2019; Qin et al., 2021), primarily focusing on exploring the effects of psychosocial factors such as attitudes on risky riding practices. Nevertheless, there remains a significant gap in understanding the influence of job-related factors such as working environment, time pressure, and work overload on the negative safety outcomes (engaging in risky riding practices) among delivery riders. Several studies have examined the effect of job traits on riding behaviors during the delivery process. For instance, Galière (2020) highlighted that the role of time pressure in completing orders within a company's stipulated timeframe may lead to risky riding practices. Similarly, Chen (2023) pointed out that certain work environment factors (e.g., job stress and fatigue) increase the likelihood of risk-taking behaviors among food delivery riders. However, the relationship between job-related factors and safety compliance in the food delivery process remains unexplored. Therefore, there is a need to develop a comprehensive model to examine the impact of time pressure and work environment factors on the intention to violate traffic rules among food delivery riders.

Prior research has started to investigate how food delivery jobs impact the safety of delivery riders. Nguyen-Phuoc et al. (2022) laid the groundwork with their exploration of how job design within the gig economy impacts food delivery riders' adherence to road safety, offering a novel application of the Job Demands-Resources (JD-R) model. This initial study uniquely highlighted the balance between job demands and resources as a pivotal factor in promoting safer riding practices and mitigating health risks. Building on this, Nguyen-Phuoc et al. (2023) innovated by integrating personal demands and resources into the JD-R model, broadening the scope of the investigation into the risks faced by delivery riders and pinpointing job burnout as a key predictor of risky riding behaviors. This extension of their research provided unique insights, emphasizing the necessity of organizational changes to enhance safety. In 2024, Nguyen-Phuoc et al. (2024) further refined their distinctive approach by incorporating the dual processes of the JD-R model to examine direct effects and the nuanced roles of in-role and extra-role safety behaviors. The research distinctly contributed to the field by demonstrating the mediating role of job burnout in safety behavior and revealing how motivational mechanisms can enhance such behaviors. Despite substantial research into the dynamics of job-related factors influencing the safety outcomes among food delivery riders, the literature still lacks a detailed exploration of how individual intentions to engage in such behaviors and their compliance with safety regulations interact with these dynamics. This oversight suggests a need for a more nuanced understanding that considers the direct impacts of job demands and resources and examines the roles of personal intention and regulatory compliance.

To address this gap, the study developed an enhanced theoretical model based on the Job Demands-Resources (JD-R) framework. This model assesses the factors contributing to negative safety outcomes among delivery riders and incorporates elements such as riders' intentions to violate traffic rules and their compliance with safety regulations. The findings of this study are particularly significant as they elucidate the complex interactions between job-related factors and negative safety outcomes within the context of the gig economy. These insights provide valuable theoretical contributions and practical implications, enabling governments and delivery companies to devise targeted strategies to reduce traffic crashes involving this vulnerable group.

2. Theoretical background and hypothesis development

2.1. Job Demands-Resources model

The Job Demands-Resources model (JD-R), as conceptualized by Demerouti et al. (2001), pertains to the balance between job demands and job resources. Job demands include physical, psychological, social, and organizational aspects of work, requiring employee effort and potentially leading to physical or psychological stress. Notably, failing to manage these job demands effectively can increase the likelihood of occupational hazards and risks (Bakker and Demerouti, 2007). Conversely, job resources are supportive factors within the work environment that aid in achieving work goals, reducing job demands, and promoting personal growth and development. These resources form a foundational framework that assists employees in coping with their roles while enhancing their overall well-being and work-related outcomes.

In the working environment, employees encounter various requirements, including risks and cognitive and physical tasks. However, the workplace also offers conditions that foster knowledge acquisition, skill development, and goal attainment, facilitated by resources such as a positive work atmosphere, peer support, and autonomy (Crawford et al., 2010). A supportive workplace and colleagues contribute to safety compliance and reduce the risk of emotional exhaustion (Li et al., 2013; Bronkhorst, 2015). In contrast, job burnout, characterized by a gradual decline in engagement, is associated with reduced employee commitment to their work (Schaufeli and Bakker, 2004; Leiter et al., 2014). In the transportation sector, delivery firms provide adequate job resources for food delivery riders, enhancing work engagement, performance, coping strategies, job satisfaction, and emotional intelligence (Zhang et al., 2022b). Furthermore, the reinforcement of job resources through algorithmic management processes embedded within applications not only serves to optimize profitability but also enhances operational efficiency (Zhang et al., 2022a). Nonetheless, food delivery riders often face risky working conditions such as traffic crashes and adverse weather. These challenges can lead to physical fatigue, reduced cognitive abilities, and negative emotions, prompting workers to expedite task completion. This expedited pace increases their likelihood of involvement in crashes, which in turn can heighten the risk of fatalities and injuries (Nguyen-Phuoc et al., 2023).

In the context of road safety, Fuller's Task Capability Interface (TCI) model is often used to explore factors affecting the safety outcomes of drivers/riders (Fuller, 2000). Similar to JD-R, this model also highlights the importance of balancing demands and resources to achieve positive outcomes. It focuses on aligning task demands (e.g., complex driving environments) with the driver's capabilities (e.g., experience, cognitive abilities). In this study, we focus on the impact of demands and resources at the individual level and the role of delivery organizations. We examine how the structural and operational aspects of these organizations influence the balance between job demands and resources, shaping the safety and well-being of delivery riders. By applying the JD-R model, we aim to understand how organizational factors – such as delivery schedules, support systems, and technological resources – interact with individual capacities to influence outcomes like safety compliance or risk-taking behaviors. This approach allows us to capture a more comprehensive view of how both individual and organizational factors contribute to the overall safety and performance of delivery riders, bridging the gap between the personal capacities emphasized in the TCI model and the broader organizational context considered in the JD-R model.

2.1.1. Job demands

2.1.1.1. Time pressure. Time pressure, an important aspect of job demands, reflects the perception of an excessive workload within a limited timeframe. Notably, among the job-related attributes relevant to food delivery individuals, operating under conditions of time pressure has consistently emerged as a significant predictor of job-related stress (Chen, 2023). This finding aligns with previous research, which has demonstrated correlations between time pressure and other work aspects (e.g., job demands, stress levels, job burnout) among food delivery riders (Silla and Gamero, 2018). Moreover, stress induced by delivery time constraints has been shown to positively influence the intention to

engage in unsafe riding behaviors, including red light running among delivery riders. This predicament is exacerbated by the potential penalties that delivery riders may face for delayed deliveries, including financial penalties and subsequent reductions in their workloads (Christie and Ward, 2019; Zheng et al., 2019).

2.1.1.2. Work overload. Work overload refers to a situation where employees grapple with an excessive workload, irregular work patterns leading to work piling up, the need to work at an accelerated pace, or the obligatory engagement in overtime to fulfill job requirements (Parasuraman et al., 1996). In the context of the food delivery industry, riders face various challenges such as long working hours, time constraints, psychosocial stress, and a high risk of traffic crashes, all of which affect their physical well-being and increase the risk of cardiovascular diseases (Teixeira et al., 2020). Additionally, the demands of work overload and the accumulation of tasks due to irregular work patterns also increase food delivery riders' willingness to take risks or engage in unsafe riding behaviors (Sandhåland et al., 2017). Moreover, excessive workload or insufficient rest days can lead to fatigue and exhaustion among riders, consequently elevating the risk of traffic collisions (Wang et al., 2019).

2.1.1.3. Working environment. The working environment presents a variety of external challenges that hinder the seamless execution of work processes. In the context of delivery services, food delivery riders often face adverse weather conditions (e.g., rain, storms) and encounter obstacles such as communication issues, restaurant errors, and equipment failures while performing their work. Notably, in developing countries such as Vietnam, the poor development of road infrastructure contributes to increased vulnerability to traffic collisions (Rusli et al., 2020). Several previous studies (Zhao et al., 2015; Meng et al., 2015) have emphasized the crucial role of work conditions as an important predictor of both workplace fatigue and inherent risks. Additionally, adverse weather conditions emerge as a notable risk factor, promoting an increased tendency to engage in risky riding behaviors among food delivery riders (e.g., red light running) (Satiennam et al., 2018).

2.1.2. Job resources

2.1.2.1. Feedback. Feedback refers to information provided to employees about their performance, behavior, or work results. It cultivates learning habits among employees to cope with high job demands and enhance job motivation (Taris and Schaufeli, 2015; Schaufeli and Taris, 2014). Previous studies (Salanova and Schaufeli, 2008; Dijkhuizen et al., 2016) have demonstrated the pivotal role of feedback in increasing work engagement. Additionally, the communication of relevant and appropriate information significantly contributes to improving employee safety knowledge (Vinodkumar and Bhasi, 2010). Moreover, it is important to note that the effectiveness of the feedback process depends on meaningful discussions and deliberations among management, supervisors, and employees regarding the work results. This collaborative approach is key to fostering commitment and confidence among management and employees in implementing interventions to improve motivation and engagement at work (Schaufeli and Taris, 2014).

2.1.2.2. Job autonomy. Job autonomy refers to the degree of independence and control that employees have over their tasks, decisions, and work processes. Bakker and Demerouti (2007) suggest that job autonomy can help employees improve their work engagement, generate a sense of energy, and increase efficiency. Furthermore, Sardeshmukh et al. (2012) emphasized that empowerment in a remote work setting can provide the freedom to effectively organize work schedules, thereby reducing the likelihood of job burnout. In the online transportation industry, delivery riders often require a high level of initiative and autonomy, which encompasses activities such as customer acquisition, order processing, and navigating delivery locations. These proactive behaviors are crucial for increasing personal income (Chen, 2023).

2.1.2.3. Safety communication. Safety communication is the systematic exchange of information, feedback, and instructions about potential safety hazards and related risks (Braunger et al., 2015). Its main goal is to prevent crashes and injuries in the workplace by sharing detailed information about potential hazards and offering preventative safety measures. Additionally, effective communication within an organization also improves employee acceptance and adherence to safety protocols, which leads to a noticeable decrease in the likelihood of crashes and increased compliance with safety regulations in the work environment (Hofmann and Morgeson, 1999; Clarke, 2006; Vinodkumar and Bhasi, 2010). Research by Kines et al. (2010) underscores the crucial role of workplace communication in upholding safety standards and improving overall operational performance.

2.1.2.4. Safety training. Safety training is the process of educating employees about recognizing workplace hazards and learning strategies to avoid and reduce them (Vinodkumar and Bhasi, 2010). It is a fundamental element that bolsters employee adherence to safety protocols within the workplace (Cooper and Phillips, 2004). Demirkesen and Arditi (2015) have observed that organizations adopt various methods to meet or enhance safety learning goals, significantly decreasing the number and severity of work-related crashes. In the domain of road traffic safety, delivery companies have put in place extensive programs to increase delivery personnel's understanding of safety rules, including rider training programs and detailed guidance on navigating traffic regulations (Oviedo-Trespalacios et al., 2022). Nonetheless, there is a need for further research to evaluate the actual effects of such training measures on behavioral outcomes, such as the inclination to engage in risky riding practices.

2.2. Safety compliance

Safety compliance is the act of following relevant safety regulations and standards to protect employees from hazards and risks at work (Neal et al., 2000; Clarke, 2006). For delivery riders, this means obeying traffic laws such as wearing helmets, using protective gear, and staying in the correct lanes (Olumide and Owoaje, 2015; Ndagire et al., 2019; Nguyen-Phuoc et al., 2020a). Previous studies have identified frequent violations among delivery riders, like using phones while riding and running red lights (Chen, 2023; Zheng et al., 2019). Governments typically enforce compliance through warnings, fines, and legal actions (Oviedo-Trespalacios, 2018; Rusli et al., 2020; Pervez et al., 2024), but these methods have shown limited success in Vietnam (Nguyen-Phuoc et al., 2019; Nguyen-Phuoc et al., 2020b). Food delivery companies, which have a direct impact on rider behavior, often play a minimal role in promoting safe riding practices. Thus, there is a pressing need to further investigate what influences road safety compliance among food delivery riders within the framework of existing regulations.

2.3. Intention to violate traffic rules

During order fulfillment, delivery riders often intentionally violate traffic rules in an effort to complete multiple deliveries more quickly, thereby increasing their income. These deliberate violations, such as running red lights or speeding, are frequently seen as strategies to enhance job efficiency. Job burnout significantly contributes to this intention, as riders under stress may prioritize speed over safety, leading them to disregard traffic regulations (Chen, 2023). This issue is exacerbated when riders observe colleagues engaging in similar violations, creating a culture of imitation and competition (Palat and Delhomme, 2012). In such an environment, riders may feel pressured to break traffic rules in order to maximize the number of orders completed within a

limited time (Shen et al., 2020). Additionally, demographic factors, such as education level and age, may indirectly influence a rider's willingness to follow traffic rules, as they impact their understanding of traffic regulations and vehicle handling (Wang et al., 2021).

2.4. Negative safety outcomes

Safety outcomes are typically assessed through a combination of structural and quantitative indicators, such as the number of injuries, fatalities, and traffic violations (Christian et al., 2009). In this current study, the evaluation of negative safety outcomes focuses specifically on the prevalence of unsafe riding practices, which include actions such as running red lights, speeding, riding under the influence of alcohol, and becoming distracted while riding. These behaviors are critical indicators of the risks delivery riders take to meet tight deadlines and fulfill multiple orders. Research has consistently highlighted the alarming rate of traffic violations among delivery riders. A study by Qin et al. (2021) revealed that nearly 80 % of delivery riders admitted to running red lights, a figure vastly higher than the 18.06 % observed among regular riders. This stark difference underscores the pressure delivery workers face, which often leads to a greater propensity for risky behaviors in order to complete more deliveries in a shorter period. Similarly, Zhang et al., (2020) reported that 96.3 % of delivery riders admitted to using mobile phones while riding, primarily for work-related tasks such as checking orders, communicating with customers, and navigating. This reliance on mobile phones while riding further increases the likelihood of distracted riding, heightening the risk of crashes.

2.5. Hypothesis development

Empirical research on the link between job demands and safety compliance has produced varied results. Yet, it is essential to investigate how individuals interpret the relationship between job demands and safety compliance – as either challenging opportunities or burdensome tasks. In delivery services, riders tend to neglect safety compliance when dealing with multiple job demands like time pressure (Nguyen-Phuoc et al., 2022) and work overload (Egozi et al., 2022; Chen, 2023). Further, previous studies have indicated that excessive workload prompts employees to take more risks (Sandhåland et al., 2017; Santos et al., 2019). Moreover, the interplay of time pressure and unconventional work settings adds complexity to jobs, motivating delivery riders to adopt unsafe riding behaviors (Oviedo-Trespalacios et al., 2022; Satiennam et al., 2018). Hence, the following hypotheses are proposed:

H1: Job demands negatively affect safety compliance.
H2: Job demands positively affect intention to violate traffic rules.

Past research has underscored the importance of support from supervisors and coworkers in fostering safety compliance at work (Li et al., 2013; Nguyen-Phuoc et al., 2022). For example, in the airline sector, Chen and Chen (2014) found that flight attendants' autonomy is linked to better adherence to safety rules. Similarly, providing real-time auditory feedback to bus drivers has been effective in curbing the intention to violate traffic rules like speeding (Rolim et al., 2014). Communication between supervisors and truck drivers also significantly reduces risky driving tendencies (Hussain et al., 2019). Thus, the following hypotheses are formulated:

H3: Job resources positively affect safety compliance.
H4: Job resources negatively affect intention to violate traffic rules.

In delivery work, increased adherence to safety measures can reduce crash incidences (Nahrgang et al., 2011). Aljabri et al. (2020) reported that strict following of safety rules helped over 80 % of workers avoid injuries. Previous studies also suggested that motorcycle riders equipped with proper protective gear, such as helmets, are less prone to negative safety outcomes (Wang et al., 2021; Muni et al., 2020). Therefore, this hypothesis is advanced:

H5: Safety compliance negatively affects negative safety outcomes.

Intentions represent an individual's plans, which can lead to the execution of a particular behavior (Ajzen, 1996). Gollwitzer et al. (2009) suggested that publicly declaring intentions related to one's identity might reduce the motivation to follow through, potentially impacting performance. In the context of traffic safety, the intention to engage in risky driving has been strongly associated with actual risky behaviors among truck drivers (Poulter et al., 2008; Li et al., 2021). Similarly, motorcyclists with a higher intention to ride unsafely are more likely to exhibit unsafe riding behaviors (Esmaeli et al., 2022). Based on these findings, we propose the following hypothesis:

H6: Intention to violate traffic rules positively affects negative safety outcomes.

The conceptual model to examine the relationships among the latent constructs is showed in Fig. 1.

3. Method

3.1. Survey

To empirically test the proposed theoretical model, a standardized questionnaire was developed, consisting of three distinct sections. The first section serves as an introduction to the study, providing context and pertinent details relevant to the survey, including aspects such as timing, as recorded by the surveyors. The second part of the questionnaire contains a series of questions drawn from relevant literature systematically designed to assess the underlying constructs. Job demands are evaluated through three separate scales: time pressure, work overload, and work environment, while work resources are assessed using four essential factors: feedback, job autonomy, safety communication, and safety training. Safety compliance is measured by five items (e.g., 'I always wear protective gear when carrying out my job', 'I guarantee the highest level of safety when participating in traffic'), while intention to violate traffic rules is evaluated by four items (e.g., 'I intent to violate traffic rules when riding for work'). Engage in unsafe riding behaviors is measured by 13 items such as 'I disregarded red lights when riding for work', 'I held a phone in my hand when riding', 'I felt fatigued when driving for work'. Respondents' opinions are collected using a seven-point Likert scale, ranging from "strongly disagree" to "strongly agree". Subsequently, the questionnaire probes unsafe riding behavior using a frequency-based approach, ranging from "never" to "very often", to ascertain the frequency of such incidents over the past month. The final section of the questionnaire focuses on gathering information on the socio-demographics of the riders, including variables such as gender, age, education, marital status, and income.

The questionnaire was initially drafted in English and later translated into Vietnamese. The English version was carefully reviewed by experts in the field of transportation, and their feedback was incorporated into the final version of the questionnaire. The improved version was then used for a pilot survey with 30 delivery staff in Danang City. During this period, the research team provided minor feedback on word usage. Once these revisions were addressed, the final version of the questionnaire was validated and subsequently deployed for the final survey.

3.2. Data collection

The study used a cross-sectional survey method facilitated by trained investigators, including university students in Danang City, who underwent training to ensure their proficiency. To recruit participants, surveyors strategically targeted public spaces frequented by delivery

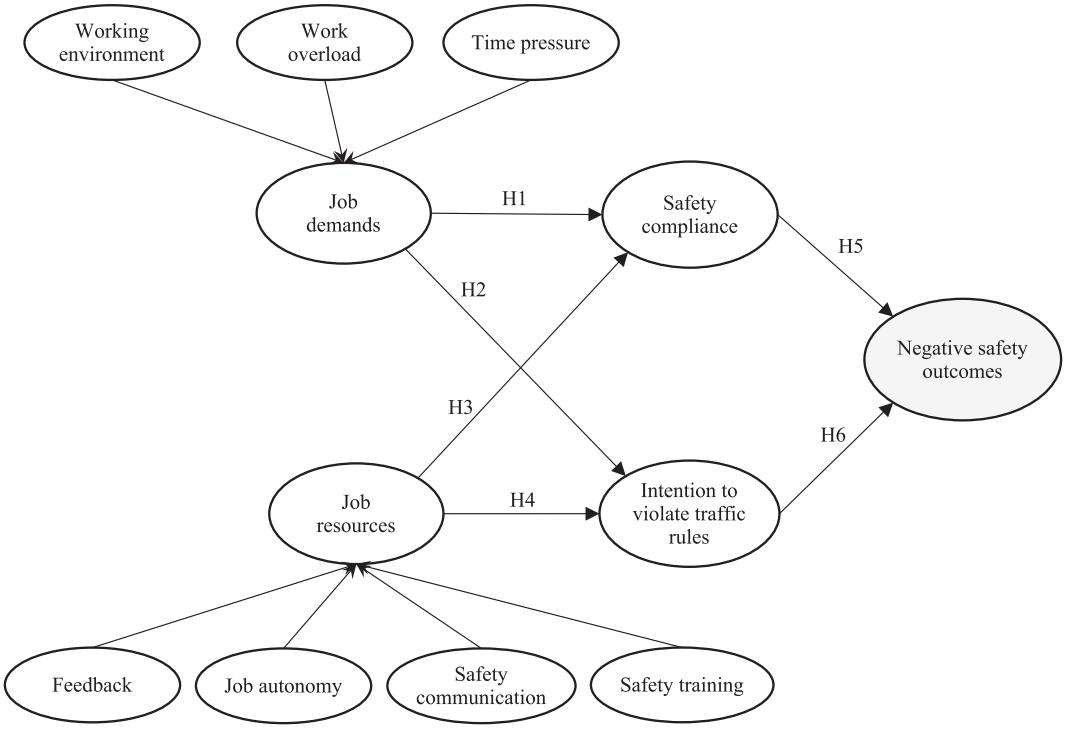

Fig. 1. Proposed theoretical model

riders while waiting for orders in various areas such as lakeside, department stores, parks, and restaurants. Personal invitations were extended directly to the riders, and those who agreed to participate were provided with pens to facilitate the completion of the form. To ensure data quality, participants were compensated with 20,000 VND (around 1 USD) each, while surveyors received 15,000 VND (around 0.7 USD). Surveys were conducted on both weekdays and weekends, carefully avoiding peak delivery times (11:00–13:00 and 17:30–19:30) to minimize incomplete response rates. The survey was conducted in August 2022. Out of the 480 collected forms, 47 were excluded due to incompleteness, inconsistency, or ambiguous responses. The field-based data was subsequently digitized, resulting in 433 responses. After the removal of statistical outliers, the final dataset consisted of 419 valid and usable responses.

3.3. Analytical analysis

The study employs the Partial Least Squares Structural Equation Modeling (PLS-SEM), a dynamic variant of structural equation modeling, chosen specifically due to its distinct advantages. PLS-SEM offers several desirable properties, making it an appropriate choice. First, unlike traditional methods, PLS-SEM does not require normal distributions or a large sample size to provide robust estimates of the underlying models (Hair et al., 2021). In addition, unlike covariance-based SEM (CB-SEM), PLS-SEM operates on a compositional modeling principle instead of following a common factor modeling framework, optimizing the convergence of many indicators. Moreover, PLS-SEM has shown strong performance in the field of safety research (Nguyen-Phuoc et al., 2022, Nguyen-Phuoc et al., 2023). Given the hierarchical structure complexity inherent in the proposed job demands-resources framework, PLS-SEM emerges as the preferred method. This study elaborates a theoretical framework derived from the JD-R model, aiming to shed light on the formation of road safety compliance motivations of food delivery riders, focusing specifically on the frequency of unsafe riding behaviors. The complex nature of higher-order constructs, including job demands and resources, further emphasizes the suitability of PLS-SEM for testing theoretical constructs.

A Structural Equation Model (SEM) consists of two main components: the measurement and structural models. The measurement model defines how latent variables (unobserved constructs) are measured by observed variables (indicators), with factor loadings representing the strength of these relationships and measurement errors accounting for inaccuracies. This involves confirmatory factor analysis (CFA) to assess how well the indicators represent their respective constructs. Each latent construct is represented as a linear combination of its indicators, with factor loadings representing the strength of the relationship. The equation for an indicator y_{ij} can be expressed as:

$$y_{ij} = \alpha_{ij} n_j + \varepsilon_{ij} \quad (1)$$

Where: y_{ij}: is the observed indicator i of latent construct j; α_{ij}: is the factor loading; n_j: is the latent construct score; ε_{ij}: is the measurement error term.

While the measurement errors (ε_{ij}) are assumed to follow a normal distribution with a mean of zero and constant variance, the latent constructs (n_j) are typically standardized to have a mean of zero and variance of one unless otherwise specified. Assessment metrics include indicator reliability assessed through standardized factor loadings, internal consistency measured, convergent validity, and discriminant validity.

On the other hand, the structural model specifies the causal relationships between latent variables, using path coefficients to show the strength and direction of these relationships, and may include mediators

and moderators. The structural model uses path coefficients to represent direct effects. The relationship between an endogenous latent variable n_k and exogenous latent variables n_j is modeled as:

$$n_k = \sum_j \beta_{jk} n_j + \sigma_k \quad (2)$$

Where: β_{jk}: is the path coefficient from latent variable j to latent variable k; σ_k: is the structural error term.

The structural error terms (σ_k) are assumed to follow a normal distribution with a mean of zero and are uncorrelated with the latent constructs and indicators, and the relationships between latent variables are linear unless specified otherwise. Assessment metrics include path coefficients estimated via Partial Least Squares (PLS), with significance determined by t-values and p-values, and model fit evaluated using indices like the Standardized Root Mean Square Residual (SRMR).

By evaluating the measurement and structural components, SEM ensures the validity and reliability of the proposed model. The linear functional forms and the specified distributional assumptions provide a robust framework to explore the relationships between latent constructs and their impact on the research hypotheses.

4. Results

4.1. Descriptive statistics

An overview of the survey participants' demographic profiles is shown in Fig. 2. The majority of respondents were male, and the demographic dominated the sample, comprising 99 % of respondents. Regarding marriage status, nearly 79 % of survey participants identified as single, with the average age being 25.30 years (SD = 6.01). In terms of occupation, the number of part-time delivery staff is much higher than that of full-time employees, accounting for around 73 % and 27 %, respectively. Regarding education level, about half of respondents have a college or university degree. Furthermore, nearly 50 % of participants reported a monthly income ranging between 5 and 10 million VND.

Fig. 3 illustrates the frequency of unsafe riding behaviors exhibited by delivery riders using applications in the month before the survey. Notably, the most common behavior was using mobile phones while riding, with the majority (74.7 %) of respondents admitting to their involvement in such behavior. In addition, a notable portion (12.6 %) of respondents admitted to red light running in approximately half of their journeys. Moreover, instances of other unsafe riding behavior were

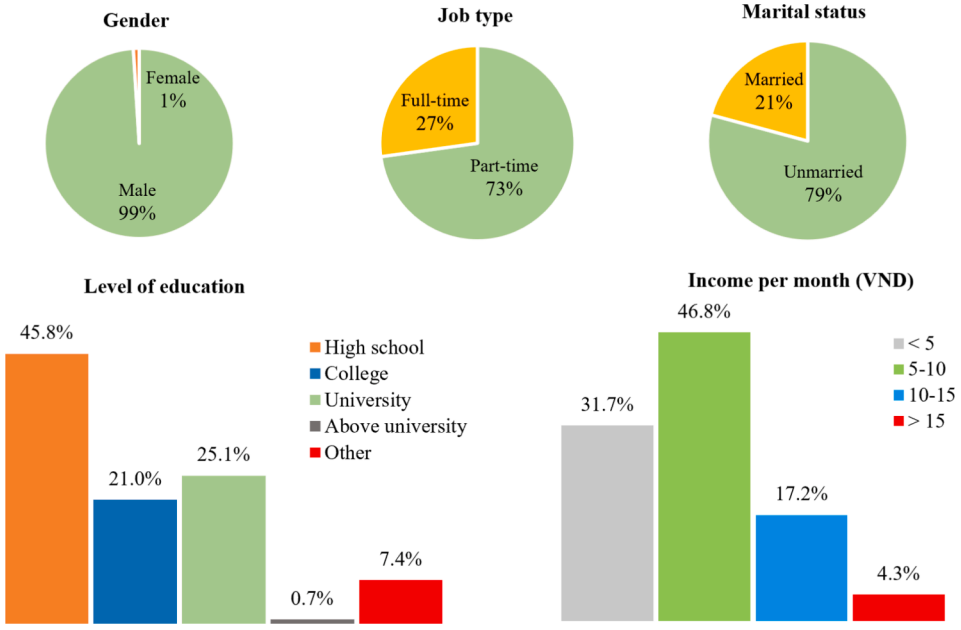

Fig. 2. Survey respondent characteristics (Note: *1 USD = 23,000VND)*

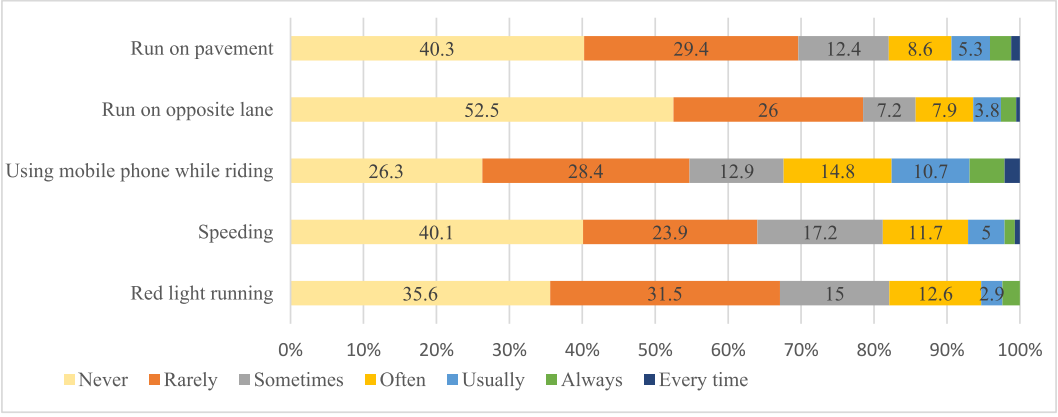

Fig. 3. Self-reported involvement in unsafe riding behaviors among food delivery riders

Table 1
Evaluation of the first-order measurement model

Constructs	Items	Outer loadings	CA	CR	AVE
Time pressure (TIP)			0.838	0.847	0.758
	TIP1	0.704			
	TIP2	0.909			
	TIP3	0.903			
Work overload (WOL)			0.701	0.714	0.626
	WOL1	0.735			
	WOL2	0.783			
	WOL3	0.852			
Working environment (WEN)			0.742	0.747	0.795
	WEN1	–			
	WEN2	0.881			
	WEN3	0.902			
Feedback (FDB)			0.778	0.788	0.693
	FDB1	0.838			
	FDB2	0.887			
	FDB3	0.769			
Job autonomy (JAT)			0.862	0.863	0.784
	JAT1	0.890			
	JAT2	0.909			
	JAT3	0.856			
Safety communication (SAC)			0.843	0.843	0.761
	SAC1	0.887			
	SAC2	0.875			
	SAC3	0.854			
Safety training (SAT)			0.912	0.913	0.919
	SAT1	0.961			
	SAT2	0.957			
Safety compliance (SCP)			0.858	0.866	0.639
	SCP1	0.731			
	SCP2	0.851			
	SCP3	0.844			
	SCP4	0.786			
	SCP5	0.779			
Intention to violate traffic rules (ITT)			0.830	0.838	0.664
	ITT1	0.807			
	ITT2	0.865			
	ITT3	0.839			
	ITT4	0.742			
Negative safety outcomes (Engage in unsafe riding practices) (SAO)			0.888	0.896	0.640
	SAO1	0.850			
	SAO2	–			
	SAO3	0.778			
	SAO4	0.791			
	SAO5	–			
	SAO6	0.754			
	SAO7	–			
	SAO8	–			
	SAO9	–			
	SAO10	–			
	SAO11	–			
	SAO12	0.833			
	SAO13	0.790			

recorded, including speeding (11.7 %), riding on the sidewalk (8.6 %), and traveling in the opposite direction (7.9 %) in about half of their trips.

4.2. Evaluation of measurement models

4.2.1. First-order measurement model

To assess the first-order measurement model, Cronbach's alpha (CA) and composite reliability (CR) scores were computed for each construct, following the guidelines outlined by Hair et al. (2021). As displayed in Table 1, the results of the CA and CR scores for all variables exceeded the recommended threshold of 0.7, thereby confirming the reliability of the model, which is consistent with the standards established by Henseler and Sarstedt (2013). In assessing internal consistency reliability, a threshold value of 0.7 was employed, resulting in the retention of all indices across measurement models, with outer loadings ranging from 0.704 to 0.961. Notably, this led to the exclusion of WEN1, SO2, SO5, SO7, SO8, SO9, SO10, and SO11 from the theorized dimensions of working environment and engagement in unsafe riding behaviors, respectively, due to their outer loadings falling below the threshold value of 0.7 (Henseler et al., 2009). Furthermore, the average variance extracted (AVE) values, as shown in Table 3, consistently exceeded the minimum threshold of 0.5, which is in line with the guideline proposed by Fornell and Larcker (1981). The confirmation of high convergence of these external models emphasizes the validity and robustness of the proposed constructs.

To determine the validity of the discrimination, the present study used both the Fornell-Larcker criteria (Fornell and Larcker, 1981) and the recently validated Heterotrait-Monotrait Ratio (HTMT) approach (Henseler et al., 2015). The evaluation involves comparing the square root of AVE of each construct, represented by bold diagonal elements in Table 2, with the correlation coefficients linked to their associations with other latent variables in the model. The HTMT values, as shown in Table 3, are below the threshold value of 0.85. This comprehensive evaluation is reinforced by the combination of results from both methods, ultimately corroborating the establishment of a satisfactory discriminant value (Henseler et al., 2015), thus affirming the validity of the model and ensuring readiness for the subsequent analytical analysis.

4.2.2. Second-order measurement model

The analysis reveals a second-order configuration in both job demands and job resources, particularly highlighting the construction and evaluation of a higher-order measurement model. This assessment was conducted by taking into account the external loadings of the first-order constructs and their corresponding Variance Inflation Factors (VIF), as displayed in Table 4 (Duarte and Amaro, 2018). In the case of second-order constructs related to job demands, including TIP, WOL, and WEN, all three components represent outer weights that exceed the cut-off value of 0.1 (Lohmöller, 2013). The respective t-values, established over 5,000 repetitions, represent their respective levels of statistical significance. This empirical validation demonstrates the significant contribution of these components to the formation of higher-order structures (Hair Jr et al., 2021). In addition, the VIF values for these first-order structures range from 1.146 to 1.578, much lower than the widely accepted threshold of 5.0, indicating no multicollinearity among the constructs (Hair et al., 2011). Concurrently, the quadratic structure related to work resources includes four indicators: FDB, JAT, SAC, and SAT. These values, retained as scores for external loads, meet the outlined criteria for t-value and VIF value, as shown earlier. Parameters identified as statistically significant in this context were included in the subsequent evaluation of the structural model.

4.3. Structural model

4.3.1. Model fit

To evaluate the model's adequacy compared with the proposed structure, this study used a standard root mean square (SRMR) derived from a process based on bootstrap. The SRMR, calculated at 0.077, falls below the recommended threshold of 0.08, as recommended by Hu and Bentler (1999). This indicates a favorable association between the tested

Table 2
Fornell-Larcker indicator of first-order measurement model

Constructs	AVE	FDB	SAO	ITT	JAT	SAC	SCP	SAT	TIP	WOL	WEN
FDB	**0.693**	**0.833**									
SAO	**0.640**	−0.110	**0.800**								
ITT	**0.664**	−0.091	0.517	**0.815**							
JAT	**0.784**	0.408	0.014	0.050	**0.885**						
SAC	**0.761**	0.303	−0.206	−0.137	0.234	**0.872**					
SCP	**0.639**	0.402	−0.192	−0.164	0.370	0.344	**0.800**				
SAT	**0.919**	0.205	−0.362	−0.177	0.084	0.561	0.160	**0.959**			
TIP	**0.758**	0.033	0.274	0.282	0.200	−0.042	−0.007	−0.003	**0.870**		
WOL	**0.626**	0.192	0.084	0.096	0.277	0.084	0.150	0.034	0.344	**0.791**	

Table 3
HTMT of first-order measurement model

Constructs	FDB	SAO	ITT	JAT	SAC	SCP	SAT	TIP	WOL	WEN
FDB										
SAO	0.129									
ITT	0.115	0.591								
JAT	0.499	0.068	0.064							
SAC	0.370	0.237	0.165	0.273						
SCP	0.488	0.210	0.180	0.433	0.400					
SAT	0.242	0.403	0.202	0.095	0.640	0.176				
TIP	0.042	0.326	0.343	0.234	0.058	0.076	0.035			
WOL	0.285	0.140	0.140	0.360	0.127	0.215	0.045	0.446		
WEN	0.268	0.070	0.115	0.227	0.029	0.162	0.057	0.362	0.402	

Table 4
Assessment of the second-order measurement model

Second-order / First order constructs	VIF	Outer loadings	SD	t-value	p-value
Job demands					
Time pressure (TIP)	1.184	0.665***	0.187	3.562	< 0.001
Work overload (WOL)	1.194	0.355**	0.167	2.127	0.038
Working environment (WEN)	1.146	0.301**	0.143	2.110	0.035
Job resources					
Feedback (FDB)	1.275	0.445***	0.050	8.808	< 0.001
Job autonomy (JAT)	1.226	0.377***	0.059	6.397	< 0.001
Safety communication (SAC)	1.578	0.395***	0.043	9.158	< 0.001
Safety training (SAT)	1.471	0.212***	0.055	3.839	< 0.001

Notes: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 5
Direct effects among constructs

Path Relation (Hypothesis)	Path Coefficient (β)	SD	t-value	p-value	Result
H1: JDE → SCP	−0.001^{ns}	0.056	0.006	0.995	**Rejected**
H2: JDE → ITT	0.275***	0.058	4.785	< 0.001	Supported
H3: JRE → SCP	0.488***	0.055	8.868	< 0.001	Supported
H4: JRE → ITT	−0.163***	0.054	3.031	0.002	Supported
H5: SCP → SAO	−0.109*	0.048	2.300	0.021	Supported
H6: ITT → SAO	0.499***	0.046	10.849	< 0.001	Supported

Notes: ^{ns} non-significant; ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

model and the collected data, confirming the model's fit.

4.3.2. Relationships

Using a bootstrapping algorithm consisting of 5,000 resamplings, a comprehensive assessment of the hypothesized relationships of the proposed structural model was conducted. This thorough testing confirmed 6 hypotheses, each supported by statistical evidence, with corresponding test t-values below the 5 % significance level, as shown in Table 5 and Fig. 4 (Hair et al., 2021). Specifically, the study revealed that job demands had a positive effect on the intention to be involved in unsafe riding behavior ($\beta_{JDE\rightarrow ITT} = 0.275$, t = 4.785, $p < 0.001$), while job resources had a negative impact ($\beta_{JRE\rightarrow ITT}$ = -0.163, t = 3.031, $p < 0.002$). In contrast, job resources had a positive impact on safety compliance ($\beta_{JRE\rightarrow SCP} = 0.488$, t = 8.868, $p < 0.001$). Besides, the intention to be involved in unsafe riding behavior had a positive effect on the frequency of unsafe riding behavior ($\beta_{ITT\rightarrow SAO} = 0.499$, t = 10.849, $p < 0.001$), while safety compliance displayed a negative impact ($\beta_{SCP\rightarrow SAO}$ = -0.109, t = 2.300, $p < 0.021$). The relationship between job demands and safety compliance was not statistically significant.

In addition to assessing the direct relationships, this study also explores the potential mediating effects caused by the proposed constructs. As displayed in Table 6, the findings revealed that the relationship between job resources and unsafe riding behavior was fully mediated by safety compliance ($\beta_{JRE\rightarrow SCP\rightarrow SAO} = 0.137$, t = 4.307, $p < 0.001$) and intention to be involved in unsafe riding behavior ($\beta_{JRE\rightarrow ITT\rightarrow SAO} = -0.081$, t = 2.759, $p < 0.006$). Safety compliance also played a mediating role in the relationship between job demands and unsafe riding behavior ($\beta_{JDE\rightarrow SCP\rightarrow SAO} = 0.053$, t = 2.253, p = 0.024). In contrast, the relationship between intention to be involved in unsafe riding behavior in the interaction between job demands and unsafe riding behavior was eliminated because there were no statistically significant results.

The present study also conducted a comprehensive investigation of the combined effects of all constructs on risky riding behaviors, as detailed in Table 7. The results highlighted the role of key job aspects in predicting the unsafe riding behavior of delivery riders. Job demands had a positive effect on unsafe riding behavior ($\beta_{JDE\rightarrow SAO} = 0.117$, t = 3.963, p < 0,001). Conversely, job resources had a negative impact ($\beta_{JRE\rightarrow SAO} = -0.135$, t = 3.824, $p < 0.001$). These results shed light on the complex relationship between job-related factors and unsafe riding behaviors, offering valuable insights for interventions aimed at enhancing delivery rider safety.

4.3.3. Predictive capability evaluation

The evaluation of prediction accuracy (R^2) and predictive relevance (Q^2), is a standard process in assessing the predictive ability of structural models (Hair et al., 2021). This assessment is conducted using a blindfolding algorithm, which requires that both R^2 and Q^2 values for each

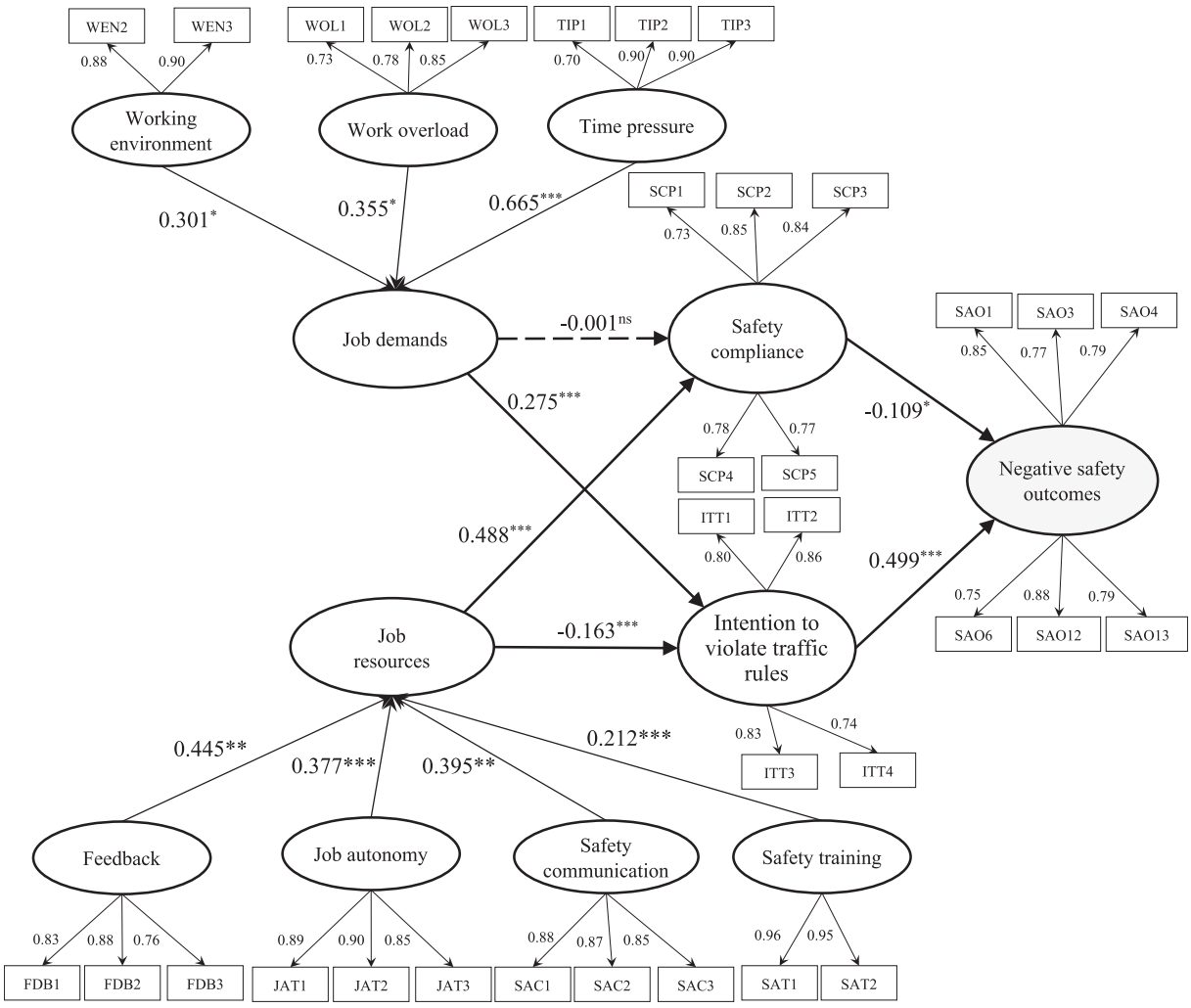

Fig. 4. Result of PLS-SEM model

Table 6
Indirect effects among constructs

Indirect Effect	Path Coefficient (ß)	SD	t-value	p-value
JDE → SCP → SAO	−0.053*	0.024	2.253	0.024
JDE → ITT → SAO	−0.001^{ns}	0.007	0.005	0.996
JRE → SCP → SAO	0.137***	0.032	4.307	< 0.001
JRE → ITT → SAO	−0.081**	0.030	2.759	0.006

Notes: ^{ns} non-significant, $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 7
Total effects among constructs

Total Effect	Path Coefficient (ß)	SD	t-value	p-value
JDE → SAO	0.137***	0.035	3.963	<0.001
JRE → SAO	−0.135***	0.035	3.824	<0.001

Notes: ^{ns} non-significant, $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

structure should be larger than zero to achieve a certain level of prediction accuracy (Henseler et al., 2009; Hair et al., 2021). In accordance with this, all three constructs in the present study satisfy this criterion, as indicated by their respective R^2 values ($R^2_{ITT} = 0.073$, $R^2_{SCP} = 0.254$, $R^2_{SAO} = 0.279$) and Q^2 values ($Q^2_{ITT} = 0.054$, $Q^2_{SCP} = 0.142$, $Q^2_{SAO} = 0.171$) (Hair et al., 2021).

5. Discussion

5.1. Theoretical implications

The present study delved into the factors affecting safety compliance and unsafe riding behaviors among food delivery riders, extending the Job Demands-Resources (JD-R) model to provide new theoretical insights. Firstly, our findings, in line with prior research (Turner et al., 2012; Nguyen-Phuoc et al., 2022), indicate that job demands alone do not directly lead to safety compliance. This lack of direct causation might reflect more systemic and widespread cultural issues in Vietnam, where there is generally low adherence to rules. Nonetheless, a positive link between job resources and safety compliance has been established, consistent with the literature (Li et al., 2013; Chen and Chen, 2014; Chu et al., 2020), suggesting that sufficient job resources, like feedback and safety communication, encourage riders to follow safety regulations more closely. The study underscores that in places like Vietnam, enhancing rule compliance among food delivery riders may require active and explicit industry support and involvement, thus emphasizing the industry's responsibility in making safety factors more prominent.

Secondly, our findings reveal that job demands positively affect the intention to engage in unsafe riding behaviors, whereas job resources have a negative effect on this intention. This introduces a new aspect to the existing literature by associating job-related factors with the psychological inclination to perform unsafe behaviors, a subject not extensively covered by previous research (Nguyen-Phuoc et al., 2022;

Nguyen-Phuoc et al., 2023), which typically examined factors that directly result in unsafe riding behaviors. These findings highlight the importance of interventions that address predispositions to behaviors at a cognitive level as well as the behaviors themselves.

Thirdly, we noted a weak but significant negative correlation between safety compliance and unsafe riding behaviors, affirming the findings of earlier research (Nahrgang et al., 2011; Lemke et al., 2021; Li et al., 2013) and reinforcing the significance of adhering to safety regulations. Additionally, the study identified that the connection between job resources and unsafe riding behaviors is influenced by the riders' intentions to engage in these behaviors, providing a more detailed perspective on the interplay between safety compliance and intention within the framework of job characteristics.

Finally, the research demonstrated that job demands and resources are complex constructs that greatly contribute to our understanding of the delivery industry's workings. In particular, time pressure was identified as significant job demand, whereas feedback and job autonomy were shown to be key job resources. These insights emphasize the critical role of job characteristics in influencing unsafe riding behavior and in promoting safety compliance among delivery riders, particularly in low- and middle-income countries. Furthermore, the findings suggest that future research should avoid oversimplifying job demands, as its multidisciplinary nature can unveil more subtle underlying causes.

This research significantly advances our understanding of safety compliance and unsafe riding behaviors in the food delivery industry by elucidating the intricate interplay between job demands, job resources, and the psychological intentions of riders. By integrating these elements into the Job Demands-Resources model, the research highlights how psychological factors mediate the relationship between job conditions and negative safety outcomes, particularly emphasizing the role of intentions. These findings underscore the complexity of job demands and resources, suggesting that interventions need to be thoughtfully designed to address both the structural and psychological dimensions of work. The study's insights are especially pertinent for low- and middle-income countries, where the rapid expansion of the gig economy can benefit from enhanced safety protocols tailored to the unique challenges faced by delivery riders. The theoretical and practical contributions of this research provide a robust foundation for future studies and offer valuable guidance for both policymakers and industry stakeholders aiming to foster safer working environments.

5.2. Practical implications

The results of this study offer several practical implications for organizations, particularly those within the food delivery services industry. First, the primary finding underscores the urgent need for companies to implement strategies that alleviate the pressures of job demands faced by the riders, thereby reducing intention to violate traffic rules and negative safety outcomes. Time pressure has been identified as the most critical factor among job demands, highlighting the challenges posed by tight delivery schedules, which often lead to increased risk-taking on the roads. To address this issue, platform companies can implement targeted interventions, such as extending order fulfillment times, to reduce the impact of potential delivery obstacles like traffic congestion or unforeseen delays. By creating a more flexible and supportive environment for delivery riders, these measures would reduce the intention to violate traffic rules and encourage safer driving practices during deliveries.

Second, it is essential to strengthen job resources to mitigate the effects of increasing job demands in the delivery industry. Feedback and safety communication play a key role in promoting safety behaviors and minimizing the intention to violate traffic regulations within organizations. Platform companies can create safer working environments by providing riders with detailed feedback from customers or supervisors after deliveries. Moreover, companies should encourage open discussions with their employees about the challenges they encounter during deliveries. Since riders play a crucial front-line role, it is important to involve them in shaping safety policies. By fostering collaboration, businesses can develop comprehensive safety regulations that help prevent dangerous incidents on the roads. Ultimately, these strategies are crucial for improving safety compliance and reducing the intention to violate traffic rules among delivery riders, which in turn reduces negative safety outcomes.

5.3. Limitations

While the current study makes several important contributions, it also has some limitations that warrant consideration. First, the study focused primarily on the effects of two key aspects of the JD-R model – job demands and job resources – on safety compliance, intention to violate traffic rules, and negative safety outcomes among delivery riders. Future research could enhance the scope of this model by incorporating additional factors, such as job stress and job motivation, as suggested by Bakker and Demerouti (2007). Including these elements could provide deeper insights into how to proactively boost rider motivation and overall well-being, thereby reducing negative safety outcomes. Second, this study relied on self-reported measures to assess safety-related variables, which introduces the potential for common method bias. In safety research, such self-reporting can lead to underreporting of injuries and near misses due to social desirability or environmental pressures (Hofmann and Stetzer, 1996). Future studies could benefit from employing a more diversified approach to data collection, incorporating objective data sources or observational methods to enhance the accuracy and reliability of the findings. Third, exploring the application of safety climate theory could be highly beneficial in the context of food delivery services. Future research could integrate this theory to better understand and improve the working conditions of delivery riders, fostering a safer work environment and strengthening the connection between delivery riders and their job roles. This approach could significantly contribute to the development of safety interventions that are both effective and sustainable. Finally, a potential limitation of this study is that it does not account for risk-compensating behaviors, where the delivery riders may engage in risky practices, such as mobile phone use, but simultaneously take measures to mitigate perceived risks. As noted by Oviedo-Trespalacios et al. (2020), drivers may adjust their behavior to compensate for the distraction, which may reduce the immediate safety risks, and this complexity is not fully explored in our current model. This point presents an excellent opportunity for further research.

6. Conclusions

The current study comprehensively examines the factors influencing negative safety outcomes among food delivery riders in Danang City. By applying an extended Job Demands-Resources (JD-R) model, the research evaluates various job demands and resources within the work environment and their impact on safety compliance and the intention to violate traffic rules. This study has highlighted several significant findings: the critical role of time pressure as a job demand and how it notably increases the likelihood of unsafe riding practices; the protective effect of job resources like feedback and safety communication in enhancing safety compliance; and the mediating role of riders' intentions in the relationship between job conditions and safety outcomes. These relationships provide clear insights for service companies to delve into what motivates delivery riders' engagement in risky riding practices. Leveraging these findings, the research proposes practical interventions to reduce traffic collisions, thereby promoting a safer and more dynamic work environment for this highly vulnerable group within the delivery industry. These interventions can significantly contribute to the ongoing efforts to ensure the well-being of delivery riders and the safety of the broader community.

CRediT authorship contribution statement

Nhat Xuan Mai: Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Duy Quy Nguyen-Phuoc:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Bien Van Nguyen:** Conceptualization, Writing – review & editing, Writing – original draft. **Amjad Pervez:** Writing – review & editing, Writing – original draft. **Oscar Oviedo-Trespalacios:** Writing – review & editing, Writing – original draft, Conceptualization.

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