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What factors contribute to in-role and extra-role safety behavior among food delivery riders?

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ABSTRACT

Food delivery riders face significant road safety risks globally. Previous studies have primarily focused on the direct relationship between job demands, job resources, and road safety behaviors, often neglecting the potential indirect paths through dual processes, namely the health impairment process and the motivational process, which may lead to dangerous riding behaviors. Additionally, the impact of organizational citizenship behaviors on the safety of food delivery riders within the industry remains unexplored. This study aims to address these gaps by applying the dual processes of the Job Demands-Resources model (JD-R) to identify factors influencing the safety behaviors of food delivery riders in Vietnam. Data were collected through face-to-face surveys with 410 riders in public places. The findings show a nuanced interplay between job demands, resources, and safety behaviors. Specifically, job burnout acts as a bridge, mediating the influence of job demands on in-role safety behaviors. On the other hand, job resources-encompassing facets like job autonomy, performance feedback, technology support, and work support-indirectly shape both in-role and extra-role safety behaviors via the conduit of motivation. These resources not only bolster motivation but also serve as pillars in fostering a culture of safety among riders. This research not only deepens our understanding of the determinants of food delivery riders' safety behaviors but also highlights the pivotal role food delivery companies play in shaping these behaviors. By prioritizing the holistic well-being of their riders and offering robust support, these companies can foster an environment conducive to safety. Additionally, by integrating additional dimensions of job demands and resources into the JD-R model, this study paves the way for more comprehensive and nuanced future research in this domain.

1. Introduction

Over the past few years, there has been a significant shift in how people consume food worldwide. Thanks to the emergence of user-friendly apps, the adoption of a 'hybrid' consumption culture, and tech-enabled driver networks, the online food delivery industry has

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been experiencing a remarkable surge (Su et al., 2022). In fact, since 2017, the global online food delivery market has tripled in value, with its worth surpassing USD 150 billion in 2021 (Ahuja et al., 2021). Vietnam's food service industry is the third-largest market in south-east Asia, which has contributed to the growth of food delivery services across the country (Pham, 2022). Moreover, the food delivery sector in Vietnam is currently witnessing intense competition among various domestic and foreign food service providers, such as Grab Food, Shopee Food, Baemin, and GoJek.

While online food delivery services have gained immense popularity in recent years, especially in low- and middle-income countries, there are pressing concerns about the safety, health, and welfare of food delivery riders. Numerous studies (refer to Table A1) have documented a high frequency of delivery-related crashes and safety violations. For instance, Li et al. (2020) reported more than 3,000 food delivery-related crashes in Nanjing, China, during the first half of 2019. In a startling revelation, a delivery rider in Shanghai, China, faced fatal injuries in a road crash approximately every 2.5 days in early 2017 (Zheng et al., 2019). Such dismal safety outcomes often arise from unfavorable working conditions and job-related hazards (Zheng et al., 2019; Byun et al., 2020; Qin et al., 2021; Nguyen-Phuoc et al., 2023; Nguyen-Phuoc et al., 2022; Oviedo-Trespalacios et al., 2022; Christie and Ward, 2023; Nguyen et al., 2023). For context, delivery riders in Shanghai and Nanjing typically worked about 9.1 h daily (Zheng et al., 2019), and a significant 64 % of delivery riders in Athens, Greece, did not have crash insurance (Papakostopoulos and Nathanael, 2021). Furthermore, various studies highlighted the industry's lax road safety protocols, including inadequate helmet use and motorcycle upkeep (Byun et al., 2020; Goods et al., 2019; Papakostopoulos and Nathanael, 2021). Therefore, to address the road safety challenges in the food delivery industry, a deeper understanding of delivery riders' safe riding behaviors and the determinants behind them is essential.

Over the past few decades, the Job Demands-Resources model (JD-R) and its subsequent versions have been extensively applied to explore the link between organizational antecedents and job outcomes across diverse sectors (Demerouti et al., 2001; Chen and Chen, 2014). The JD-R model posits that specific job demands and resources shape the working conditions of individuals. These conditions, in turn, give rise to two primary processes: job burnout and job engagement, both of which influence a range of job outcomes (Schaufeli and Bakker, 2004). Unlike other theoretical frameworks in occupational health psychology research, such as the demand-control-support model and job crafting models, the JD-R model does not solely focus on either job demands or resources. Instead, it suggests that any job demand or resource can influence employee health and well-being. This flexibility makes the JD-R model highly adaptable, fitting a broad spectrum of work settings. For example, within the realm of food delivery services, employees often face job demand-related challenges like time pressure, work overload, and physically strenuous tasks. These challenges are closely linked to heightened burnout and diminished job motivation (Bakker et al., 2003). Conversely, workplaces might offer various job resource-driven benefits, such as social support, job autonomy, and performance feedback. These resources can foster employee self-growth and facilitate goal achievement (Crawford et al., 2010).

Empirical studies within the transport sector have validated the influence of job demands and resources on aspects such as job burnout (Schaufeli, 2004; Friswell and Williamson, 2008; Nguyen-Phuoc et al., 2022) and job motivation (Nahrgang et al., 2011; Hakanen et al., 2008). However, when considering food delivery riders specifically, there is limited research applying the JD-R model to comprehensively assess both the positive and negative factors influencing riders' safety practices within an integrated framework. Much of the current literature primarily focuses on the direct relationships between job demands, resources, and road safety behaviors (Turner et al., 2012; Bronkhorst, 2015), often overlooking potential indirect pathways via dual processes that might contribute to unsafe riding behaviors.

In work-related transport situations, risky behaviors are not merely consequences of adhering to road rules but can also be viewed as an aspect of organizational citizenship in the workplace. Recent research has delineated the concept of organizational citizenship behaviors into two distinct categories: in-role behaviors and extra-role behaviors (Fugas et al., 2012b; Hofmann et al., 2003). Drawing from their research on Taiwanese aircrew settings, Chen and Chen (2014) emphasized the need for more studies to examine the causal relationships between organizational antecedents (such as job demands and job resources) and both in-role and extra-role safety behaviors across various professions and cultures. In the context of food delivery riders, there is an expectation for them to exhibit in-role safety behaviors that align directly with organizational goals. This includes the correct use of protective equipment, adhering to safety policies, and following work procedures. Additionally, they often engage in extra-role safety behaviors that bolster the organizational safety climate, such as displaying attitudes against other drivers' recklessness and discouraging driving under the influence. Thus, food delivery riders adept in both in-role and extra-role safety behaviors are less susceptible to road accidents (Yang et al., 2021; Ji et al., 2019). Grasping how specific job demands and resources shape the in-role and extra-role safety behaviors of food delivery riders can empower organizations to design effective safety training initiatives and foster a sustained safety culture. However, to date, no research has integrated these two facets (i.e., in-role and extra-role safety behaviors) of organizational citizenship behaviors to understand safety practices among riders in the food delivery sector.

A key gap in the literature is the predominant focus of existing studies on the direct relationship between job demands, job resources, and road safety behaviors (Turner et al., 2012; Bronkhorst, 2015), often neglecting potential indirect pathways through dual processes leading to risky riding behaviors. Furthermore, no research has integrated the two sub-concepts of organizational citizenship behaviors to probe into riders' safety practices within the food delivery sector. This study aims to bridge these gaps by adapting the dual processes of the JD-R model to discern factors affecting the safety behaviors of food delivery riders, both within and beyond their job roles. The adapted JD-R model seeks to clarify not just the negative psychological state (burnout) but also its positive counterpart (job motivation). This research enhances the established JD-R model by incorporating dimensions of job demands (such as work overload and application issues) and job resources (including job autonomy, rewards, information, technological support, and work support). Additionally, while prior research on delivery riders' road safety predominantly centers on high and upper-middle-income nations like China and South Korea, this study is set in two major cities, Hanoi and Ho Chi Minh City, in Vietnam, a lower-middle-

income country. This shift in focus provides valuable insights into the motorcycle traffic dynamics in lower-middle-income countries, especially given the immense disparities highlighted by previous studies regarding the availability of safety-related research in LMICs (Haghani et al., 2022). The findings from this investigation can assist authorities and delivery service providers in formulating strategies to mitigate road safety risks in the food delivery industry.

2. Theoretical background

2.1. Job demands-resources (JD-R) model

The JD-R model systematically assesses the impact of working environments on workers from two perspectives: job demands and job resources (Demerouti et al., 2001). Job demands refer to "physical, social, or organizational aspects of the job that require sustained physical or mental effort and are associated with certain physiological and psychological costs" (Demerouti et al., 2001). Job resources involve the physical, psychological, social, or organizational aspects of the job that can either (1) help in achieving professional goals, (2) reduce job demands and the associated physiological and psychological costs, or (3) support self-growth (Demerouti et al., 2001). Therefore, while job resources foster a positive interaction between an organization and its employees, job demands are associated with a negative one (Demerouti et al., 2001).

Empirical studies have applied the JD-R theory to identify critical indicators of job demands within the general field of transport services, although not in the specific context of food delivery (Nahrgang et al., 2011). Physical work environment and work schedule are two main antecedents of transport employees' job demands, as validated in other studies that also identified time pressure and workload as notable aspects of job demands faced by employees (Andrei et al., 2020, Hansez and Chmiel, 2010). Work overload and application problems have also been identified as demanding aspects challenging employees in different job contexts (Bakker et al., 2003). In the case of food delivery riders, their jobs typically lead to emotional exhaustion due to their limited delivery times and penalties for delayed orders (Zheng et al., 2019). Additionally, food delivery riders constantly cope with extreme weather, bad road conditions, long working hours, conflicts with other road users, and pressurized delivery time, which exacerbate the suffering of job strain and evoke riders' sacrifices of safety compliance (Truong et al., 2020, Zheng et al., 2019, Nguyen-Phuoc et al., 2022, Oviedo-Trespalacios et al., 2022). Therefore, this study considers time pressure, work overload, work environment, and application problems as key antecedents of food delivery riders' job demands (see Fig. 1).

With regard to job resources, various intrinsic and extrinsic sources of job motivation for employees have been identified. Prior research has identified job autonomy as a leading antecedent in encouraging greater job motivation and more satisfactory performance among employees (Chen and Chen, 2014; Sardeshmukh et al., 2012; Borst et al., 2019). In the case of food delivery riders, they must constantly decide how and when to handle numerous individual orders and respond to customer demands (Nguyen-Phuoc et al., 2022; Truong et al., 2020). Therefore, it is presumed that job autonomy can positively enhance food delivery riders' motivation to fulfill delivery orders. Moreover, rewards and recognition (Babakus, Yavas, & Ashill, 2009; Demerouti, Taris, Schaufeli, & Schreurs, 2003), as well as access to adequate work-related information (Demerouti, Taris, Schaufeli, & Schreurs, 2003; Van den Broeck, Vansteenkiste, De Witte, & Lens, 2008), can boost individuals' confidence levels at work, thus reinforcing their motivation and performance. Previous studies have also identified performance feedback as a key factor among job resources for workers in the transport services sector (Demerouti et al., 2001; Dijkhuizen et al., 2014). In terms of interactive food delivery applications, food delivery riders can quickly and easily exchange feedback with customers (Nguyen-Phuoc et al., 2022). Additionally, social support, which includes work support and technical assistance, can contribute to a safe organizational climate, thus motivating employees to deliver satisfactory work performance (Babakus et al., 2009; Andrei et al., 2020). Specifically, work support, involving worker-to-worker communication (Dollard et al., 2012; Nielsen et al., 2011), and organizational support, including organizational policies and practices (Zohar, 2000), can evoke
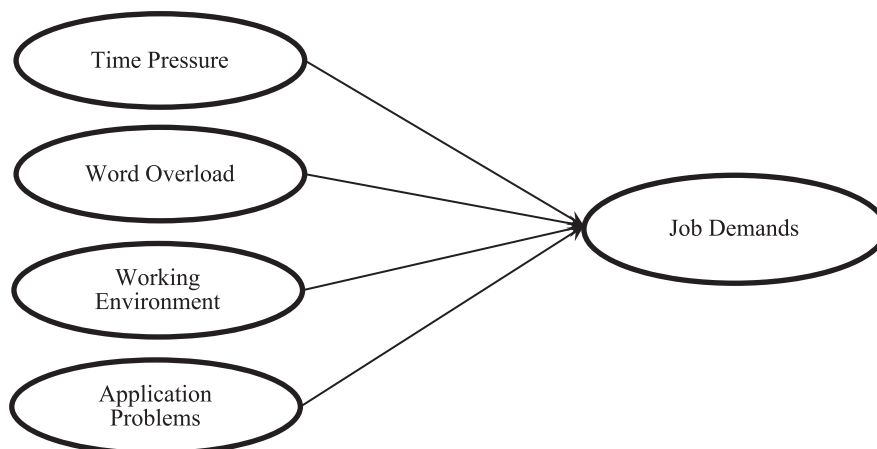

Fig. 1. Key antecedents of food delivery riders' job demands.

employees' job motivation (Hakanen et al., 2007). Similarly, technology support, which encompasses technological updates and investment, enables employees to engage easily and conveniently in service-oriented interactions with customers, making them more committed and satisfied (Babakus et al., 2009). Thus, the present study identifies job autonomy, rewards, information, performance feedback, technology support, and work support as critical indicators of job resources for food delivery riders (Fig. 2).

Fig. 3 shows the conceptual model of the current research.

2.2. Dual processes

The initial JD-R model introduced two processes to explain the development of burnout (Demerouti et al., 2001). Three years after its initial introduction, Schaufeli and Bakker (2004) presented a modified version of the JD-R model. The revised JD-R model proposes that job demands and job resources can impact health and motivation. Poorly designed job demands, such as work overload, can lead to health impairment processes during which employees experience exhausted mental and physical resources, ultimately resulting in burnout (Demerouti et al., 2001). Studies in the transport sector have highlighted the mediating role of burnout in the link between job demands and ill-health outcomes among bus drivers, taxi drivers, truck drivers, and food delivery riders (Albright et al., 1992; Meng et al., 2015; Wang et al., 2019; Li et al., 2019; Nguyen-Phuoc et al., 2022, Nguyen-Phuoc et al., 2023). Motorcycle riders, in particular, may experience higher levels of fatigue due to the constant manipulation of their vehicles under various weather conditions (Balasubramanian and Jagannath, 2014; Truong et al., 2020), while food delivery riders may be more susceptible to burnout due to extreme weather, bad road conditions, and long working hours (Nguyen-Phuoc et al., 2022, Nguyen-Phuoc et al., 2023).

On the other hand, job resources are positively linked to motivational processes, leading to higher job motivation, work engagement, and outstanding performance (Demerouti et al., 2001). Job resources provide employees with both intrinsic and extrinsic motivational sources, resulting in a sense of energetic and effective connection with work activities (Schaufeli et al., 2008). In the transport field, job resources have been shown to improve job motivation and safety behaviors. For example, professional delivery riders who experience a strong sense of community may be intrinsically motivated to pursue further self-development and comply with safety measures through feedback sessions and knowledge sharing with supervisors and co-workers (Cini et al., 2022; Popan, 2021). Supportive environments, such as a safety climate and adequate service-related technological support, can also enhance employees' sense of value and appreciation, resulting in higher safety compliance, participation in safety measures, and engagement in their work (Demerouti, 2011; Nguyen-Phuoc et al., 2022; Neal & Griffin, 2006; Goldenhar, Williams, & Swanson, 2003). Additionally, a lack of social support has been shown to increase the likelihood of traffic infringements and accidents among professional drivers (Useche et al., 2018).

2.3. Safety behaviors

Individuals' safety behaviors in the workplace are often shaped by their expectations and preferences (Chen and Chen, 2014). The
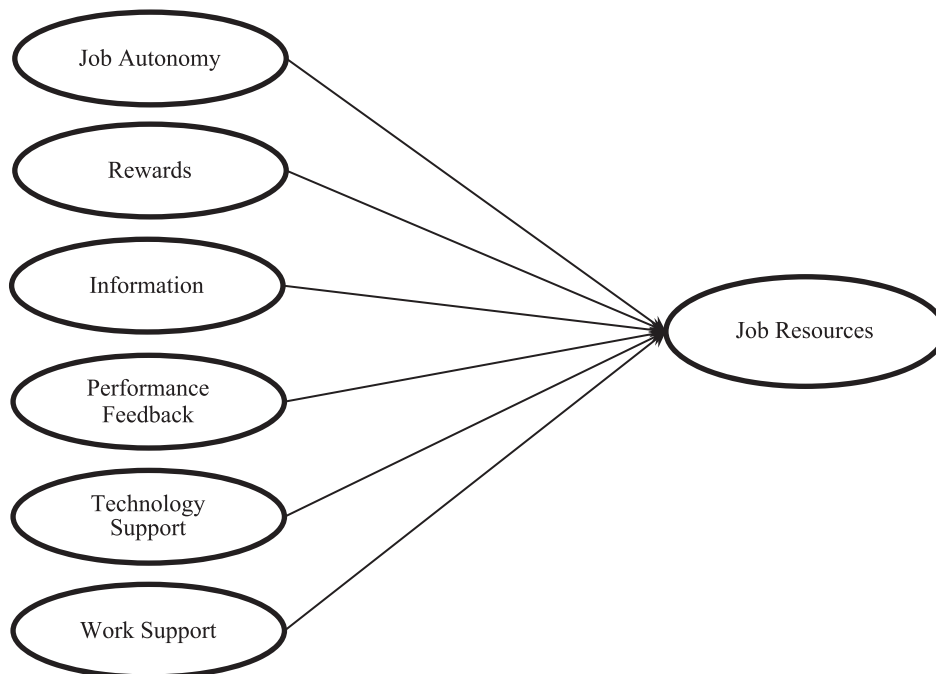
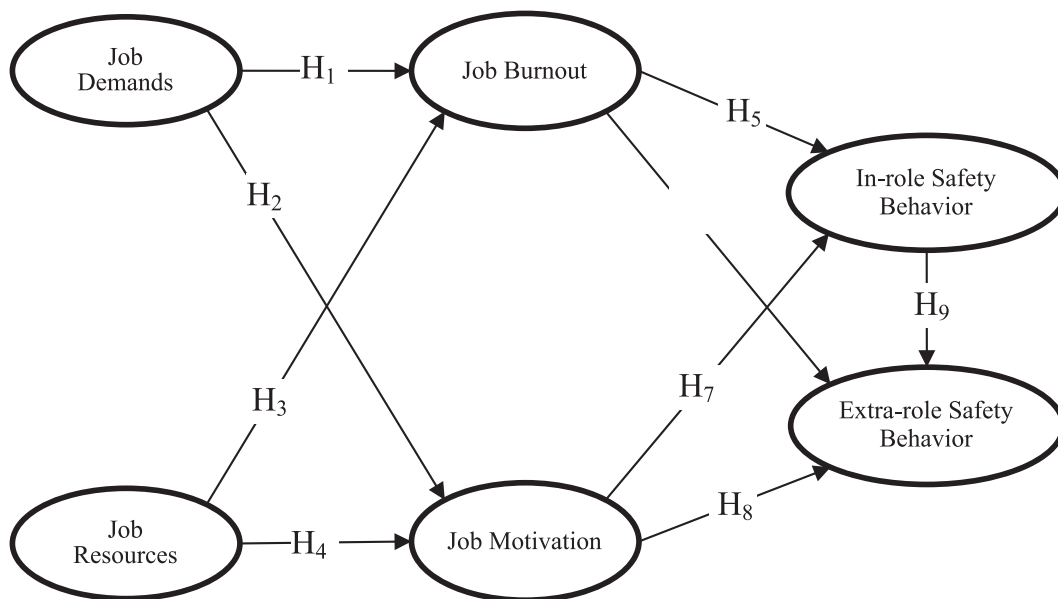**Fig. 2.** Key antecedents of food delivery riders' job resources.

Fig. 3. Proposed conceptual model.

concept of organizational citizenship behaviors distinguishes between in-role and extra-role behaviors, both of which play a pivotal role in shaping safety performance at work (Podsakoff et al., 2000; Hofmann et al., 2003). Elaborating on this, Fugas et al., (2012b) identified two distinct categories of safety behavior within a transportation organization: compliance safety behavior (referred to as in-role safety behavior) and proactive safety behavior (termed extra-role safety behavior). Specifically, in-role safety behaviors encompass practices like using protective equipment, adhering to safety policies, and following procedures to mitigate risks and prevent injuries. On the other hand, extra-role safety behaviors aim to foster a safety-centric atmosphere, which includes supporting colleagues, championing safety initiatives, and actively participating in safety-related activities (Podsakoff et al., 2000).

Within the realm of food delivery services, riders' in-role safety behaviors encompass adherence to safety regulations and procedures. This includes complying with speed limits, obeying traffic signals, avoiding extended riding durations by taking adequate breaks, using hands-free kits while riding, and wearing appropriate safety gear. Conversely, extra-role safety behaviors entail championing safety principles, participating in safety programs facilitated by service providers, and endorsing safety practices even outside of work hours. By consistently exhibiting both in-role and extra-role safety behaviors, food delivery riders can significantly reduce their risk, thereby fostering the sustainable growth of the food delivery industry and societal development.

3. Hypothesis development

3.1. Job demands

The JD-R model suggests that unchecked job demands can lead to increased levels of job burnout among employees (Demerouti et al., 2001). Job burnout, which can surface in any profession, may result in a range of negative outcomes, including anxiety, emotional exhaustion, and psychological detachment (Schaufeli, 2004). Within the transport sector, there's evidence to indicate that elevated job demands can precipitate burnout for various professionals: short-haul transport drivers (Friswell and Williamson, 2008), taxi drivers (Useche et al., 2019; Husain et al., 2019), long-haul truck drivers (Crizzle et al., 2020), seafarers (Shan and Neis, 2020), and food delivery riders (Nguyen-Phuoc et al., 2022). When exploring the relationship between job demands and job motivation, findings have been mixed (Li et al., 2017). Crawford et al. (2010) categorized job demands into two main types: challenge demands and hindrance demands. Challenge demands, which include factors promoting personal growth and goal attainment in workers, such as workload and time pressures, are generally viewed positively. Yet, Xanthopoulou et al., (2007) found that while increased workload correlated positively with job motivation, emotional incongruity had a negative association.

In the realm of food delivery, research by Zheng et al. (2019) and He et al. (2023) underscored the challenging working conditions delivery riders face in China, marked by long hours, insufficient rest, and an overwhelming number of daily orders. These riders also face hurdles like stringent delivery schedules, penalties for delivery lateness, adverse weather conditions, and poor road infrastructure (Papakostopoulos and Nathanael, 2021; Tran et al., 2022). Such working conditions amplify their mental workload, culminating in increased stress levels. In the context of this study, job demands such as time pressures, workload, difficult working environments, and application challenges are classified as hindrance demands due to their propensity to heighten stress. Increased stress is often inversely proportional to motivation (Radic et al., 2020). Consequently, this research puts forth hypotheses related to job demands within the food delivery sector.

H$_1$: Job demands have a direct and positive impact on job burnout.
H$_2$: Job demands have a direct and negative impact on job motivation.

3.2. Job resources

Job resources can buffer the adverse effects of job demands on job burnout (Demerouti et al., 2001). In the absence of adequate job resources, the likelihood of job burnout intensifies, as employees struggle to manage job demands. For professional drivers, elements such as work support and a positive safety climate have been identified as factors that diminish fatigue (Strahan et al., 2008; Nahrgang et al., 2011). Additionally, feedback, task variety, emotional and physical resources, and job autonomy have been linked to reduced emotional exhaustion and enhanced personal development among employees (Hakanen et al., 2008; Ruysseveldt et al., 2011; Nguyen-Phuoc et al., 2022; Chen and Chen, 2014).

Previous work also suggests a positive association between job resources and job motivation. These resources can foster extrinsic motivation by facilitating goal achievement and intrinsic motivation through personal growth and learning (Demerouti et al., 2003; Bakker et al., 2003). In the realm of food delivery, riders who possess safety knowledge tend to prioritize the use of protective equipment and adhere to safety guidelines (Burke et al., 2002). Moreover, safety communication and commitment can bolster an individual's autonomy, catering to their desire for flexibility in attaining work-related objectives (Parker et al., 2001). Based on these insights, this study advances two specific hypotheses related to job resources within the food delivery sector:

H$_3$: Job resources have a direct and negative impact on job burnout.
H$_4$: Job demands have a direct and positive impact on job motivation.

3.3. Job burnout

Job burnout is a work-related stress syndrome that is present across various occupations (Maslach, 1982; Maslach and Leiter, 1997; Li et al., 2013). Burnout can lead to a negative spiral of poor performance and decreased confidence in solving work-related problems (Bakker et al., 2004; Schaufeli et al., 2001). Additionally, burnout is negatively correlated with extra-role performance, including organizational citizenship behaviors and social support (Klein and Verbeke, 1999; Ocampo et al., 2018). In the context of safety behaviors, high job demands and limited job resources have been shown to negatively affect safety behaviors in cabin crews (Chen and Chen, 2014). It is reasonable to assume that job burnout may also have a similar negative impact on safety behaviors. Therefore, the present study proposes the following job burnout-related hypotheses for food delivery services:

H$_5$: Job burnout has a direct and negative impact on in-role safety behaviors.
H$_6$: Job burnout has a direct and negative impact on extra-role safety behaviors.

3.4. Job motivation

The dual processes of the JD-R model propose that ample job resources positively influence job motivation and work engagement (Schaufeli, 2004). When provided with sufficient job resources, employees often surpass their personal goals and indulge in extra-role activities, such as assisting their colleagues (Hu et al., 2011; Van den Broeck et al., 2008). Rewards and acknowledgment significantly motivate employees to exert additional effort in accomplishing both team and individual tasks (Smissen et al., 2013). Intrinsic motivators also bolster employees' in-role performance as they feel inspired to enhance their job-related skills (Bakker et al., 2003; Burke et al., 2002). Conversely, in the absence of adequate job resources, individuals may find it challenging to counteract the detrimental effects of job demands, leading to diminished in-role performance and reduced discretionary efforts to mitigate losses (Schnake, 1991).

Within the framework of safety behaviors, job demands tend to undermine individuals' safety practices (Chen and Chen, 2014). Nevertheless, the safety motivation of employees can positively steer their safety adherence and involvement (Chen and Chen, 2014). Given these findings, this study posits that job motivation might similarly influence the safety behaviors of employees in the food delivery domain. Thus, the subsequent hypotheses related to job motivation are posited:

H$_7$: Job motivation has a direct and positive impact on in-role safety behaviors.
H$_8$: Job motivation has a direct and positive impact on extra-role safety behaviors.

3.5. Interactions between in-role safety behaviors and extra-role safety behaviors

In-role safety behaviors, also termed as safety compliance, pertain to the "core activities essential for maintaining workplace safety" (Neal and Griffin, 2006). On the other hand, extra-role safety behaviors, also known as safety participation, involve actions that transcend personal safety compliance and aim to cultivate a secure work environment (Neal and Griffin, 2006). Research indicates a direct and positive correlation between in-role and extra-role safety behaviors. While in-role safety actions, such as adhering to traffic regulations and wearing helmets, constitute fundamental job prerequisites that service professionals are educated to execute, the

continuous enhancement of safety performance mandates proactive extra-role initiatives (Nguyen-Phuoc et al., 2022; Tunnicliff et al., 2012). Neal and Griffin (2006) ascertained that an individual's motivation for in-role safety and compliance might exert a deferred influence on their safety participation. Consequently, this research posits that food delivery riders exhibiting consistent in-role safety behaviors are inclined to participate in extra-role actions. Based on this context within food delivery services, the ensuing hypothesis is formulated:

H_9: In-role safety behaviors have a direct and positive impact on extra-role safety behaviors.

3.6. Mediating relationships

This research postulates a mediating relationship between job demands and both in-role and extra-role safety behaviors exhibited by food delivery riders. It is hypothesized that heightened job demands can foster a taxing environment, leading to elevated burnout levels. This burnout, in turn, might detract riders from concentrating on their core safety behaviors, thereby compromising adherence to vital safety guidelines. Furthermore, the strain from increased job demands is predicted to have a dual consequence: not only suppressing the riders' motivation but also curtailing their inclination to engage in extra-role safety behaviors. This nexus of distraction from burnout and diminished motivation acts as a formidable obstacle, inhibiting the diligent practice of in-role safety protocols and the discretionary participation in safety endeavours beyond job mandates. In light of these insights, the research puts forth the ensuing hypotheses.

H_{10a}: Job demands have a negative mediating effect on in-role safety behaviors mediated by job burnout.
H_{10b}: Job demands have a negative mediating effect on extra-role safety behaviors mediated by job burnout.
H_{10c}: Job demands have a negative mediating effect on in-role safety behaviors mediated by job motivation.
H_{10d}: Job demands have a negative mediating effect on extra-role safety behaviors mediated by job motivation.

This research suggests a mediating framework linking job resources to both in-role and extra-role safety behaviors of food delivery riders, with job burnout and motivation serving as mediators. The study posits that ample job resources can serve as a buffer, reducing burnout among these riders. By providing essential support - like comprehensive training, appropriate safety equipment, and fair compensation - such resources are anticipated to bolster riders' dedication to in-role safety protocols. Concurrently, these resources can invigorate riders' motivation, prompting them to actively pursue additional safety practices. As the detrimental effects of burnout wane and motivation is amplified by these resources, riders are likely to feel more empowered. This empowerment is expected to foster their adherence to safety behaviors, both within their standard job duties and beyond. Taking these considerations into account, the research introduces the subsequent hypotheses:

H_{11a}: Job resources have a positive mediating effect on in-role safety behaviors, mediated by job burnout.
H_{11b}: Job resources have a positive mediating effect on extra-role safety behaviors, mediated by job burnout.
H_{11c}: Job resources have a positive mediating effect on in-role safety behaviors, mediated by job motivation.
H_{11d}: Job resources have a positive mediating effect on extra-role safety behaviors mediated by job motivation.

4. Methodology

4.1. Questionnaire design

This present investigation used a structured questionnaire with three sections to collect data. The first section of the questionnaire provided a concise introduction outlining the survey's objectives and its scope. The core content of the questionnaire was the second section which asked participants to respond to attitudinal statements using a 7-point Likert scale ranging from 'strongly disagree' to 'strongly agree'. In total, there were 47 items across 13 constructs, based on previous studies (see Table A2 for details). Four dimensions of job demands, including time pressure, work overload, work environment, and application problems, were measured using measurement items adapted from (Demerouti et al., 2001, Zheng et al., 2019, Chen and Chen, 2014, Babakus et al., 2009, Schaufeli and Taris, 2014). Six dimensions (i.e., job autonomy, rewards, information, performance feedback, technology support, and work support) forming job resources were measured by items modified from studies conducted by Chen and Chen (2014), Sardeshmukh et al. (2012), Borst et al. (2019), Babakus et al. (2009), Bakker et al., 2003, Van den Broeck et al. (2008), Xanthopoulou et al. (2007), Schaufeli (2015) and Bakker et al., (2007). The scales of job burnout (four items) and job motivation (three items) were derived from Li et al., (2013) and Thakor (1994). Five items adapted from Chen and Chen (2014), Tunnicliff et al. (2012), Neal and Griffin (2006) were used to measure in-role safety behavior, while four items adapted from Braunger et al. (2015) and Chen and Chen (2014) were used to measure extra-role safety behavior. The final section collected socio-demographic information, such as gender, age, marital status, work type, educational degree, and monthly income. The questionnaire was initially developed in English and later translated into Vietnamese for feedback from five transport experts. After minor revisions to the wording based on feedback from thirty delivery riders, the final version was used for the official survey.

4.2. Data collection

The data was collected through face-to-face surveys conducted with delivery riders. The interviewers were undergraduate students who underwent careful training before approaching public places (such as lakes and commercial centers) where the riders often took a break. When a rider participated in and completed the survey with the support of our staff, he or she received a reward of approximately 1 USD for their assistance. The survey was conducted from August 11, 2022, to August 30, 2022, and a total of 417 delivery motorcycle riders provided their responses. However, seven unreliable and incomplete forms were excluded, resulting in 410 eligible responses for further analysis.

4.3. Descriptive statistics

As can be seen in Table 1 providing the description of the sample, almost all delivery riders questioned (99 %) were male with an average age of 25.41 (standard deviation = 6.18). Nearly 80 % of the participants were single, while for the vast majority (72.9 %), delivery was a full-time job. Regarding the educational level of the respondents, more than half failed to obtain a college or university degree. Riders with monthly income levels between 5 and 10 million VND accounted for the largest rate (46.8 %), followed by those earning less than 5 million VND per month (26.8 %).

4.4. Modeling platform

Structural equation modeling (SEM) is a powerful, multivariate technique used to depict, estimate, and evaluate a complex network of connections between variables, encompassing both observed variables (measurement scales) and latent variables. SEM can be divided into two main components. The measurement model establishes the connections between observed variables and latent variables. In contrast, the structural model establishes the relationships among latent variables themselves. In a measurement model, latent variables or composite variables are quantified, whereas the structural model examines all the hypothesized relationships using path analysis. SEM distinguishes itself from other modeling methods by evaluating both the direct and indirect impacts within pre-defined causal relationships.

To empirically analyze the proposed theoretical framework (Fig. 1), we applied Partial Least Squares Structural Equation Modelling (PLS-SEM) utilizing the commercial software SmartPLS. Despite some controversial debate on the PLS-SEM's limitations, the method has rapidly emerged as a standard tool for investigating complex inter-relationships between unobserved and observed variables in social sciences like marketing, tourism, hospitality, and transportation (Nguyen-Phuoc et al., 2022; Su et al., 2022; Nguyen-Phuoc et al., 2020). The dissemination of PLS-SEM is a result of its bright advantages. It is highly recommended for a complex and exploratory model based on an extended theory like the current study. Moreover, employing PLS-SEM does not require the normally distributed data and can handle both formative and reflective constructs well (Hair et al., 2021).

5. Results

5.1. Measurement model

5.1.1. First-order measurement model evaluation

The first stage in first-order measurement model evaluation involves investigating the indicator loadings. The factor loading (FL) values were recommended to be greater than the critical value of 0.708 (Hair et al., 2021). Here, two items with low loadings (<0.7), including WOO1 and WOE1 were dropped. After eliminating these two indicators, the factor loading values of the remaining items ranged from 0.727 to 0.931, thus the acceptable item reliability was reached (Table 2). Subsequently, internal consistency reliability was examined using composite reliability Rho_C (CR Rho_C), Cronbach's Alpha (CA), and composite reliability Rho_A (CR Rho_A). The CR Rho_C values (ranging from 0.856 to 0.948) and the CA values (ranging from 0.725 to 0.932) were all within the recommended

Table 1
Sample characteristics.

	n	%		n	%
Gender			*Level of education*		
Male	406	99.0	Middle school	28	6.8
Female	4	1.0	High school	189	46.1
Age			College	86	21.0
Mean (Standard Deviation)	25.41 (6.18)		University	104	25.4
Married status			Above university	3	0.7
Single	322	78.5	*Monthly income (million VND)*		
Married	88	21.5	No income	21	5.1
Job type			< 5	110	26.8
Part-time	111	27.1	5 - <10	192	46.8
Full-time	299	72.9	10 - <15	69	16.8
			15 and higher	18	4.4

Notes: 1 USD = 23,000VND.

Table 2
First-order measurement model evaluation.

Constructs	Items	Factor loadings	CA	CR Rho_A	CR Rho_C	AVE
Time Pressure			0.838	0.848	0.903	0.757
(TIP)	TIP1	0.793				
	TIP2	0.907				
	TIP3	0.906				
Word Overload			0.752	0.763	0.889	0.801
(WOO)	WOO1	–				
	WOO2	0.879				
	WOO3	0.911				
Working Environment (WOE)			0.725	0.729	0.879	0.784
	WOE1	–				
	WOE2	0.875				
	WOE3	0.896				
Application Problems (APP)			0.844	0.845	0.906	0.762
	APP1	0.871				
	APP2	0.888				
	APP3	0.860				
Job Autonomy			0.855	0.856	0.912	0.775
(JOA)	JOA1	0.896				
	JOA2	0.887				
	JOA3	0.858				
Rewards			0.834	0.838	0.900	0.751
(REW)	REW1	0.878				
	REW2	0.882				
	REW3	0.838				
Information			0.832	0.836	0.922	0.856
(INF)	INF1	0.931				
	INF2	0.919				
Performance Feedback (PEF)			0.749	0.771	0.856	0.666
	PEF1	0.845				
	PEF2	0.868				
	PEF3	0.727				
Technology Support			0.863	0.864	0.907	0.709
(TES)	TES1	0.827				
	TES2	0.888				
	TES3	0.854				
	TES4	0.797				
Work Support			0.803	0.806	0.871	0.628
(WOS)	WOS1	0.771				
	WOS2	0.815				
	WOS3	0.779				
	WOS4	0.805				
Job Burnout			0.853	0.870	0.901	0.694
(JOB)	JOB1	0.770				
	JOB2	0.840				
	JOB3	0.879				
	JOB4	0.839				
Job Motivation			0.780	0.788	0.872	0.695
(JOM)	JOM1	0.790				
	JOM2	0.873				
	JOM3	0.835				

Table 2 (*continued*)

Constructs	Items	Factor loadings	CA	CR Rho_A	CR Rho_C	AVE
In-role Safety Behavior (ISB)			0.932	0.932	0.948	0.786
	ISB1	0.868				
	ISB2	0.907				
	ISB3	0.893				
	ISB4	0.882				
	ISB5	0.882				
Extra-role Safety Behavior (ESB)			0.830	0.848	0.887	0.663
	ESB1	0.804				
	ESB2	0.890				
	ESB3	0.756				
	ESB4	0.801				

Notes: CA: Cronbach's Alpha, CR Rho_C: composite reliability Rho_C, CR Rho_A: composite reliability Rho-A, AVE: Average Variance Extracted.

range between 0.7 and 0.95 (Hair et al., 2021), while for each construct, the value of CR Rho_A lay between the CA value and the CR Rho_C value. Accordingly, internal consistency reliability was achieved. The next step was to assess the convergent validity of each construct measure through average variance extracted (AVE). The AVE scores of all constructs, which fell between 0.628 and 0.856, exceeded the minimum level of 0.5 (Hair et al., 2021), verifying the convergent validity of indicators.

Afterwards, discriminant validity, which is the degree to which a construct is different from others, was tested using two criteria. First, the value of each construct on the principal diagonal in Table 3 (i.e., square root of AVE) was higher than the correlations of that construct with others (i.e., the Fornell and Larcker criterion). Second, all of the heterotrait-monotrait (HTMT) ratios were lower than the benchmark value of 0.85 (Henseler et al., 2015) (Table 4). Therefore, the discriminant validity was satisfied (Hair et al., 2017).

5.1.2. Second-order measurement model evaluation

Job demands and job resources were formulated as formative second-order constructs in the current study since they were partially explained by the first-order constructs. Adhering to the guideline of Duarte & Suzanne (2018), the evaluation of the higher-order measurement model was applied using the outer loadings of the lower-order constructs and their variance inflation factor (VIF). Based on the suggestion of Lohmöller (1989), who recommended only keeping first-order variables with outer weights being over 0.1, we removed rewards (0.083) and information (0.070) from the formulation of job resources. When re-running the model, all the kept first-order dimensions (of job demands and job resources) had outer weights greater than 0.1 while their VIFs were far below the cut-off value of 5 (*see model 2 in* Table 5), demonstrating that these first-order constructs were distinct and qualified as formative measures (Hair et al., 2021). As such, job demands and job resources had sufficient quality for further structural analysis. The weight of word overload was insignificant (p = 0.252); therefore, job demands were formatively formed by the three first-order constructs, including application problems, working environment, and time pressure. Meanwhile, job resources were formatively established based on the four dimensions, including job autonomy, performance feedback, technology support, and work support.

5.2. Structural model

5.2.1. Predictive relevance assessment

The structural model assessment involves the coefficient of determination (R^2) and cross-validated redundancy measure Q^2 estimated from the blindfolding process. The R^2 is mentioned as in-sample predictive power since it measures the explained variance of each endogenous construct. The R^2 values of the four constructs in this study, including extra-role safety behavior ($R^2 = 0.233$), in-role safety behavior ($R^2 = 0.054$), job burnout ($R^2 = 0.107$), and job motivation ($R^2 = 0.213$) were satisfactory but being considered as a weak exploratory power ($0 < R^2 < 0.25$) (Hair et al., 2021). The Q^2 value is another metric to evaluate the model predictive accuracy. It is recommended to be over zero to indicate an acceptable predictive capacity of the path model for a construct. All constructs in the current research had the Q^2 values ranging from 0.037 to 0.142, suggesting a small predictive relevance of the structural model (Hair et al., 2021). Extra-role safety behavior had the highest level of Q^2 (0.142).

5.2.2. Model fit

To evaluate the model fit, we considered the standard root mean square residual (SRMR). According to (Hair et al., 2021), an acceptable value of SRMR should be under 0.08. The SRMR score in the present analysis was 0.068, demonstrating the fit between the data and the structural model.

5.2.3. Direct effects

Table 6 and Fig. 4 present the results of direct effects of the structural model. The positive impacts of job demands was significant on job burnout ($\beta = 0.340$, $p < 0.001$) but insignificant on job motivation ($\beta = 0.073$, $p = 0.168$), thereby validating H_1 and rejecting H_2. Job resources had an insignificant effect ($\beta = -0.066$, $p = 0.243$) on job burnout, leading to a rejection of H_3. Whereas H_4 was supported

Table 3
Fornell and Larcker criterion.

Constructs	APP	ESB	ISB	INF	JOA	JOB	JOM	PEF	REW	TES	TIP	WOO	WOS	WOE
APP	0.873													
ESB	0.172	0.814												
ISB	0.136	0.437	0.886											
INF	0.186	0.413	0.291	0.925										
JOA	0.288	0.289	0.226	0.380	0.880									
JOB	0.233	−0.003	−0.115	0.018	0.015	0.833								
JOM	0.150	0.279	0.181	0.300	0.378	0.163	0.833							
PEF	0.181	0.411	0.230	0.595	0.402	−0.018	0.320	0.816						
REW	0.029	0.285	0.230	0.503	0.251	0.065	0.261	0.400	0.867					
TES	0.088	0.406	0.341	0.553	0.279	0.025	0.299	0.458	0.536	0.842				
TIP	0.198	−0.084	−0.144	0.062	0.172	0.222	0.131	0.030	0.000	−0.052	0.870			
WOO	0.329	0.118	−0.003	0.155	0.211	0.178	0.127	0.175	0.095	0.124	0.304	0.895		
WOS	0.073	0.464	0.272	0.334	0.308	0.078	0.276	0.400	0.338	0.378	0.016	0.179	0.793	
WOE	0.369	0.138	0.070	0.187	0.170	0.241	0.123	0.186	0.064	0.102	0.287	0.318	0.126	0.886

Table 4
Heterotrait-monotrait (HTMT) ratios.

Constructs	APP	ESB	ISB	INF	JOA	JOB	JOM	PEF	REW	TES	TIP	WOO	WOS	WOE
APP														
ESB	0.212													
ISB	0.154	0.490												
INF	0.223	0.488	0.330											
JOA	0.340	0.338	0.253	0.447										
JOB	0.264	0.072	0.132	0.093	0.070									
JOM	0.187	0.344	0.212	0.369	0.460	0.211								
PEF	0.230	0.519	0.269	0.734	0.494	0.133	0.407							
REW	0.081	0.338	0.259	0.596	0.291	0.084	0.314	0.496						
TES	0.105	0.474	0.381	0.650	0.323	0.078	0.363	0.557	0.628					
TIP	0.236	0.105	0.161	0.077	0.204	0.255	0.164	0.040	0.043	0.065				
WOO	0.410	0.179	0.057	0.194	0.257	0.217	0.168	0.230	0.112	0.150	0.375			
WOS	0.103	0.564	0.314	0.407	0.374	0.093	0.349	0.508	0.402	0.451	0.100	0.226		
WOE	0.470	0.186	0.087	0.240	0.213	0.298	0.178	0.260	0.080	0.128	0.367	0.424	0.166	

Table 5
Second-order measurement model evaluation.

Model	Second-order/ First-order constructs	VIF	Outer weight	SD	t-value	p-value
Model 1	**Job Demands (JDs)**					
	Application Problems (APP)	1.216	0.454***	0.159	2.856	0.004
	Word Overload (WOO)	1.211	0.179 ns	0.156	1.146	0.252
	Working Environment (WOE)	1.259	0.371**	0.152	2.442	0.015
	Time Pressure (TIP)	1.153	0.433***	0.133	3.250	0.001
	Job Resources (JRs)					
	Job Autonomy (JOA)	1.216	0.565***	0.117	4.838	<0.001
	Rewards (REW)	1.528	0.083 ns	0.156	0.888	0.375
	Information (INF)	1.877	0.070 ns	0.156	0.451	0.652
	Performance Feedback (PEF)	1.806	0.187 ns	0.145	1.288	0.198
	Technology Support (TES)	1.698	0.221*	0.131	1.678	0.093
	Work Support (WOS)	1.344	0.213*	0.128	1.664	0.096
Model 2	**Job Demands (JDs)**					
	Application Problems (APP)	1.216	0.454***	0.159	2.850	0.004
	Word Overload (WOO)	1.211	0.179 ns	0.155	1.155	0.248
	Working Environment (WOE)	1.259	0.371**	0.151	2.463	0.014
	Time Pressure (TIP)	1.153	0.433***	0.136	3.187	0.001
	Job Resources (JRs)					
	Job Autonomy (JOA)	1.175	0.585***	0.119	4.925	<0.001
	Performance Feedback (PEF)	1.452	0.239*	0.137	1.742	0.082
	Technology Support (TES)	1.547	0.304**	0.124	2.451	0.014
	Work Support (WOS)	1.447	0.228*	0.126	1.814	0.070

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

Table 6
Results of direct effects.

Path relation (Hypothesis)	Path Coefficient	SD	t-value	p-value	Result
H_1: Job Demands -> Job Burnout	0.340***	0.049	6.939	<0.001	Supported
H_2: Job Demands -> Job Motivation	0.073 ns	0.053	1.379	0.168	Rejected
H_3: Job Resources -> Job Burnout	−0.066 ns	0.057	1.167	0.243	Rejected
H_4: Job Resources -> Job Motivation	0.432***	0.042	10.221	<0.001	Supported
H_5: Job Burnout -> In-role Safety Behavior	−0.148***	0.053	2.812	0.005	Supported
H_6: Job Burnout -> Extra-role Safety Behavior	0.009 ns	0.050	0.179	0.858	Rejected
H_7: Job Motivation -> In-role Safety Behavior	0.205***	0.055	3.749	<0.001	Supported
H_8: Job Motivation -> Extra-role Safety Behavior	0.205***	0.051	3.989	<0.001	Supported
H_9: In-role Safety Behavior -> Extra-role Safety Behavior	0.401***	0.059	6.811	<0.001	Supported

Notes: ns non-significant, ***$p < 0.01$, **$p < 0.05$.

since job resources were found to be a significant contributor to job motivation (β = 0.432, p < 0.001). As regards job burnout, it was a relevant barrier to in-role safety behavior (β = -0.148, p = 0.005), thus supporting H_5. Yet, its effect on extra-role safety behavior was irrelevant (β = 0.009, p = 0.858), thus rejecting H_6. Job motivation was found to significantly facilitate both in-role (β = 0.205, p < 0.001) and extra-role (β = 0.205, p < 0.001) safety behaviors, thereby validating H_7 and H_8. The significant positive correlation between in-role safety behavior and extra-role safety behavior (β = 0.401, p < 0.001) supported H_9.

5.2.4. Indirect effects

Table 7 reveals that job resources caused significant positive mediating effects on in-role and extra-role safety behaviors. Interestingly, extra-role safety behavior was indirectly deterred by job burnout and indirectly facilitated by job motivation.

6. Discussion

6.1. Theoretical contribution

The findings of this investigation contribute to the existing body of research on the safety behaviors of food delivery riders and the factors that influence them. This study harnesses the dual processes of the JD-R model to pinpoint the determinants of food delivery riders' safety behaviors, thereby expanding the current discourse on this subject. While previous studies have leveraged this model to probe the impact of job demands and resources on work performance in various settings, there is a paucity of research applying the JD-R model specifically to the safety behaviors of food delivery riders. This research sets itself apart by utilizing the JD-R model across both dual processes, offering a more comprehensive understanding of the influencing variables.

The findings highlight the mediating roles of job demands and job resources in shaping the safety behaviors of food delivery riders,
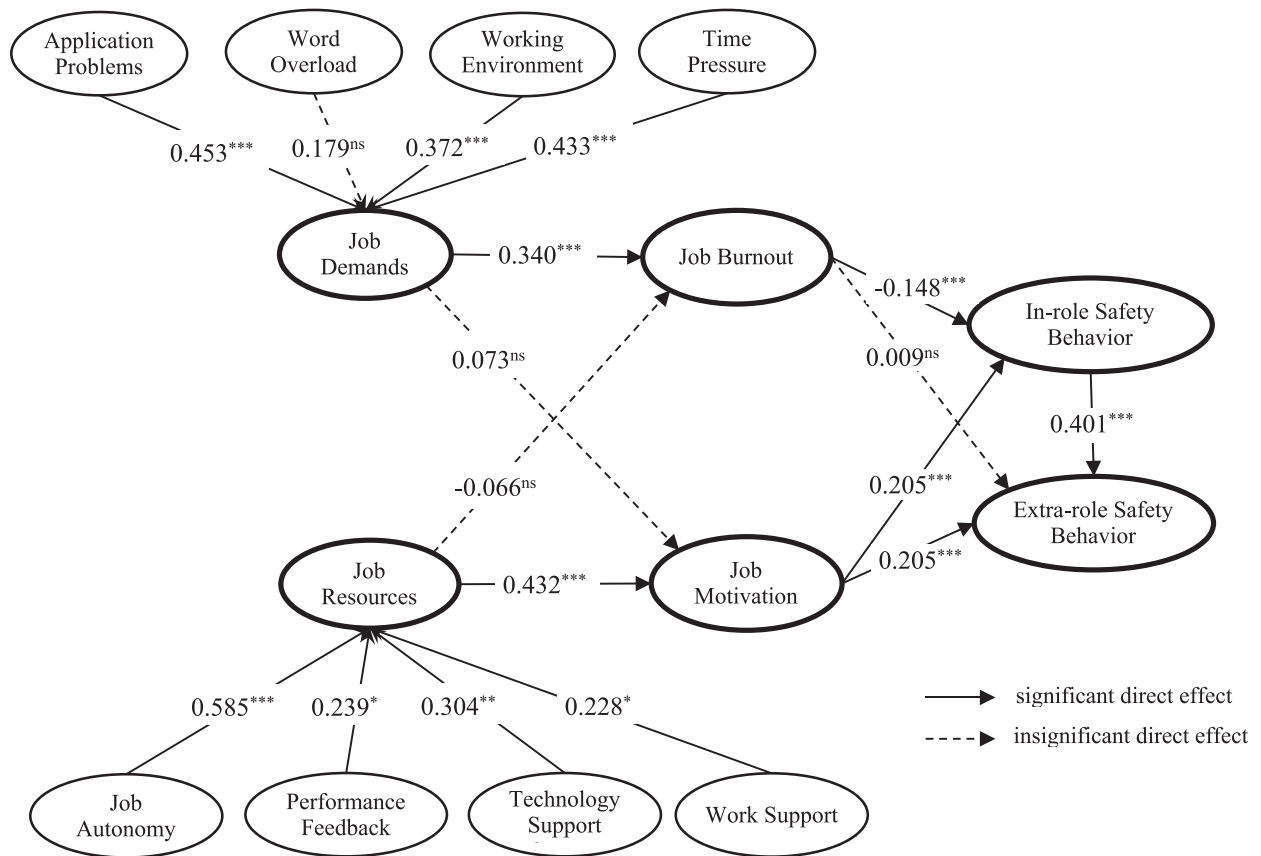
Fig. 4. Structural equation model: estimation results.

Table 7
Results of indirect effects.

Path relation	Path Coefficient	SD	t-value	p-value	Result
H_{10a}: Job Demands -> Job Burnout -> In-role Safety Behavior	−0.050[**]	0.020	2.504	0.012	Supported
H_{10b}: Job Demands -> Job Burnout -> Extra-role Safety Behavior	0.003	0.018	0.171	0.865	Rejected
H_{10c}: Job Demands -> Job Motivation -> In-role Safety Behavior	0.015	0.012	1.207	0.228	Rejected
H_{10d}: Job Demands -> Job Motivation -> Extra-role Safety Behavior	0.015	0.012	1.275	0.203	Rejected
H_{11a}: Job Resources -> Job Burnout -> In-role Safety Behavior	0.010	0.010	0.951	0.341	Rejected
H_{11b}: Job Resources -> Job Burnout -> Extra-role Safety Behavior	−0.001	0.005	0.132	0.895	Rejected
H_{11c}: Job Resources -> Job Motivation -> In-role Safety Behavior	0.089[***]	0.028	3.118	0.002	Supported
H_{11d}: Job Resources -> Job Motivation -> Extra-role Safety Behavior	0.088[***]	0.026	3.372	0.001	Supported

Notes: [ns] non-significant, ***$p < 0.01$, **$p < 0.05$.

with the former influencing through job burnout and the latter through job motivation. This observation is consistent with previous research that has identified analogous effects of JD-R model-based factors on safety outcomes in sectors like coal mining (Tong et al., 2019) and four primary industries (Nahrgang et al., 2011). In earlier studies that employed the dual processes of the JD-R model, such as the one by Halbesleben and Buckley (2004), both the health-impairment and motivational processes were found to be intertwined. Yet, the current study diverges from these findings: job demands did not significantly influence job motivation (H_2), and the correlation between job resources and job burnout was not statistically significant (H_3). This shows that job burnout is predominantly influenced by job demands, while job motivation is primarily driven by job resources.

Contrary to previous studies that explored delivery riders' safety behavior (Nguyen-Phuoc et al., 2022), this investigation differentiates safety behavior into in-role and extra-role behaviors. The results suggest that in-role safety behavior is adversely influenced by job burnout and positively by job motivation. Meanwhile, extra-role safety behavior is positively associated with job motivation. Moreover, when delivery riders exhibit in-role safety behaviors, they tend to also display extra-role safety behaviors.

Finally, this study introduces a conceptual model to pinpoint the primary indicators of job demands and resources and their impact on both types of safety behaviors. Job demands and job resources are treated as first-order constructs derived from specific indicators. The data reveals that job demands are characterized by three pivotal indicators: application problems, working environments, and

time pressure. Among them, application problems emerge as the most significant indicator, followed by time pressure and working environments. Conversely, job resources are constructed from four indicators: job autonomy, performance feedback, technology support, and work support, with job autonomy and technology support ranking as the most crucial. These insights hold value for the formulation of effective road safety strategies.

6.2. Practical implications

Recent global trends highlight a sharp increase in road incidents involving food delivery riders, emphasizing the pressing need for reinforced safety protocols. In Vietnam, a country heavily dependent on motorcycles, the food delivery sector has seen rapid growth. Identifying the factors influencing riders' safety behaviors is pivotal for implementing effective interventions, such as policy adjustments and job redesign. A significant finding of this study illustrates the adverse impact of burnout on riders' fundamental safety behaviors. Hence, addressing burnout becomes a top priority for stakeholders in the food delivery ecosystem.

Addressing the excessive job demands stemming from application glitches, time constraints, and challenging work settings can enhance safety outcomes. Service providers in the food delivery industry should refine their application platforms to guarantee data precision and dependable location tracking. Incorporating cognitive relaxation strategies, such as removing daily quotas or revising payment structures, can alleviate stress arising from time pressures. A more thoughtful compensation approach is essential, especially given that certain operational models in the food delivery sector have been identified as safer (Lu et al., 2022; Oviedo-Trespalacios et al., 2022). Companies might also consider waiving penalties for delays caused by circumstances beyond riders' control, like heavy traffic, inclement weather, or hold-ups at restaurants. Adopting such strategies can cultivate a safer operational environment for riders.

Another impactful revelation from this study is the significant indirect effect of job resources on both primary and additional safety behaviors, mediated by job motivation. By enhancing job resources, which include elements like autonomy, feedback, tech support, and general assistance, delivery companies can boost job motivation. Collaborating with tech companies for app advancements can lead to regular updates, integrating features like precise GPS tracking and fare estimates. An up-to-date and user-friendly app can empower riders, leading to heightened motivation and safer practices. It is crucial for the delivery industry to prioritize their riders' well-being by providing extensive support and resources. Such measures can reduce rider burnout and elevate job satisfaction, resulting in safer and more efficient road behaviors.

7. Limitations and future research

Despite providing important theoretical and practical implications, this study is not without limitations. The first limitation pertains to sampling bias, as the survey primarily targeted delivery riders during off-peak hours, which could have excluded those who exclusively work during peak hours. Thus, the sample may not be fully representative of all delivery riders in Vietnam. Secondly, the use of self-reports to collect research data may have been influenced by social desirability bias or memory recall bias, warranting careful interpretation of the results. Thirdly, the study was conducted in two cities in Vietnam, which limits the generalizability of the findings to other regions or countries. Further research in other motorcycle-dependent countries is necessary to validate the results and advance our understanding of the factors that shape safety behaviors among food delivery riders. Fourthly, several dimensions of job demands and job resources, such as safety culture, leadership, access to well-maintained vehicles, and incentives recognizing safe behaviors, were not incorporated into the proposed model. These factors may significantly influence the safety behaviors of delivery riders, necessitating further investigation. Lastly, this study did not explore the influence of key moderators (e.g., age, job type, and income) on the established model. Future research should delve into these aspects to derive more comprehensive conclusions.

8. Conclusion

The rising popularity of online food delivery services has heightened safety concerns for food delivery riders, especially in low- and middle-income countries. This research employs the JD-R model to pinpoint factors influencing the in-role and extra-role safety behaviors of food delivery riders. Job burnout acts as a mediator between job demands, encompassing application challenges, work environment, and time pressures, and in-role safety behaviors. Meanwhile, job resources such as job autonomy, performance feedback, technological assistance, and workplace support indirectly influence both in-role and extra-role safety behaviours through job motivation. This research offers deeper insights into the safety behaviours of food delivery riders and the factors that shape them. Such findings can guide authorities and delivery service providers in crafting strategies to address road safety risks within the food delivery domain.

CRediT authorship contribution statement

Duy Quy Nguyen-Phuoc: Conceptualization, Data curation, Formal analysis, Investigation, Validation, Visualization, Writing – original draft, Writing – review & editing. **Nhat Xuan Mai:** Conceptualization, Writing – original draft, Writing – review & editing. **Thao Nhi Ho-Mai:** Writing – original draft, Writing – review & editing. **Minh Hieu Nguyen:** Writing – original draft, Writing – review & editing. **Oscar Oviedo-Trespalacios:** Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgment

Appendix

See Table A1, A2.

Table A1
Relevant studies.

Authors	Country	Data Used	Methodology	Key Constructs	Findings
(Zheng et al., 2019)	China	Self-administered questionnaire among 824 delivery riders	Quantitative	- Working condition - Fatigue - Crash involvement - Time pressure - Risky riding - Moderator: demographic characteristics (i.e., age, gender, and educational background)	- Heavy workload, feelings of fatigue, and risk-taking behaviors exerted direct impacts on the involvement in crashes - Time pressure and work-related traits affected crash involvement indirectly through influencing riders' feeling of fatigue and riding behaviors
(Byun et al., 2020)	South Korea	Analysis of 1,317 injured couriers (received from the Korea Occupational Safety and Health Agency (KOSHA)) regarding rider-related factors and crash-related factors according to rider's age or violations	Quantitative	- Rider-related factors: age, work experience, type of employment, and company size - Crash-related factors: violation, time of crash, crash type, injury type, injured body part, and severity of injury	- The proportion of 'fracture,' 'rider alone,' or 'death or disability' accidents increased with age. - Among injured riders, 67.4 % were temporary workers, 76.1 % worked in small companies with < 5 employees, 58.7 % in the nighttime, and 51.5 % had a work experience of < 1 month
(Qin et al., 2021)	China	A field observation studyconsisting of 4 typical signalized urban intersections in Beijing, and video recorded traffic behaviors of meal delivery riders for eight hours. In total, 1891 couriers crossing intersections on electric bicycles were observed.	Quantitative	- Risk behaviors: red-light running, using the phone, riding on the motor-vehicle lane, contra-flow riding - Risk behaviors of couriers from different third-party delivery platforms - Risk behaviors of couriers from different non-third-party delivery platforms - Risk behaviors of normal riders	- Red-light-running and riding-on-the-motor-lane were the most frequent risky traffic behaviors. - The ratios of risk behaviors from delivery couriers were almost all significantly higher than those of normal riders ($p < 0.05$). - There was no significant difference in these risk behaviors for riders across different platforms
(Papakostopoulos and Nathanael, 2021)	Greece	A 2-item questionnaire exploring delivery riders' demographic characteristics, terms of employment, issues of concern during work and type of traffic offenses committed.	Quantitative	- **Dependent variables:** two traffic offenses (i.e., red-light running and non-use of helmet) - **Independent variables:** - Gender - Age - Riding experience - Work experience - Involvement in a serious accident - Use of personal vehicle for work	- Typical health and safety measures had no effect on serious traffic offenses - Young age was related to both offenses - Different sets of work conditions were associated with reports of red-light running (i.e., low work experience, use of personal vehicles for work, and payment by hour) and helmet non-use (i.e., intense work pace, high tip

Table A1 (*continued*)

Authors	Country	Data Used	Methodology	Key Constructs	Findings
				- PPE provided to the rider - Accident insurance provided to the rider - Employer control over helmet use - Typical mileage per week - Work pace - The payment method - Average tip income per day - Concern about wayfinding - Concern about the road condition - Concern about the weather condition - Concern about the vehicle condition	income per day and low concern about vehicle condition)
(Dong et al., 2021)	China	An intercept survey among 204 food delivery riders in Tianjin, China	Quantitative	- Time pressure - Perceived traffic enforcement - Personal norm - Aggressive driving behaviors	- Traffic enforcement and personal norms negatively influence the frequency of self-reported aggressive driving behaviors - Both external and internal regulations can effectively reduce the tendency of riders to drive aggressively. For food delivery drivers, time pressure was positively correlated with aggressive driving behaviors - For food delivery drivers, traffic enforcement has a powerful inhibiting effect on the aggressive driving behaviors of food delivery drivers - For normal e-bike riders, personal norms were stronger regulators than perceived traffic enforcement
(Tran et al., 2022)	Vietnam	A web-based survey of more than 800 riders	Quantitative	- Risk attitudes - Risk perceptions - Risk behaviors of delivery riders	- Male, older, less-educated, and vaccinated riders were less consistent in adopting health and safety measures - Male, older, less-educated, and vaccinated riders were under greater financial pressure and had suffered a larger loss of income during the pandemic - The job pressure, long working hours, and financial burdens led many drivers to adopt risky traffic behaviors, such as speeding. - Where the companies and co-workers were more supportive, riders tended to adopt health prevention measures more often
(Nguyen-Phuoc et al., 2022)	Vietnam	A cross-sectional survey involving 550 motorcycle delivery riders in two megacities in Vietnam	Quantitative	- Job demands: time pressure, work/life imbalance, working environments - Job resources: social support (organizational level), social support (co-worker level), feedback - Job strain - Risk-taking attitude - Road safety compliance - Control variables: age, gender, immigration, education and income	- Demands that non-commercial motorcycle riders experience when on the road are not directly comparable to those experienced by food delivery riders - Job strain and risk-taking attitude mediate the relationships between job demands and resources and safety compliance - Job demands and job resources are higher-order formative constructs - Male and younger riders should be the main target of safety

Table A1 (*continued*)

Authors	Country	Data Used	Methodology	Key Constructs	Findings
					interventions as they are at a higher risk - Better-paid riders were more likely to engage in risky riding behaviors
(He et al., 2023)	China	A cross-sectional questionnaire survey among 824 couriers across three regions in China.	Quantitative	- Work conditions: emotion (anger, anxiety), objective workload (packages, hours), cognitive workload (NASA task load measure) - Road risk status: risky behaviors, road crash risk level	- Beijing-Tianjin Urban Agglomeration has the highest road crash frequency, and RCRL - Distracted driving and wrong-lane-use are among the top three risky behaviors. - For Beijing-Tianjin Urban Agglomeration, distracted driving, aggressive driving, and lack of protection are the top three risky behaviors - Time demand and personal efforts are important factors contributing to the cognitive workload of couriers - Objective workload can affect the cognitive workload and both workloads influence drivers' emotions (anxiety and anger - The objective, cognitive workload, drivers' emotions influence the RCRL through their impacts on risky behavior but in different paths for three agglomerations
(Jing et al., 2023)	China	Survey data from 5,703 riders of an online food-delivery platform in ChinaSemi-structured interviews with 43 riders	Qualitative and Quantitative	- Income dependence - Riders' work injury - Mediator: workload - Mediator: difficulty in obtaining subsidies - Control variables: gender, age, marital status, children, education, location, work city, hourly wage, and job type.	- A rider's degree of income dependence is positively related to work injury - Workload mediates the relationship between income dependence and work injury, - Difficulty in obtaining subsidies moderates the relationship between income dependence and workload.
(Nguyen-Phuoc et al., 2023)	Vietnam	A cross-sectional survey involving 554 food delivery riders in the two biggest cities in Vietnam	Quantitative	- Job demands - Job resources - Personal demands - Personal resources - Job burnout - Risky riding behaviors - Perceived safety risks	- Job burnout, job resources, and personal demands directly impact risky riding behaviors, in which job burnout was the most significant predictor. - Constructs such as job demands, personal resources, and perceived safety risk were not significant predictors of risky riding behaviors.

(Christie and Ward, 2023)	Great Britain	Interviews with six gig riders and 14 employed ridersAn online survey by 164 riders working via apps and 155 employed by restaurants.	Qualitative and Quantitative	**Dependent variable**
				  - Time pressure of meal delivery work
				Independent variables
				  - Key demographics
				  - Exposure variables such as the number of hours worked per week, license status and type of company
					- Gig workers tended to agree that their phone was a distraction and that they violated traffic laws related to speeding, red light running
					- Gig riders tended to be incentivized to ride in dangerous conditions and carry unstable loads.
					- Gig workers were more likely to report being involved in collisions where their vehicle was damaged and where someone was injured.

Table A2
Measurement scales and their sources.

Constructs	Measurement scales	Mean	Standard Deviation	Sources
Job Demands (Time Pressure)	I am always in a hurry to fulfill the assignment on time	4.290	1.830	(Demerouti et al., 2001, Zheng et al., 2019)
	I often think about the penalty for late delivery	4.415	1.784	(Demerouti et al., 2001, Zheng et al., 2019)
	I often worry about late delivery while working because of the time limit for each order	4.495	1.807	(Demerouti et al., 2001, Zheng et al., 2019)
Job Demands (Word Overload)	Usually, my job requires me to work very hard	5.846	1.332	(Chen and Chen, 2014)
	The performance standards on my job are too high	4.654	1.627	(Babakus et al., 2009)
	Every day, I have to run the minimum number of orders to hit the KPI.	5.090	1.658	(Schaufeli and Taris, 2014)
Job Demands (Working Environment)	I am often required to ride in adverse road conditions (e.g., poor road surfaces), which increases the risk of an accident	5.044	1.686	Author developed
	I am required to work in all weathers, even bad weather conditions	4.037	1.891	Author developed
	I work under pressure because I am required to ship at the right point and in a timely manner	4.051	1.848	(Schaufeli and Taris, 2014)
Job Demands (Application Problems)	During my work, I often encounter problems related to the application. (e.g., the application is slow, misplaced, etc.)	5.324	1.508	(Bakker et al., 2003)
	Application errors frequently occur during my work.	5.012	1.531	(Bakker et al., 2003)
	Application errors have significantly affected my work.	5.420	1.467	Author developed
Job Resouces (Job Autonomy)	I have significant autonomy in determining how I do my job	5.610	1.372	(Chen and Chen, 2014)
	I have the freedom to schedule my work as per my desire.	5.680	1.306	(Sardeshmukh et al., 2012)
	I am always looking for better ways to do my work	5.924	1.112	(Borst et al., 2019)
Job Resouces (Rewards)	The company has bonuses for employees who have a large number of orders and good service.	4.954	1.786	(Babakus et al., 2009)
	I receive visible recognition when I excel in serving customers	5.000	1.689	(Babakus et al., 2009)
	I receive sufficient pay for the work that I do.	5.180	1.561	(Bakker et al., 2003)
Job Resouces (Information)	I get sufficient information about the goal of my work	5.563	1.229	(Bakker et al., 2003)
	I get full information about my workload	5.488	1.263	(Van den Broeck et al., 2008)
Job Resouces (Performance Feedback)	I receive sufficient information about the results of my work	5.710	1.105	(Xanthopoulou et al., 2007)
	I get feedback from my company about how well I do my job.	5.639	1.190	(Bakker et al., 2003)
	I often get feedback from clients on how I do my job.	5.451	1.328	(Schaufeli, 2015)
Job Resouces (Technology Support)	The company has "state of the art" technology to enhance service quality	5.510	1.392	(Babakus et al., 2009)
	The company has enough money to provide technology to support my work to make the service better	5.544	1.349	(Babakus et al., 2009)
	I have the necessary technology support to serve my customers better	5.629	1.291	(Babakus et al., 2009)
	The company can afford to continuously upgrade technology to better serve its customers	5.651	1.296	Author developed
Job Resouces (Work Support)	I can count on my colleagues when I have a hard time at work.	5.366	1.308	(Bakker et al., 2007)
	I can ask a colleague for help if necessary.	5.578	1.137	(Bakker et al., 2007)
	The company has policies to help me drive safer.	5.302	1.326	Author developed
	The company knows how to effectively coordinate our activities.	5.385	1.287	Author developed
Job Burnout	I feel fatigued when I get up in the morning and have to face another day on the job	3.980	1.745	(Li et al., 2013)
	I feel exhausted at the end of a working day	4.349	1.712	(Li et al., 2013)
	I feel burnout by my work	3.778	1.693	(Li et al., 2013)
	I feel emotionally drained from my work	3.759	1.752	(Li et al., 2013)
Job Motivation	My job lets me make full use of my abilities	5.010	1.569	(Thakor, 1994)
	My job allows me to have control over my life	5.368	1.431	(Thakor, 1994)
	My job is another way to make a living	5.607	1.212	(Thakor, 1994)
In-role Safety Behavior (Safety Compliance)	I always wear protective gear when carrying out my job.	5.837	1.345	(Chen and Chen, 2014)
	I guarantee the highest level of safety when participating in traffic.	5.815	1.332	(Chen and Chen, 2014)
	I have taken action to prevent the recurrence of my previous incidents in traffic.	5.746	1.282	(Fugas et al., 2012)
	It is likely that I will refuse to ride if I am tired, affected by drugs or alcohol, or my judgment is impaired in any way	5.951	1.348	(Tunnicliff et al., 2012)
	I use the correct safety procedures for carrying out my job	5.856	1.288	(Neal and Griffin, 2006)
Extra-role Safety Behavior (Safety Participation)	I voluntarily attend safety training organized by the company.	5.432	1.326	(Braunger et al., 2015)
	I voluntarily carry out tasks or activities that help to improve the safety of riders	5.763	1.128	(Chen and Chen, 2014)
	I promote some safety programs within the organization.	5.456	1.289	(Chen and Chen, 2014)
	I put in extra effort to improve safety when riding to work	5.863	1.053	(Chen and Chen, 2014)

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