Traffic Transportation

Exploring Factors That Influence Instant Delivery Service Riders' Red Light Running Behaviour – Development and Validation of a Questionnaire Based on the Theoretical Domains Framework

Fei YE[1], Wen CHENG[2]

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[1] yefei@zjvtit.edu.cn, Zhejiang Institute of Communications, Hangzhou; School of Transportation Engineering, Chang'an University

[2] Corresponding author, excellentwenzi2011@163.com, Zhejiang Institute of Communications, Hangzhou; School of Economic and Management, Chang'an University

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ABSTRACT

To develop effective interventions to transit the instant delivery service riders towards avoiding red light running behaviour, a valid and reliable questionnaire is needed to identify the potential theoretical factors that influence the intention. This study describes the development and validation of the red light running behaviour causes questionnaire based on the theoretical domains framework. First, the exploratory factor analysis was used to identify the initial questionnaire's underlying structure, including a set of 67 items in 13 domains. Next, confirmatory factor analysis was undertaken to assess the questionnaire's reliability, discriminant validity and goodness of fit. CFA produced a proper fit with adequate discriminant validity and internal consistency. CFA and Cronbach's alpha results in the final version of the RLRBCQ consisted of 39 items assessing 13 domains, explaining 69.799% of the variance, and internal consistency reliability values ranging from 0.710 to 0.825. These results suggest that the RLRBCQ demonstrates reliable, stable and valid properties, which can be used to assess potential determinants of avoiding red light running behaviour following the domains of the TDF. It can be utilised by safety managers and practitioners to guide the design of interventions for various traffic safety behaviours.

KEYWORDS

instant delivery service riders; red light running behaviour; quantitative; theoretical domains framework; questionnaire development and validation.

1. INTRODUCTION

It is common for instant delivery service (IDS) riders to run red lights with high accident frequencies [1]. Compared with ordinary e-cyclists, IDS riders are individuals belonging to an organisation. Intense competition among delivery platforms intensifies the high requirements for delivery punctuality and efficiency. However, IDS riders often have not undergone pre-employment traffic safety training, and their awareness of riding safety is weak. To strive to meet the professional requirements stipulated by the company, they expect more orders to obtain higher income and, in most cases, are faced with time pressure. When the intersection shows a red signal light, the delivery may risk saving time and often cannot stop at the stop line and wait until the green light is on, that is red-light-running (RLR) behaviour. Moreover, the IDS riders' understanding of various traffic violations is far behind the correct version [2]. Although some of them recognise the detrimental effects of risky behaviours, risk perceptions do not inhibit their risky behaviours [3] and they maintain them [4, 5].

Research on RLR behaviours and formulation of interventions should be based on scientific theories. However, there are many existing psychological theories, and many theories contain constructs that are very close in connotation, such as self-efficacy (SE) in the theory of self-efficacy and perceived behavioural control (PBC) in the theory of planned behaviour (TPB). These two constructs have very similar meanings, making it difficult for researchers to choose a suitable theoretical framework to guide their research. At present, many theoretical models have been applied to behaviour problems, and the most common ones include the theory of rational action (TRA), health belief model (HBM), TPB, social cognitive theory (SCT), etc. These theories

contain many identical or overlapping constructs, such as intention, social norms, beliefs, control/self-efficacy, etc. These theories are primarily intended to explain or predict behaviour, not to understand the barrier to behaviour change. Some studies focus on a single domain, such as personality traits, motivational systems and intentional motivation. Therefore, the theoretical basis for the selection is insufficient. Also, the behaviour-based safety (BBS) approach is used as a common strategy in the field of behaviour change [6]. BBS has been criticised for its lack of theoretical basis and largely top-down and simplified implementation procedures.

Furthermore, BBS assumes that behaviour is the sole cause of security incidents, thus diverting attention away from the role of complex, multi-layered factors. Scholars have sharply criticised the narrow focus on behavioural observation and reinforcement in the workplace for unfairly blaming employees for accidents and not actively engaging them in the behaviour change process other than blindly criticising them for misconduct [7, 8]. Although criticism of safety management has produced behavior change strategies, its effectiveness has also received some support [6, 9]. However, because their theoretical basis is often unclear, the relevant knowledge about under what circumstances and on which issues is effective is relatively limited.

The evidence of behaviour change research suggests that the choice to implement a specific intervention should depend on specific factors (e.g., knowledge, skills, motivation, confidence, environment and social influences) that influence specific behaviour change [10, 11]. In practice, the factors influencing behaviour change are not explored at different levels, resulting in little evidence of those responsible for implementing safe behaviour change. According to the literature, the most common interventions are educating, persuading, monitoring behaviour and providing feedback. These interventions are often formulated through intuitive perception and do not fully utilise theoretical methods to understand specific barriers and facilitating factors to implementing specific behaviour changes [12].

2. LITERATURE REVIEW

In the social and behavioural sciences, many psychological theories are used to explain and understand individual or organisation behaviour. Scholars have carried out some studies on e-cyclists' RLR behaviour. Guo et al. explored the heterogeneity of RLR behaviour under different intersection facilities and found that e-cyclists' self-identity and attitude affect the behaviour. They think that interventions need to be tailored to the psychological factors [13]. Wang et al. conducted a cross-sectional survey, including a field and online survey, to understand the awareness, riding behaviour and legislative attitude of e-cyclists [14]. Yao et al. studied the influence of psychological factors on the risky riding behaviour (sudden braking, unexpected lane change, etc.) of Chinese e-cyclists. They pointed out that the e-cyclist's attitude and risk perception significantly impact risky riding behaviour [15]. Yang et al. used subjective norms, risk perception, conformity, self-perception and exemplary norms as extended variables to study the influence of psychological factors on the intention of RLR based on the extended TPB. The results showed that attitude, PBC, subjective norm and self-cognition are the main factors affecting behavioural intention [16].

In recent years, some scholars have successfully paid attention to the characteristics of risk riding behaviour of IDS riders and have proposed some interventions. Qin et al. used video to record the dangerous riding behaviours of IDS riders at four typical intersections in Beijing and found that running red lights and occupying vehicle lanes were the most common risk behaviours. The rate of dangerous behaviours of IDS riders was significantly higher than that of general e-cyclists [17]. Shen et al. examined the psychological characteristics of IDS riders' intention to RLR by using a questionnaire to collect data in China [18]. Fan et al. used TPB to study the influencing factors of red-light running behaviour of IDS riders [19].

In response to the problem of overlapping constructs in various theories, Michie et al. synthesised 128 constructs involved in 33 psychological theories [11] and formed a Theoretical Domains Framework (TDF) with 14 domains. Each domain also includes several theoretical constructs. For example, the "beliefs about capabilities" domain includes constructs such as self-confidence, perceptual ability, self-efficacy, belief and self-esteem. However, there are no overlapping constructs between each domain, and it covers different levels of individual, organisational and social factors. Currently, no causal elements are proposed to link constructs in the theoretical part of TDF, so TDF is a suitable framework for adaptation [11, 20], either by removing domains that are less relevant to the target behavior [12, 21] or by considering the addition of additional relevant domains [11, 22].

TDF almost covers the main factors affecting behaviour change in psychological theories, which prevents researchers from falling into one or several psychological theories before analysing the data. Furthermore, the involved constructs have been simplified and merged, which facilitates the selection of psychological theories by researchers, and can help researchers explore the influencing factors of behaviour from different levels and predict behaviour changes [11]. In recent years, more and more researchers have begun to pay attention to and apply TDF. They found that TDF provides an effective and practical analytical framework for explaining specific behaviours, identifying predictors of behaviours and formulating interventions. Beyond human behaviour, TDF extends to other important areas related to behavioural change.

At present, the early application of TDF is mainly limited to the medical setting and clinical behaviour, relying on qualitative interviews to gain a detailed understanding of the factors affecting the behavioural changes of patients [23] and healthcare workers [24, 25]. However, qualitative methods are often time-consuming, resource-intensive, and usually only collect data from small samples of the population of interest. Therefore, in recent years, scholars have gradually started to use TDF to design questionnaires for quantitative research [12, 26–28]. They believe that in addition to saving time and resources and increasing the sample size, the questionnaire method is more likely to be adopted by practitioners [12]. For example, Taylor et al. used a questionnaire constructed based on TDF to summarise the behavioural factors that are likely to lead to risk occurrence in the process of nasogastric tube use [29] and used a randomised controlled experiment to observe the implementation effect of TDF-based intervention measures and found that it was better than the traditional method [30]. They also applied TDF to develop and improve the healthy exercise behaviour questionnaire. They added, deleted and modified items through confirmatory factor analysis (CFA) and cross-validation so that the questionnaire has good reliability and validity, and can more effectively predict the influencing factors of behaviour change [27]. These studies provide useful references for the design, validation and application of TDF-based questionnaires.

Some scholars pointed out that the interview syllabus based on the TDF design is not open enough, which will lead to researchers being limited to selecting subject-related viewpoints and opinions, resulting in attribution bias and missing some vital information. In this regard, Dyson et al. designed a randomised controlled experiment using a TDF-based interview outline and routine interview and questionnaire design under non-theoretical guidance to explore the factors affecting medical staff's hand hygiene behaviour. TDF-based surveys screened more comprehensive influencing factors than controlled surveys [23]. This study preliminarily shows that the behavioural influencing factors detected based on TDF have the characteristics of strong inclusiveness and comprehensive coverage, and the use of TDF can help reduce the omission of critical factors.

Understanding the barriers at the level of individuals, platforms (organisations) and public management is an essential prerequisite for developing effective interventions for RLR behaviour. TDF provides a systematic theoretical basis for it. While TDF has been used to create and validate healthy behaviour change questionnaires, a valid and reliable questionnaire to assess potential causes of RLR behaviour for IDS riders does not currently exist. It is urgent to expand the application of TDF to research traffic safety behaviours.

Therefore, this study refers to the TDF and the definition of each domain developed by social psychologists in recent years, takes IDS riders' RLR behaviour as the target behaviour, and adopts a staged development process and cross-validation strategy [31] to design items for each domain of the red light running behaviour causes questionnaire (RLRBCQ). Stratified sampling was used to collect sample data from 612 valid IDS riders from Hangzhou, Xi'an and Aral. First, pre-test questionnaires were screened and refined through a small sample survey, and the underlying structure of the initial items was identified through exploratory factor analysis (EFA). Then, CFA was carried out to verify the validity of the questionnaire, and a structured formal questionnaire consisting of 13 domains and 39 items was finally determined and a formal survey was carried out. The analysis verified the validity of the questionnaire and found that the final version of the RLRBCQ had generally acceptable levels of discriminant validity, internal consistency and test-retest reliability.

3. METHODS

3.1 Questionnaire development

Following the methodology in previous studies that modified theoretical frameworks for behaviours, the occupational safety-related literature was reviewed to identify the most relevant TDF domains and to consider

whether additional factors should be included. The "behavioural regulation" domain, considered unrelated to target behaviour, was removed from the current framework [21, 28]. The "intent" domain, which is similar to "safety motivation", often seen as a mediator or outcome variable in safety science research [32], was also removed. The original definition of the "environmental context and resources" domain included "organisational culture and climate" [22]. The safety climate is increasingly recognised as having a substantial impact on individual and organisational safety outcomes [31, 33]. Therefore, we replaced the "environmental context and resources" domain with "safety climate" and identified two sub-domains: "safety climate of organisational level" and "safety climate of group level". Therefore, the final developed framework consists of 13 domains, including 11 subdivision domains from the original TDF [11, 20] and two other indirect developments. The following methods and procedures were adopted in designing the questionnaire structure, preparation and revision of measurement items.

First, the relevant literature on health and safety behaviours using TDF was researched and analysed. Then, the items with different expressions in the same domain were selected and integrated through the cross-scale comparison referring to the safety behaviour change questionnaire [28, 34], and the sentence expressions were adjusted according to Chinese culture and language habits. Then, we selected five IDS riders from Meituan and Ele.me platforms to conduct in-depth interviews, mainly on questions about the wording of the questionnaire items, understanding of sentence meaning, whether there is ambiguity, and how to improve it to be more suitable for IDS riders.

Table 1 – EFA results of pre-test items in each theoretical domain

Domains	KMO	Bartlett's test of sphericity approx. chi-square	Eigenvalue	Variance explained	Factor 1	Loading on Factor 1	Factor 2	Loading on Factor 2	Factor 3	Loading on Factor 3
Knowledge, KN	0.725	26.328	1.011	63.462%	KN1	0.812	KN2	0.607	KN3	0.575
Skills, SK	0.792	35.009	1.042	67.197%	SK3	0.651	SK2	0.557	SK1	0.471
Memory, Attention and Decision Processes, ME	0.716	170.087	1.015	72.184%	ME1	0.931	ME2	0.923	ME4	0.519
Social Influences, SC	0.802	84.344	1.387	70.635%	SI3	0.693	SI4	0.613	SI2	0.586
Social/ Professional Role and Identity, SR	0.755	185.751	1.074	69.048%	SR1	0.784	SR3	0.759	SR4	0.672
Beliefs about Capabilities, CA	0.708	183.467	1.046	72.496%	CA1	0.908	CA5	0.783	CA2	0.765
Optimism, OP	0.796	177.771	1.047	84.34%	OP1	0.873	OP2	0.854	OP3	0.744
Goals, GO	0.726	356.152	1.029	82.362%	GO3	0.784	GO4	0.752	GO2	0.544
Beliefs about Consequences, CO	0.792	250.837	1.197	65.445%	CO5	0.835	CO1	0.781	CO4	0.694
Safety Climate of Organisational Level, SO	0.767	101.351	1.072	66.34%	SO2	0.762	SO1	0.52	SO3	0.462
Safety Climate of Group Level, SG	0.714	14.825	1.107	69.889%	SG1	0.621	SG3	0.559	SG2	0.442
Reinforcement, RE	0.713	76.320	1.166	73.371%	RE4	0.766	RE1	0.677	RE2	0.478
Emotions, EM	0.786	168.418	1.106	72.171%	EM2	0.639	EM3	0.633	EM1	0.56

Table 2 – Demographic characteristics of the sample

Essential information	Category	Number of samples	Proportion (%)
City	Hangzhou	213	34.8
	Xi'an	196	32.0
	Aral	203	33.2
Age/years	18–20	42	6.9
	21–25	179	29.2
	26–30	233	38.1
	31–35	71	11.6
	36–40	35	5.7
	41+	52	8.5
Gender	Male	532	86.9
	Female	80	13.1
Marriage situation	Non-married	247	40.4
	Married	365	59.6
Education	Primary school	31	5.1
	Junior high school	146	23.9
	Senior high school	315	51.5
	College/undergraduate	120	19.6
Monthly income (thousand Yuan RMB)	<2	58	9.5
	2–4	136	22.2
	4–6	201	32.8
	6–8	153	25.0
	>8	64	10.5
Delivery experience	<6 months	126	20.6
	6–12 months	58	9.5
	1–2 years	217	35.5
	2–3 years	164	26.8
	>3 years	47	7.7
Daily working hours (hours)	<3	34	5.6
	3–6	89	14.5
	6–9	149	24.3
	9–12	236	38.6
	>12	104	17.0
Whether part-time	Yes	166	27.1
	No	446	72.9
Do you have a driver's license?	Yes	201	32.8
	No	411	67.2
Have you ever been fined by the traffic police for electric vehicle violations in the past year?	Yes	115	18.8
	No	497	81.2
Whether there has been an electric two-wheeler traffic accident in the past year?	Yes	46	7.5
	No	566	92.5

The initial RLRBCQ with 67 5-point Likert scale items in 13 domains was revised and proposed based on the above interviews, discussions and suggestions. The order of items was subsequently adjusted for random distribution to minimize respondent consistency motives and to attenuate the problem of homogeneous variance that may result from self-reporting methods. In addition, demographic information such as gender, age, education and income level was collected.

The survey was carried out in March 2022. 50 IDS riders in Hangzhou, Xi'an and Alar were recruited to form 3 samples to participate in the preliminary survey. Online questionnaires are distributed to participants through on-site QR code scanning during non-peak delivery periods around commercial centres, hotel entrances, parks and universities. Participants have participated in delivery at least within the last month. At the same time, the purposeful snowball sampling technique was used to obtain a sufficient overall sample size, and 20 yuan was given as a reward for completing the entire questionnaire.

Based on the TDF-based questionnaire development and verification process [11, 12, 21, 22, 26–28, 35], the pre-test questionnaire was revised. Using the pre-test survey data, EFA was adopted to screen the items. The results of the evaluation for floor and ceiling effects show that the absolute value of the skew coefficient of all items is less than 3, and the absolute value of the kurtosis coefficient is far less than 10, indicating that the sample data conform to the multivariate normal distribution and meet the requirements of the independent sample t-test. The popularity value of 67 items is between 0.17–0.79, and the score value of the item is slightly in the middle; the popularity of each item is basically acceptable, and there is no floor and ceiling phenomenon, so all test items are temporarily reserved.

For EFA, each domain is extracted by the principal axis factorisation strategy with direct oblimin, and items with partial factor loadings below the threshold of 0.40 were removed. In order to keep the questionnaire in a practical, short and balanced form, the three items with the highest factor loadings are reserved for each domain. *Table 1* shows the retention of things in the pre-test questionnaire and the characteristics of each theoretical domain.

3.2 Recruitment and data collection

A formally structured questionnaire survey was conducted to recruit various IDS riders currently working in platforms in Hangzhou, Xi'an and Aral, China in April 2022. The demographic characteristics of the sample are shown in *Table 2*. A total of 750 questionnaires were distributed. Among the 612 valid questionnaires, males accounted for 86.9%, and females accounted for 13.1%, which reflected the differences in the gender distribution structure of IDS riders. Regarding age distribution, most respondents are relatively young, of which 6.9% are 18–20 years old, 8.5% are over 41 years old, and the largest age group is 26–30. In terms of marriage distribution, 40.4% of the participants were non-married. Regarding education, primary school accounted for 5.1% of the total, college/undergraduate accounted for 19.6%, and the highest education was senior high school accounting for 51.5%. The monthly income is mainly concentrated in the two segments of 4–6,000 yuan and 6–8,000 yuan, and the delivery experience is concentrated in the two segments of 1–2 years and 2–3 years, and the working hours per day generally reach 6 hours above. All entries in the 13 domains have absolute values of skew less than 1 and kurtosis less than 2.

4. RESULTS

4.1 Validity analysis

The SPSS 23.0 and Amos 25.0 were used to test the construct validity, convergent validity and discriminant validity of the questionnaire.

Construct validity. EFA was performed with principal component analysis and maximum variance rotation method, and factors were extracted with eigenvalues greater than 1. The KMO value was 0.794, and the Bartlett test value was 11218.228 (df=741, $p<0.001$). The preliminary results based on rubble plots and eigenvalues show that the sample is very suitable for factor analysis. As shown in *Table 3*, the 39 items formed a clear 13-factor structure, and the cumulative explained variance rate was 69.799%, which was consistent with the theoretical assumption model and the domain design of the questionnaire.

Convergent and discriminant validity. Convergent validity can be judged by the average variance extracted (AVE). If the AVE exceeds 0.5, it indicates that the items of each domain have sufficient convergent validity

Table 3 – EFA results of formal questionnaire survey

TDF domain	Eigenvalue	Variance explained (%)	Item 1	Loading on Item 1	Item 2	Loading on Item 2	Item 3	Loading on Item 3
KN	1.641	4.207	KN1	0.819	KN2	0.787	KN3	0.635
SK	1.758	4.506	SK3	0.807	SK2	0.725	SK1	0.605
ME	2.238	5.738	ME1	0.876	ME2	0.846	ME4	0.749
SI	1.608	4.122	SI3	0.819	SI4	0.757	SI2	0.658
SR	2.472	6.338	SR1	0.848	SR3	0.807	SR4	0.774
CA	2.313	5.93	CA1	0.891	CA5	0.797	CA2	0.613
OP	2.361	6.055	OP1	0.793	OP2	0.759	OP3	0.681
GO	2.544	6.523	GO3	0.882	GO4	0.872	GO2	0.673
CO	2.438	6.252	CO5	0.859	CO1	0.847	CO4	0.813
SO	1.671	4.284	SO2	0.812	SO1	0.769	SO3	0.688
SG	1.514	3.882	SG1	0.827	SG3	0.730	SG2	0.721
RE	2.161	5.54	RE4	0.723	RE1	0.717	RE2	0.659
EM	2.504	6.421	EM2	0.847	EM3	0.844	EM1	0.729

[36]. If the correlation coefficient between the two domains is less than the square root of the AVE, it indicates that the discriminant validity meets the analysis requirements [37]. Considering that the CFA is more operational for evaluating the reliability and validity of measurement tools, here we used the CFA to conduct convergence and discriminant validity of the overall model composed of all variables. The maximum likelihood method was applied according to the calibration method of the previous TDF questionnaire validation study [12,27], and several fit metrics were used, as shown in *Table 4*. The overall model fitting effect reaches an acceptable level, and the absolute goodness-of-fit indicators are: the ratio of model χ^2 to the degrees of freedom χ^2/df =1.969, goodness of fit index GFI=0.955, the root mean square error of approximation RMSEA=0.057 is better than the recommended value or reaches the acceptable level. The relative fit index is: root mean square residual RMR=0.029, normed fit index NFI=0.912, relative fit index RFI=0.803, incremental fit index IFI=0.996, tucker-lewis index TLI=0.929, the comparative fit index CFI=0.996 is also better than the recommended value or exceeds the acceptable level, so the model is set to fit well. The AVE value of each domain exceeded the lower critical value of 0.50, and the overall model and questionnaire had acceptable convergent validity. The square root of AVE in parentheses on the diagonal is greater than the pairwise correlation coefficient between the latent variables in the row and column, indicating that the overall model has good discriminant validity.

4.2 Reliability test

Reliability refers to the degree of consistency of measurement or the likelihood that a measurement tool will obtain the same result when repeated measurements are performed on the same subject under the same circumstances. It reflects the consistency or stability of measurement tools and generally uses Cronbach's alpha value as a predictor of reliability. It is usually believed that when Cronbach's alpha value of the internal consistency coefficient of an item measuring a construct is greater than 0.70, each domain's internal reliability is outstanding. These domains can be used to evaluate the construct, and the measurement item has good reliability. The internal reliability of each domain is mainly measured by the change in the coefficients after item deletion. If the alpha of the domain increases, this item can be deleted.

The corrected item-total correlation (CITC) value, Cronbach's alpha value and combined reliability (CR) of each domain are shown in *Table 5*. They were greater than 0.7, indicating that the questionnaire met the reliability requirements and had good internal consistency. In addition, the CITC values of all items were above 0.60, and after removing any item, Cronbach's alpha value for that domain did not increase, so there were no items to delete.

Table 4 – Convergent validity and discriminant validity of the overall model measurement domains

	AVE	KN	SK	ME	SI	SR	CA	OP	GO	CO	SO	SG	RE	EM
KN	0.56	0.75												
SK	0.51	0.255***	0.72											
ME	0.68	0.241**	0.222***	0.83										
SI	0.56	0.199***	0.297***	0.339***	0.75									
SR	0.66	0.187***	0.215**	0.295***	0.203***	0.81								
CA	0.60	0.256***	0.317***	0.272***	0.348***	0.319***	0.78							
OP	0.56	0.250***	0.322**	0.293***	0.254***	0.321***	0.331***	0.75						
GO	0.66	0.096***	0.296***	0.332***	0.233***	0.216**	0.196***	0.295***	0.81					
CO	0.71	0.175**	0.276***	0.301***	0.356***	0.336***	0.261***	0.266***	0.309***	0.84				
SO	0.57	0.204***	0.229**	0.299***	0.393***	0.298***	0.266**	0.232***	0.282***	0.146***	0.76			
SG	0.58	0.234***	0.283***	0.146***	0.266**	0.263***	0.363***	0.263***	0.249***	0.167***	0.124***	0.76		
RE	0.51	0.322***	0.292***	0.336**	0.322***	0.203**	0.391**	0.210***	0.282***	0.284***	0.324***	0.396***	0.72	
EM	0.65	0.204***	0.417***	0.373***	0.356***	0.233***	0.321***	0.282***	0.248***	0.293***	0.203***	0.266***	0.381***	0.81

The absolute goodness-of-fit indicators: χ^2/df=1.969, GFI=0.955, RMSEA=0.057, RMR=0.029, NFI=0.912, RFI=0.803, IFI=0.996, TLI=0.971, CFI=0.996

*Note: *** stands for significant for 0.001, ** stands for significant for 0.01 levels, respectively*

Table 5 – Reliability analysis of questionnaires

Domains	Item	CITC	Alpha if the item deleted	Cronbach's alpha	CR
KN	KN1	0.776	0.739	0.775	0.7935
	KN2	0.687	0.761		
	KN3	0.712	0.756		
SK	SK3	0.703	0.727	0.730	0.7581
	SK2	0.698	0.719		
	SK1	0.714	0.722		
ME	ME1	0.699	0.744	0.755	0.8646
	ME2	0.727	0.738		
	ME4	0.748	0.751		
SI	SI3	0.692	0.708	0.710	0.7904
	SI4	0.688	0.705		
	SI2	0.695	0.707		
SR	SR1	0.641	0.793	0.825	0.8513
	SR3	0.692	0.805		
	SR4	0.779	0.787		
CA	CA1	0.653	0.719	0.727	0.8158
	CA5	0.685	0.713		
	CA2	0.655	0.707		
OP	OP1	0.762	0.772	0.796	0.7893
	OP2	0.698	0.738		
	OP3	0.755	0.767		
GO	GO3	0.732	0.756	0.792	0.8538
	GO4	0.751	0.780		
	GO2	0.739	0.767		
CO	CO5	0.739	0.763	0.821	0.8778
	CO1	0.698	0.760		
	CO4	0.741	0.764		
SO	SO2	0.772	0.775	0.794	0.8014
	SO1	0.759	0.764		
	SO3	0.751	0.789		
SG	SG1	0.738	0.782	0.791	0.8042
	SG3	0.755	0.778		
	SG2	0.769	0.781		
RE	RE4	0.745	0.765	0.783	0.7599
	RE1	0.694	0.780		
	RE2	0.739	0.757		
EM	EM2	0.755	0.785	0.801	0.8493
	EM3	0.771	0.792		
	EM1	0.763	0.776		

4.3 Criterion-related validity

The mean, standard deviation, and correlation analysis results of each domain in the 39-item questionnaire are shown in *Table 6*. The measured value of the Pearson correlation coefficient is at the maximum value of 0.64 (the "goals" domain) and a minimum value of 0.20 (the "safety climate of organisational level" domain). There were significant correlations between some domains, with reported Pearson correlation coefficients between 0.73 ($p<0.05$; "knowledge" and "skills") and 0.12 ($p<0.1$; "optimism" and "memory, attention and decision processes").

4.4 Difference analysis

T-test and ANOVA found significant differences in the mean values of the 13 TDF domains corresponding to different characteristic groups. The results are shown in *Table 7*. Age had a significant effect on the scores of 11 domains, including "knowledge" ($F=3.550$, $P=0.004<0.01$) and "skills" ($F=4.894$, $P=0.000<0.01$). Compared with female IDS riders, males scored higher in domains such as "knowledge" and "social influences". IDS riders with undergraduate degrees scored significantly higher in domains such as "knowledge" and "skills" than other educational groups. IDS riders with less experience have lower scores in domains such as "knowledge", "social influences" and "emotions" than experienced ones. Part-time IDS riders had fewer scores for domains like "knowledge", "goals" and "beliefs about consequences" than full-time IDS riders. IDS riders with a driver's license had lower scores in domains such as "skills" and "memory, attention and decision processes" than those without a license. The IDS riders whom the traffic police have punished for violations in the past year have more scores in domains such as "skills" and "optimism". IDS riders who have experienced an electric two-wheeler traffic accident in the past year have lower scores in domains such as "social influences" and "social/professional role and identity".

"Knowledge" plays a meaningful role in RLR behaviour. Lack of knowledge is often cited as a major factor associated with poor enforcement of traffic compliance behaviour. It is generally noted that the content of the behaviour interventions is insufficient to provide IDS riders with the information or preparation they need to develop effective traffic safety behaviours. There is a clear gulf between IDS riders' knowledge and their application in the traffic environment. Increasing knowledge alone is not enough to increase the adoption of traffic safety behaviours. ANOVA testing revealed specific groups of IDS riders who lacked safety "knowledge", including older IDS riders, female IDS riders, less educated IDS riders and IDS riders with less experience. Therefore, more attention must be paid to these specific groups and security knowledge when developing educational or licensing programs. Overall, this study provides additional helpful information for improving IDS riders' safety. For example, by improving training and clarifying IDS riders' professional identities while increasing IDS riders' knowledge, the gap between behavioural intention and practice may be moderated. Although the vital role of knowledge should not be underestimated, it may be most effective to explore the interaction of knowledge with other factors.

There is a close relationship between IDS riders' motivation and their social/professional role and identity. IDS riders' professional identity is highly susceptible to and influenced by macro, micro, individual and group factors such as core beliefs, past experiences, norms and values. However, when these factors collide with new and different ways of thinking, tensions can arise that can hinder the ability to adopt the behaviour. For example, the behaviour may be inconsistent with previous experience, thereby preventing IDS riders from adopting relevant practices to promote the behaviour. Furthermore, there is still an inconsistency between IDS riders' occupational and self-imposed identities, which can negatively impact the motivation to implement behaviours. IDS riders must embrace avoiding RLR behaviour as part of their professional identity, which is essential to influence their motivation significantly. Social proof theory may inform practical interventions to strengthen IDS riders professional identity and combine it with supporting their intention to avoid the RLR behaviour.

IDS riders who said they frequently focused on green-lighting-waiting behaviour were more likely to engage in behaviour than those who paid less attention to it. The learning of knowledge about riding safety by delivery can be viewed as a dynamic and complementary process, with knowledge assimilation and consolidation carried out through a workshop-style training approach to improve behaviour [36]. To raise awareness among IDS riders about avoiding RLR behaviour, organisations should provide learning and career development opportunities in various forms to ensure dynamic learning. Learning tools, resources and policy documents

Table 6 – Correlation analysis results of formal questionnaire data

Domains	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1. KN	3.40	0.673	1												
2. SK	3.66	0.711	0.73**	1											
3. ME	3.25	0.738	0.01	0.03	1										
4. SI	3.48	0.464	0.47**	0.51**	0.06	1									
5. SR	3.50	0.771	0.58**	0.61**	0.00	0.45**	1								
6. CA	3.32	0.751	0.56**	0.64**	0.01	0.39**	0.55**	1							
7. OP	3.31	0.634	0.57**	0.49**	0.12*	0.50**	0.49**	0.46**	1						
8. GO	3.57	0.724	0.40**	0.44**	0.02	0.46**	0.34**	0.31**	0.41**	1					
9. CO	3.44	0.758	0.49**	0.26**	0.12	0.37**	0.27**	0.28**	0.55**	0.32**	1				
10. SO	3.18	0.534	0.29**	0.25**	0.00	0.46**	0.28**	0.32**	0.40**	0.43**	0.24**	1			
11. SG	2.57	0.517	0.27**	0.34**	0.00	0.43**	0.35**	0.31**	0.36**	0.37**	0.12	0.76**	1		
12. RE	3.70	0.707	0.32**	0.31**	0.11	0.45**	0.21*	0.34**	0.31**	0.32**	0.30**	0.44**	0.33**	1	
13. EM	3.00	0.423	0.34**	0.29**	0.23*	0.46**	0.38**	0.33**	0.42**	0.36**	0.45**	0.35**	0.29**	0.31**	1

*Note: * $p<0.05$, ** $p<0.01$*

Table 7 – Differences (F or t) of demographic characteristics in 13 different TDF theoretical domains

Independent variable /domains	KN	SK	ME	SI	SR	CA	OP	GO	CO	SO	SG	RE	EM
Age	3.550**	4.894**	12.581**	11.183**	2.933*	4.554**	3.955**	16.708**	16.474**	2.733*	9.728**	2.109	0.794
Gender	7.756**	3.126	14.450**	13.460**	6.372*	2.118	2.265	0.197	6.777**	0.013	0.699	0.008	3.863*
Education	6.439**	3.734*	0.727	7.969**	5.173**	6.027**	2.168	5.224**	3.584*	7.994**	3.136*	6.363**	5.412**
Delivery experience	6.465**	1.824	13.584**	7.868**	2.683	0.718	9.437**	2.263	12.693**	0.135	0.500	1.105	8.342**
Whether part-time	23.770**	2.192	0.214	0.019	0.048	0.829	1.380	10.571**	9.841**	4.212*	2.816	3.612	0.504
Do you have a driver's license?	3.826	5.399*	4.920*	2.369	7.817**	1.189	1.172	4.386*	10.493**	3.129	6.526*	1.864	9.705**
Have you ever been fined by the traffic police for electric vehicle violations in the past year?	2.205	12.062**	0.392	5.355*	0.187	1.598	5.627*	1.712	2.504	3.734	0.177	0.450	4.122*
Whether there has been an electric two-wheeler traffic accident in the past year?	0.070	0.636	2.392	4.936*	4.277*	13.890**	14.107**	33.990**	0.095	9.738**	1.023	3.017	6.013*

*Note: ** indicates the probability p-value under the corresponding F value < 0.01, * indicates p-value < 0.05*

provided in a static format (i.e. without opportunities for rehearsal or engagement) may not be sufficient. Learning tools and resources provided with interactive learning opportunities, such as workshops, may facilitate changes in the motivation and behavioural practices of transportation participation and behavioural compliance.

"Social influences" domain reflects "interpersonal processes that may lead an individual to change thoughts, feelings, or behaviours" [20]. Social influences, which may include social norms, group conformity and social pressure, emerged as the strongest predictors of behavioural intentions to implement waiting for a green light. The concept of social influences is rarely discussed in the literature on traffic safety behaviour research, which may be contrary to previous research that the attitude of IDS riders is the strongest predictor of their intention to implement the green light behaviour. However, Shen Xiaoyan, Zhang Fan et al. found that IDS riders' intention to wait for a green light behaviour is more likely to be triggered by external factors (such as social pressure and external conditions) rather than internal motivation (such as their attitudes) [18, 19]. In other words, when IDS riders recognise the approval of significant others (such as family, friends and colleagues) for the behaviour, their intention to carry out the behaviour increases. Therefore, leveraging peer mentoring opportunities, peer professional development and communities of practice can be a means of promoting the advancement of traffic safety behaviours. The results of the current study support the idea that social influences are an essential factor that may influence IDS riders' intention to engage in avoiding RLR behaviour. Rooting interventions in strategies that promote social influences may enhance IDS riders' intention to engage in the behaviour.

Attitudes toward behaviour are understood to include cognitive and affective assessments. Affective attitudes are often understood to reflect emotional states (i.e. happy/unpleasant) and are considered strong predictors of behaviour [38]. The current study measured emotion using items that assessed IDS riders' emotional experiences. The literature about road traffic safety behaviour is replete with evidence highlighting the importance of attitudes. That is, attitude is an essential factor related to the cyclist's intention to implement the behaviour. More specifically, the findings suggest that positive attitudes lead to and promote avoiding RLR behaviour. Conversely, a cyclist's negative attitude may lead to low expectations and less likelihood of the behaviour. Given that IDS riders' attitudes and affective assessments are critical to avoiding RLR behaviour, it would be remiss to ignore the ways in which emotion regulation can be used to improve risky behaviors of traffic participants. Therefore, future research should explore how to strengthen IDS riders' attitudes towards avoiding RLR behaviour for positive intervention effects.

5. DISCUSSION

The use of quantitative assessment tools to measure the field of TDF is still in its infancy, and researchers are currently challenged around the uniqueness or high correlation between each domain [27, 39]. In the current study, inhibitory variables demonstrated the challenges of quantitative studies using TDF. Guided by TDF, this study was exploratively applied in developing a behaviour change questionnaire. Despite the significant value of using quantitative tools from the TDF domain in studying traffic safety behaviour, the distinction between theoretical domains needs to be further refined conceptually and psychometrically. Furthermore, the results of this study highlight the importance of unique theoretical domains, such as "social/professional role and identity" and "memory, attention and decision processes", which are not represented in other theories.

The potential utility of TDF in this context is essential, given that current research on changes in cyclist traffic safety behaviour is often fragmented. The literature tends to propose and identify factors relevant to cyclist behaviour rather than simultaneously considering numerous factors that facilitate or hinder behavioural practices. Although pertinent to our understanding of avoiding RLR behaviour, understanding factors in a piecemeal fashion is not suitable for proper interpretation or broader applicability. Furthermore, it does not allow researchers to identify the theoretical domains that are needed or most impacted. By applying TDF, researchers can identify several factors related to behaviour and theoretically driven starting points for intervention design. Creating and delivering training resources and interventions, and prioritising the theoretical determinants of behaviour change, will hopefully yield results that yield better returns on investment.

Existing approaches to changing safety behaviours, such as BBS initiatives, lack rationale and are too narrow. This study used the TDF of behaviour change to develop, test, validate and revise a questionnaire measuring the psychosocial domain of IDS riders, and finally it obtained a questionnaire with 13 domains and

39 items. Compared with the initial version of the RLRBCQ, the overall fit statistics and internal consistency reliability have improved. The development and psychological testing of the RLRBCQ in this study provides an opportunity for safety researchers and managers to grow this knowledge to enhance the IDS riders' safety level for safety management researchers responsible for selecting or developing appropriate interventions. For practitioners, such tools should complement limited, mostly non-theoretical strategies.

Following the construction of the initial questionnaire, it is envisaged that the RLRBCQ can be used to identify barriers to similar safety behaviours across a large sample, across a range of safety-critical areas, and more and that this information may be cross-validated by focus groups supplemented by a smaller sample and further understanding identified obstacles. The RLRBCQ can potentially be a tool for developing theoretically supported large-scale interventions or working with managers at a practical level to create realistic strategies to address critical barriers. As suggested previously [27], we found that the latter approach is particularly relevant if the essential barriers to behavioural change differ within or between organisations, as this allows for targeted and quantitative tailored interventions.

Although various factors have been examined previously, early literature applied a limited theoretical perspective to consider intentions (e.g. TPB). The integrative theoretical approach employed in the current study informs the identification of various predictors of IDS riders' intention to engage in avoiding RLR behaviour, thereby providing new insights into IDS riders' intentions. From the broadest perspective, interventions that purposely target areas of TDF (e.g. social/professional role and identity, beliefs about capabilities and emotions) appear valuable.

Avoiding RLR behaviour is multifaceted and complex. Therefore, interventions to keep IDS riders motivated to implement the practice also require a multifaceted and complex approach. More comprehensive theories (e.g. TDF) and interdisciplinary approaches are proposed to change IDS riders' intentions, thereby influencing long-term and sustainable behavioural change. Using both theoretical and practical strategies will allow researchers to contextualise and interpret the results (i.e. IDS riders' avoiding RLR behaviour) in the context of the environment (i.e. a professional delivery task). Researchers can assess how interventions targeting significant TDF domains translate into traffic safety behavioural changes in IDS riders.

This study highlights the complexity of traffic compliance behaviour. The findings guide intervening IDS riders to implement the intention of avoiding RLR behaviour, suggesting that future interventions for IDS riders should include emotional and cognitive enhancements. Further research can focus on adopting a holistic approach to improve the enthusiasm of IDS riders to avoid RLR behaviour by developing interventions.

6. CONCLUSION AND LIMITATION

This study mainly includes questionnaire design and compilation methods, preparation of pre-test questionnaire items, small sample survey, and evaluation and screening of pre-test items using item analysis, CITC and reliability analysis, and EFA to form a formal questionnaire. Then, the extensive sample survey and data description are introduced, and the reliability and validity of each scale are verified by using the data. The results show that the RLRBCQ developed in this study has good construct validity, convergent validity and discriminant validity, and the questionnaire measured by Cronbach's alpha value has high internal consistency and good reliability. Frameworks based on behavioural change theory, such as TDF, can help identify these factors, and a questionnaire can be constructed that can be used by safety managers to guide the design of interventions for a range of safety behaviours.

This study is the first development and validation of a theory-based questionnaire describing the determinants of delivery traffic behaviours in an urban road environment, which can be used by researchers and practitioners working in the field of safety improvement for a range of specific traffic safety behaviour factors. Further research should be conducted to fully understand this measure's utility and limitations, but preliminary results suggest that it demonstrates reliable and practical properties. These findings provide sufficient support to indicate that this measure can be used to identify barriers to behavioural change among key occupants in road traffic safety. A logical next step should be to assess the tool's effectiveness in informing the development of rationale-based tailored interventions. Future longitudinal studies should aim to understand whether critical domains can be anchored by matching interventions guided by taxonomies of existing behavioural change technologies relevant to the TDF domain [10], thereby altering the levels of these determinants, altering specific safety behaviours, which in turn reduces the associated damage rate.

This study builds on existing research conducted in the road traffic environment, fully considers the feasibility of constructing a theory-based questionnaire using the TDF, and highlights the advantages of the questionnaire over more traditional qualitative TDF methods. Managers responsible for promoting safe behaviour in their organisations are more likely to adopt questionnaires. It is the first TDF study to understand the RLR behaviour of IDS riders from a comprehensive theoretical perspective. Of the original 67 items for the RLRBCQ, 28 were removed during the EFA and calibration steps. In the final model, the 13 domains corresponding to the TDF are composed of three items to improve the practical usability of the questionnaire.

Although the RLRBCQ developed in this paper demonstrates reliability and validity, this study also has some limitations. First, the RLRBCQ could not distinguish between high-safety behaviour performers and low-safety behaviour performers on specific subscales. For "beliefs about consequences", both groups scored relatively high, given that previous research has shown that behaviour is the result of a game of minds over the interests of the executors involved, such as the benefit of green-light-waiting versus the actual serious consequences.

Second, for "safety climate at the organisational level" and "safety climate at the departmental level", the RLRBCQ was unable to distinguish between low-safety behaviour performers and high-safety behaviour performers, and the most likely explanation is that the response range of the two groups was divided by relatively high standard deviation. Safety climate is often defined as a shared perception of the value of workplace safety. At the organisational level, the focus is on the "top management", while at the departmental level, it is the "line supervisor". Although the sample of ride-hailing delivery workers used in this study included employees with similar safety-critical job roles, it is worth noting that employees work in departmental teams across different organisational conditions and with many other direct supervisors. In the present study, we could not determine the nested nature of this organisational structure. Validity assessments of the RLRBCQ showed that domain scores for all single measures were significantly associated with safe behaviour intentions in the formal survey sample, and most domains distinguished between high and low safe behaviour performers. However, future research should extend the findings of this study by incorporating objective measures of specific safety behaviours as standard indicators, such as behavioural observations of job supervisors, a mode of assessment that is thought to be more effective and reliable than self-reporting.

We are generally encouraged by these findings. However, we also recognise that the questionnaire was developed based on the existing questionnaire. Like all new questionnaires, further research is needed to use it to test their validity, reliability and generality. Further research on the psychometric properties of the questionnaire will be valuable. Furthermore, the elimination of "behavioural regulation" domains due to inhibitory-like effects requires caution in interpreting the results and a more detailed study of the interactions between the TDF domains is recommended. The possibility of selection bias, self-report and social expectation bias cannot be ruled out.

Additionally, while the understanding of IDS riders' intentions is of great value, future research needs to examine IDS riders' behavioural practices. Although males dominate the sample, this gender difference is representative of the demographics of China's IDS riders. Furthermore, these data are collected only by Chinese IDS riders, so policy differences across regions and countries may play a central role in predicting individual values. Finally, it is recommended to supplement the findings with qualitative methods to gain further insight into IDS riders' practical considerations and barriers to avoiding RLR behaviour.

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叶飞，程文

探索影响即时配送服务骑手闯红灯行为的因素：基于理论域框架的问卷的开发与验证

摘要：
为了制定有效的干预措施，使即时配送服务骑手避免闯红灯行为，需要有效且可靠的调查问卷来识别影响意图的潜在理论因素。本研究描述了基于理论域框架的闯红灯行为诱因调查问卷的开发和验证。首先，探索性因子分析用于确定初始调查问卷的基本结构，包括 13 个领域的 67 个条目。接下来，进行验证性因子分析来评估问卷的信度、区分效度和拟合优度。 CFA 产生了适当的拟合，具有足够的判别有效性和内部一致性。 RLRBCQ 最终版本中的 CFA 和 Cronbach's alpha 结果包含评估 13 个领域的 39 个条目，解释了 69.799% 的方差，内部一致性可靠性值范围为 0.710 至 0.825。这些结果表明 RLRBCQ 表现出可靠、稳定和有效的特性，可用于评估基于 TDF的避免闯红灯行为的潜在决定因素。安全管理者和从业人员可以利用它来指导各种交通安全行为的干预措施的设计。

关键词：
即时配送服务骑手；闯红灯行为；定量的；理论域框架；调查问卷的开发和验证