

# Overview of road traffic injuries among migrant workers in Guangzhou, China, from 2017 to 2021

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# ABSTRACT

**Introduction** There are many migrant workers in China's first-tier cities, but little is known about road safety. This paper systematically analysed road traffic injuries and risk factors among migrant workers in Guangzhou, China.

**Methods** Road traffic crash data from 2017 to 2021 were obtained from the Guangzhou Public Security Traffic Management Integrated System. We plotted the crash network of road users in road traffic crashes and used logistic regression to analyse the risk factors for migrant workers of motorcycle and four-wheeled vehicle crashes. Moreover, the roles of migrant workers and control individuals as perpetrators in road traffic crashes were also analysed.

**Results** Between 2017 and 2021, 76% of road traffic injuries were migrant workers in Guangzhou. Migrant workers who were motorcyclist drivers most commonly experienced road traffic injuries. Crashes between motorcyclists and car occupants were the most common. The illegal behaviours of migrant worker motorcyclists were closely related to casualties, with driving without a licence only and driving without a licence and drunk driving accounting for the greatest number. Migrant workers were responsible for many injuries of other road users. Motorcycle drivers have a higher proportion of drunk driving.

**Discussion** Migrant workers play an important role in road traffic safety. They were both the leading source of road traffic injuries and the main perpetrators of road traffic crashes. Measures such as strict requirements for migrant workers to drive motorcycles with licences, prohibit drunk driving, greater publicity of road safety regulations, and combining compulsory education with punishment for illegal behaviours.

# INTRODUCTION

There are approximately 1.3 million deaths and 20–50 million non-fatal injuries from road traffic crashes (RTCs) worldwide each year.<sup>1</sup> Road traffic injuries (RTIs) are mainly concentrated in low/ middle-income countries, such as India and China. The WHO estimates that 256 000 people die in RTCs in China each year.<sup>2</sup> In recent years, many scholars have studied the trend of RTCs in China: Central South University<sup>3</sup> analysed road traffic mortality from 2006 to 2016; Southeast University<sup>4</sup> assessed the relationship between revised road traffic safety laws and mortality rates between 2002 and 2019; and Tsinghua University<sup>5</sup> analysed the

# WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ In some low/middle-income countries, migrant workers are an important source of road traffic injuries. However, there is a lack of epidemiological surveys of large-scale road traffic injuries specifically studied among migrant workers.

# WHAT THIS STUDY ADDS

- ⇒ Migrant workers who were motorcyclist drivers were most commonly experienced road traffic injuries.
- ⇒ Among migrant workers, drivers of fourwheeled vehicles were the main perpetrators of road traffic crashes.
- ⇒ The most important illegal behaviour of migrant motorcycle drivers was driving without a licence, and this was implicated in many road traffic injuries.
- ⇒ Motorcycle drivers had a higher proportion of drunk driving than four-wheeled vehicle drivers.

# HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ It is necessary to fully understand and attach importance to the major impact of migrant workers on road safety.
- ⇒ Encourage greater use of public transportation such as buses and subways, especially in outer urban areas.
- ⇒ Strictly implement a system of driving motorcycles with licences after training and assessment and increase the punishment for motorcycle violations.
- ⇒ Revise the Law of the People's Republic of China on Road Traffic Safety, especially the relevant provisions on motor vehicle traffic regulations, so that the front-line traffic police can clearly identify the illegal behaviours of drivers.
- ⇒ Increase the intensity of investigation of drunk driving and driving without a licence, especially motorcycle drivers.

severity of RTCs between 2000 and 2016. At the regional level, scholars have focused their research on road safety in metropolitan areas, such as Shanghai<sup>6</sup> and Shenzhen.<sup>7</sup> These urban agglomerations have developed economies, large populations, high levels of healthcare and concentrated scientific research institutions and high incidence of RTCs,

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**Figure 1** (A) Trend in road traffic injuries in Guangzhou from 2017 to 2021: Migrant workers versus the control group; (B) Number of individuals involved in road traffic crashes, road traffic injuries and road traffic perpetrators in Guangzhou from 2017 to 2021: Migrant workers versus the control group.

which is helpful for the analysis of RTCs. Nearly half of the population in these areas are migrant workers.

The National Bureau of Statistics defines migrant workers as workers whose household registration is still in rural areas who have engaged in non-agricultural industries locally or have been working outside rural areas for 6 months or more during the year. In search of higher incomes, they choose to migrate to cities, mainly to work in manufacturing, construction and services. According to the 2021 Migrant Worker Monitoring Survey Report,<sup>8</sup> there are approximately 293 million migrant workers in China, far higher than the number of international internal migrants (169 million),<sup>9</sup> and 56% of them have only received a junior high school education. A total of 51.73% of migrant workers live in eastern coastal areas, including metropolises such as Beijing, Shanghai, Guangzhou and Shenzhen and urban agglomerations in the Pearl River Delta and Yangtze River Delta. Migrant workers are an important driver of economic development but also a vulnerable group in society (the average monthly income of migrant workers is only ¥4432). At present, there are many studies on education,<sup>10</sup> mental health,<sup>11</sup> social integration,<sup>12</sup> well-being,<sup>13</sup> diseases<sup>14</sup> and other aspects involving migrant workers, covering almost all areas of their lives. There are currently few studies on road safety for migrant workers.

Due to the large number and high mobility of migrant workers, it is difficult to carry out road safety research among them. Southeast University<sup>15</sup> used the Bayesian network to study risk indicators of drivers and roadways and found that migrant workers and their dangerous violation behaviours had a substantial impact on the severity of traffic crashes. Peking University People's Hospital<sup>16</sup> found that floating migrant patients were more likely to suffer open injuries and severe traffic injuries than local resident patients through hospital records. Individual death data for all permanent residents from Guangzhou Centres for Disease Control and Prevention<sup>17</sup> found that blue-collar workers accounted for 53.2% of road traffic deaths. In addition, Harbin Medical University<sup>18</sup> investigated the causes of road traffic collisions among sanitation workers, and Tongji University<sup>19</sup> investigated the impact of traffic safety education on migrant workers. Similar studies have been conducted internationally in some countries with large migrant populations, such as Iran<sup>20</sup> and Kuwait.<sup>21</sup> Another report from Vietnam<sup>22</sup> showed a significant correlation between migrant bus drivers and RTCs compared with local bus drivers. In general, there are no large-scale studies investigating the impact of RTIs on migrant workers.

Our previous research<sup>23</sup> found that migrant workers are not only the main victims of RTCs but also have an important relationship with their occurrence. Therefore, we believe that it is of great practical importance to systematically study the role and characteristics of migrant workers in RTIs.

Guangzhou, a metropolis with a population of more than 18 million at the end of 2021, of which more than 8 million are migrant individuals, is a representative city that met the needs of this research. This study collected and analysed RTC data in Guangzhou from 2017 to 2021, aiming to systematically investigate the characteristics, risk factors and contribution of migrant workers in RTCs.

#### **METHODS**

#### Study design and statistical methods

This was a retrospective cohort study. The subjects were people who suffered RTCs in Guangzhou between 2017 and 2021 and were divided into migrant worker and control groups. Migrant workers were defined as migrant labourers with a non-urban registration, including registered labourers from other towns and rural areas outside the Guangzhou area, and were a special group under the Chinese registration system<sup>23</sup>; migrant workers from other countries were excluded. The control group was defined as mainly local residents of Guangzhou and a small number of college students and businessmen from other provinces. In

Table 1         Basic information on road traffic crashes for migrant workers and the control group in Guangzhou from 2017 to 2021					
Variable	Control group (N=8559)	Migrant worker (N=25 223)	Total (N=33 782)		
Outcome					
No injuries	4474 (13.24%)	11 950 (35.37%)	16424 (48.62%)		
Injuries	4085 (12.09%)	13 273 (39.29%)	17358 (51.38%)		
Human damage	47.73%	52.62%	51.38%		
Gender					
Male	6825 (20.20%)	20807 (61.59%)	27632 (81.80%)		
Female	1734 (5.13%)	4416 (13.07%)	6150 (18.20%)		
Age (M±SE)	38.48±17.73	40.08±14.25	1		
Age group					
0–19	1032 (3.05%)	897 (2.66%)	1929 (5.71%)		
20–39	3635 (10.76%)	12 488 (36.97%)	16123 (47.73%)		
40–59	2755 (8.16%)	9441 (27.95%)	12196 (36.10%)		
≥60	951 (2.82%)	2397 (7.10%)	3348 (9.91%)		
Unknown	186 (0.55%)	0 (0.00%)	186 (0.55%)		
Region					
Central urban	2298 (6.80%)	3136 (9.28%)	5434 (16.09%)		
Outer urban	5651 (16.73%)	20713 (61.31%)	26364 (78.04%)		
Highway	610 (1.81%)	1374 (4.07%)	1984 (5.87%)		
Road user					
Pedestrian	1025 (3.03%)	2062 (6.10%)	3087 (9.14%)		
Pedal cyclist	426 (1.26%)	1002 (2.97%)	1428 (4.23%)		
Electric cyclist	762 (2.26%)	2215 (6.56%)	2977 (8.81%)		
Motorcyclist	1659 (4.91%)	7747 (22.93%)	9406 (27.84%)		
Four-wheeled vehicle occupant	4424 (13.10%)	11 950 (35.37%)	16374 (48.47%)		
Others or unknown	263 (0.78%)	247 (0.73%)	510 (1.51%)		
Time					
Day	4076 (12.07%)	11 410 (33.78%)	15486 (45.84%)		
Nightfall or dawn	192 (0.57%)	689 (2.04%)	881 (2.61%)		
Night-time	4291 (12.70%)	13 124 (38.85%)	17415 (51.55%)		

M, mean; N, number; SE, standard error.

addition, there were a very small number (129 people in total) from Hong Kong, Macao, Taiwan and other countries, which were not included in the above two groups in this study and analysed.

According to the International Classification of Diseases for Mortality and Morbidity Statistics 11th Revision,<sup>24</sup> we divided road users into 6 categories and 11 subcategories (online supplemental appendix figure 1) and plotted the crash network according to 11 subcategories to show the distribution of RTCs in Guangzhou. According to the data, there was a significant difference in human damage (HD, number of RTIs/ number of individuals involved in RTCs) among different road users (online supplemental appendix figure 2). Motorcyclists were the main source of RTIs, while four-wheeled vehicle occupants were the main source of RTCs. We focused on these two factors, performed binary logistic regression analysis, analysed the risk factors by forward: likelihood ratio (LR), and screened the necessary risk factors according to the OR. Considering that most passengers in RTCs did not violate the law, our logistic regression excluded these. Unilateral crashes involving singlemotorcycle/car crashes are generally considered to have a large number of under-reporting, so this study also excluded these.

The available data found that motorcycle drivers and four-wheeled vehicle drivers accounted for approximately 70% of the

total RTCs. Our previous study<sup>23</sup> found that vehicle occupants are often responsible for RTCs, while pedal cyclists and pedestrians are often not. Therefore, we analysed the RTIs caused by migrant worker drivers of motorcycles and four-wheeled vehicles as perpetrators and explored their contribution in combination with illegal behaviours compared with the control group.

# Data sources

The Guangzhou Public Security Bureau has a complete RTC registration system. All data are registered into the system after the crash is handled by the front-line traffic police. This study obtained RTC data from the Guangzhou Public Security Traffic Management Integrated System between 2017 and 2021, which covered 11 administrative districts and highways in Guangzhou.

# Variables

The outcome variable of this study was the degree of injury after a collision. RTC outcomes were categorised as no injury, minor injury, serious injury and death. China developed the Criteria for the Identification of Human Injuries<sup>25</sup> to assess the severity of injuries, which is different from some existing assessment standards, such as the Abbreviated Injury Scale Injury Severity Score (AIS-ISS)<sup>26</sup> <sup>27</sup> or length of hospital



Figure 2 Crash network of road users in road traffic accidents in Guangzhou.

admission. Because minor injuries in the Criteria for the Identification of Human Injuries tend to be serious injuries according to the AIS-ISS or require admission to the hospital for at least 24 hours, this study classified the outcomes of road users as no injuries and injuries (including minor injury, serious injury and death). The time intervals for RTCs were divided into: (1) dawn: 05:00–06:59; (2) day: 07:00–16:59; (3) nightfall: 17:00–18:59 and (4) night: 19:00–04:59 of the next day. According to the report of the Guangzhou Statistics Bureau,<sup>28</sup> Guangzhou has a total of 11 administrative districts, of which Yuexiu, Liwan, Tianhe and Haizhu are the central urban, while Baiyun, Panyu, Huangpu, Nansha, Huadu, Zeng-Cheng and Conghua are outer urban.

We identified the road traffic perpetrator who bore full or primary responsibility in an RTC and divided them into uninjured perpetrators and injured perpetrators according to whether they were injured. Excluding the perpetrators, the remaining individuals who were injured in RTCs were defined as victims, while those who were not injured were defined as uninjured individuals (online supplemental appendix figure 3).

The RTC registration form was prepared in Microsoft Excel 97–2003 (Microsoft, Redmond, Washington, USA). IBM SPSS Statistics V.26.0 (IBM) was used for statistical analysis. Adobe Illustrator 2021(Adobe, San Jose, California, USA) was used for statistical drawing. The statistical test standard  $\alpha$ =0.05 when p<0.05 was considered statistically significant. All the hypothesis tests were two tailed.

# RESULTS

# **Basic information about RTCs**

From 2017 to 2021, a total of 33782 people were involved in RTCs in Guangzhou, of whom 17358 were injured. RTIs among migrant workers and the control group were basically on the rise (figure 1A). Migrant workers were both the main source of injuries and the main perpetrators of RTCs (figure 1B). The differences between migrant workers and the control group were mainly manifested in the following: (1) The HD of migrant workers was slightly higher than that of the control group (53% vs 48%); (2) individuals involved in RTCs were mostly concentrated in the working age group (20-59 years), of which migrant workers accounted for 65%, much higher than that in the control group (19%); (3) migrant workers in outer urban areas accounted for more than half of RTCs and (4) the proportion of motorcyclists and four-wheeled vehicle occupants among migrant workers was higher than that in the control group (table 1).

#### Distribution of crash types among road users

Car occupants and motorcyclists were the leading road users in RTCs. The main crash objects for pedestrians, pedal cyclists and electric cyclists included cars, motorcycles and heavy goods vehicles. The main crash objects for motorcyclists were fourwheeled vehicles (especially cars and heavy goods vehicles, figure 2).

NameImageImageImageImageImageImageSecondGradmanGradm	Table 2         Logistic regression analysis of motorcycle drivers among migrant workers and the control group in Guangzhou from 2017 to 2021							
ValueNo<			Migrant worker		Contr	Control group		
<table-container>Rep PartialEnditionSetSetSetSetSetGendenNoN</table-container>	Variable		N	P value	OR	N	P value	OR
Outer ubanOuter ubanSigner of the set of th	Region	Central urban	281	Baseline		133	Baseline	
Image:		Outer urban	5350	0.008	1.565	942	0.077	1.567
Genden ImageMain		Highway	20	0.063	7.399	6	0.071	0.203
ImageFermination of responsibilityFermination of responsibilityFe	Genden	Male	4871	Baseline		922	Baseline	
Petermination of regsonsibilityFull/Pinany2/946.0012.001<		Female	780	< 0.0001	1.972	159	0.056	/
Equal	Determination of responsibility	Full/Primary	2794	Baseline		560	Baseline	
Secondary or noneSecondary or noneSe		Equal	1089	< 0.0001	1.677	199	0.001	2.199
IndexIndexIndexIndexIndexIndexIndexIndexTimeDip		Secondary or none	1728	< 0.0001	2.165	309	< 0.0001	3.227
end final field of a set of		Unknown	40	0.594	1.255	13	0.992	1.007
Ightfall or dawn1340.0521.691.601.60Nght-time2700.0001.000.0001.70Age group20-3020-302300.0001.202300.0001.200.2001.20Ad-90.0000.00 <td>Time</td> <td>Day</td> <td>2780</td> <td>Baseline</td> <td></td> <td>484</td> <td>Baseline</td> <td></td>	Time	Day	2780	Baseline		484	Baseline	
IndependenciNoteNoteNoteNoteNoteNoteNoteAge group20-300.0141.0240.0141.0240.0141.0240.0141.0210.0101.0210.0101.0210.0101.0210.0101.0210.0101.0210.0101.0210.0101.0210.0101.0210.0101.0210.0101.0210.0101.0210.0101.0210.0100.011		Nightfall or dawn	134	0.052	1.692	14	0.571	1.508
Age group Age group 40-5020-30		Night-time	2737	< 0.0001	1.466	583	0.002	1.772
40-999019.309.1019.239.249.239.239.23600.006.200.000.200.000.550.100.550.10 <td>Age group</td> <td>20–39</td> <td>2356</td> <td>Baseline</td> <td></td> <td>486</td> <td>Baseline</td> <td></td>	Age group	20–39	2356	Baseline		486	Baseline	
60 0-19600 <td></td> <td>40–59</td> <td>2330</td> <td>0.014</td> <td>1.234</td> <td>325</td> <td>0.286</td> <td>1.238</td>		40–59	2330	0.014	1.234	325	0.286	1.238
ferm     109     100     1		60	683	< 0.0001	3.696	116	< 0.0001	5.555
Crash objectMotoryclist or electric cyclist1410Bealine26BealinePedestrian2100.101<		0–19	282	0.607	1.095	154	0.020	1.830
Pedestrian421<0.0000.275107<0.0000.318Pedal cyclist153<0.000	Crash object	Motorcyclist or electric cyclist	1410	Baseline		263	Baseline	
Pedal cyclist96al cyclist97a9.0009.0389.0009.0389.0009.0379.0009.0379.0009		Pedestrian	421	< 0.0001	0.275	107	< 0.0001	0.314
Four-wheeled vehicle occupantS168<0.001<0.826<0.646<0.000<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001<0.001 <th< td=""><td></td><td>Pedal cyclist</td><td>153</td><td>&lt; 0.0001</td><td>0.358</td><td>43</td><td>0.002</td><td>0.313</td></th<>		Pedal cyclist	153	< 0.0001	0.358	43	0.002	0.313
Others of unknown99<0.0009.8002.200.0354.074Illegal behaviourNone376Baseline7Baseline7Baseline7Baseline7Baseline1.0561.0501.0581.0561.0560.0300.9300.		Four-wheeled vehicle occupant	3568	< 0.0001	6.826	646	< 0.0001	4.757
None376Baseline71BaselineDriving without a licence only2042<0.001		Others of unknown	99	< 0.0001	9.800	22	0.035	4.074
Driving without a licence only         2042         <0.001         1.990         397         0.548         1.286           Driving without a licence and drunk driving         725         0.002         1.958         0.930         0.990           Drunk driving only         300         <0.001	Illegal behaviour	None	376	Baseline		71	Baseline	
Priving without a licence and drunk driving       725       0.002       1.958       165       0.983       0.990         Drunk driving only       330       <0.0001		Driving without a licence only	2042	< 0.0001	1.990	397	0.548	1.286
Drunk driving only       330       <0.0001		Driving without a licence and drunk driving	725	0.002	1.958	165	0.983	0.990
Other unsafe driver behaviour       504       0.251       1.268       87       0.964       1.022         Not using motor vehicle licence plate       361       0.008       1.820       45       0.063       3.362         Driving in the opposite direction       223       <0.001		Drunk driving only	330	< 0.0001	2.556	86	0.131	2.199
Not using motor vehicle licence plate       361       0.008       1.820       45       0.063       3.362         Driving in the opposite direction       223       <0.0001		Other unsafe driver behaviour	504	0.251	1.268	87	0.964	1.022
Driving in the opposite direction       223       <0.0001		Not using motor vehicle licence plate	361	0.008	1.820	45	0.063	3.362
Not following traffic signals       222       <0.0001		Driving in the opposite direction	223	< 0.0001	3.041	39	0.272	1.914
Not following rules to yield pedestrians or vehicles that have priority       215       0.006       2.104       31       0.593       1.430         Dangerous driving behaviour       185       0.057       1.701       33       0.310       1.987         Driving modified, assembled or scrapped vehicles       159       0.064       1.688       23       0.473       1.677         Illegal lane changes, overtaking, reversing, meeting cars, parking or using lights       174       0.022       1.964       28       0.231       2.536         Not following traffic signs       82       0.023       2.720       18       0.078       5.456         Speeding       53       0.404       2.69       12       0.047       6.831         Total       Total       5651       1081       1081       1081       1081		Not following traffic signals	222	< 0.0001	5.154	46	0.005	8.248
Dangerous driving behaviour       185       0.057       1.701       33       0.310       1.987         Driving modified, assembled or scrapped vehicles       159       0.064       1.698       23       0.473       1.677         Illegal lane changes, overtaking, reversing, meeting cars, parking or using lights       174       0.022       1.964       28       0.231       2.536         Not following traffic signs       82       0.023       2.720       18       0.078       5.456         Speeding       53       0.040       2.269       12       0.047       6.831         Total       5651       1081       1081       1081       1081       1081		Not following rules to yield pedestrians or vehicles that have priority	215	0.006	2.104	31	0.593	1.430
Driving modified, assembled or scrapped vehicles       159       0.064       1.698       23       0.473       1.677         Illegal lane changes, overtaking, reversing, meeting cars, parking or using lights       174       0.022       1.964       28       0.231       2.536         Not following traffic signs       82       0.023       2.720       18       0.078       5.456         Speeding       53       0.040       2.269       12       0.047       6.831         Total       5651       1081       1081       1081       1081       1081		Dangerous driving behaviour	185	0.057	1.701	33	0.310	1.987
Illegal lane changes, overtaking, reversing, meeting cars, parking or using lights       174       0.022       1.964       28       0.231       2.536         Not following traffic signs       82       0.023       2.720       18       0.078       5.456         Speeding       53       0.040       2.269       12       0.047       6.831         Total       561       1081       545		Driving modified, assembled or scrapped vehicles	159	0.064	1.698	23	0.473	1.677
Not following traffic signs         82         0.023         2.720         18         0.078         5.456           Speeding         53         0.040         2.269         12         0.047         6.831           Total         5651         1081         1081         1081         1081         1081		Illegal lane changes, overtaking, reversing, meeting cars, parking or using lights	174	0.022	1.964	28	0.231	2.536
Speeding         53         0.040         2.269         12         0.047         6.831           Total         5651         1081         1		Not following traffic signs	82	0.023	2.720	18	0.078	5.456
Total 5651 1081		Speeding	53	0.040	2.269	12	0.047	6.831
		Total	5651			1081		

N, number; OR, odd ratio.

# Risk factor analysis of motorcycle and four-wheeled vehicle drivers

# Motorcycle drivers

Being in an outer urban area, female sex, night-time and age over 40 years were risk factors for motorcycle drivers among migrant workers, while there were no significant differences in sex or region in the control group. The crash object, determination of responsibility and driver's illegal behaviour were common influencing factors among migrant workers and in the control group. Compared with the control group, almost all illegal behaviours were risk factors for motorcycle drivers among migrant workers: driving without a licence only (36.14%, OR=1.990) and driving without a licence and drunk driving (12.83%, OR=1.958) were the most common, while the risks of driving in the opposite direction (OR=3.041), not following traffic signals (OR=5.154) and not following traffic signs (OR=2.720) were higher (table 2). Notably,

among all drunk driving motorcycle drivers, the proportion of driving without a licence and drunk driving was very high (68.72% of migrant workers and 65.73% of the control group).

# Four-wheeled vehicle drivers

Region, determination of responsibility, crash object and driver's illegal behaviour were the common influencing factors among migrant workers and the control group. Similarly, for migrant workers, illegal behaviour was a risk factor for RTIs, with the highest number of other unsafe driving behaviours (33.89%, OR=1.722), while the risks of not following at a safe distance (OR=4.159), staying in place without taking safety measures after a collision (OR=4.632) and speeding (OR=2.504) were higher. Risk factors for illegal behaviour were also broadly similar in the control population (table 3).

 Table 3
 Logistic regression analysis of four-wheeled vehicle drivers among migrant workers and the control group in Guangzhou from 2017 to 2021

		Migrant worker			Control group		
Variable		Ν	P value	OR	Ν	P value	OR
Region	Central urban	1318	Baseline		1080	Baseline	
	Outer urban	8322	0.070	1.279	2329	0.041	1.454
	Highway	925	0.001	1.629	412	< 0.0001	2.230
Genden	Male	10033	Baseline		3555	Baseline	
	Female	532	0.351	/	266	0.390	1
Determination of	Full/Primary	4283	Baseline		1544	Baseline	
responsibility	Equal	1777	0.005	0.695	610	0.066	0.635
	Secondary or none	4424	< 0.0001	0.430	1629	0.015	0.541
	Unknown	81	0.322	1.603	38	0.619	1.524
Time	Day	4558	Baseline		1663	Baseline	
	Nightfall or dawn	295	0.532	1	86	0.399	1
	Night-time	5712	0.418	1	2072	0.431	1
Age group	20–39	6645	Baseline		2178	Baseline	
	40–59	3788	0.039	0.641	1573	0.375	1
	>60	72	1.467	0.000	48	0.021	1
	0–19	60	0.579	0.273	22	0.753	1
Crash object	Motorcyclist or electric cyclist	4404	Baseline		1295	Baseline	
	Pedestrian	1406	0.455	0.740	641	0.616	0.710
	Pedal cyclist	649	0.932	0.959	300	0.921	0.924
	Four-wheeled vehicle occupant	4004	< 0.0001	45.754	1540	< 0.0001	42.108
	Others of unknown	102	< 0.0001	30.620	45	< 0.0001	34.251
Illegal behaviour	None	2023	Baseline		853	Baseline	
	Other unsafe driver behaviour	3581	0.001	1.722	1395	0.006	2.153
	Drunk driving only	823	0.024	0.647	381	0.101	0.565
	Motor vehicle not meeting national standards	753	0.076	1.379	187	0.400	1.348
	Not following rules to yield to pedestrians or vehicles that have priority	706	0.847	1.056	195	0.037	2.886
	Speeding	597	< 0.0001	2.504	179	0.002	3.000
	Driving in the opposite direction, illegal lane changes, reverse, overtaking, using lights	488	0.299	0.753	142	0.194	0.471
	Not following within a safe distance	472	< 0.0001	4.159	161	< 0.0001	5.098
	Illegal parking	281	0.854	0.938	69	0.581	1.422
	Driving without a licence only	141	0.591	1.203	44	0.770	1.272
	Not following traffic signs	198	0.058	1.912	46	0.036	3.516
	Staying in place without taking safety measures after a collision	108	< 0.0001	4.632	44	< 0.0001	4.291
	Overloading	155	0.020	1.945	37	0.700	1.284
	Not following traffic signals	115	0.745	0.811	40	0.998	0.000
	Dangerous driving behaviour	72	0.265	1.542	24	0.854	1.156
	Driving without a licence and drunk driving	52	0.504	0.754	24	0.314	0.341
	Total	10 565			3821		

N, number; OR, odd ratio.

## Motorcycles versus four-wheeled vehicles

We found that motorcycle drivers with equal responsibility and secondary responsibility/none responsibility were more likely to be injured in RTCs (compared with full/primarily responsible motor-cycle drivers), while four-wheeled vehicle drivers with full/primary responsibility were more likely to be injured (compared with secondary/none responsible motor vehicle drivers). Motorcycle and four-wheeled vehicle drivers had a higher number of crashes at night (compared with during the day). Night-time and drunk driving were risk factors for motorcycle drivers but not for four-wheeled vehicle drivers. In addition, the proportion of motorcycle drivers who drove while intoxicated was higher than that of four-wheeled vehicle drivers (migrant workers: 18.67% vs 8.28%, control group: 23.22% vs 10.60%).

# Perpetrators among motorcycle and four-wheeled vehicle drivers

Between 2017 and 2021, a total of 3357 RTCs were caused by motorcycle drivers, of which 2791 (83%) were migrant workers. Similarly, 5811 RTCs were caused by four-wheeled vehicle drivers, of which 4255 (73%) were migrant workers. This study found that migrant workers caused far more RTIs than the control group (motorcycles: 3650 vs 721, four-wheeled vehicles: 4848 vs 1619). Among them, four-wheeled vehicle perpetrators were more likely to cause RTIs to others than themselves (figure 3A), while perpetrators among motorcycle drivers mainly caused RTIs to themselves (56% of perpetrators were injured, figure 3B).

In summary, although motorcyclists were the main source of RTIs in Guangzhou, four-wheeled vehicle drivers were the main



**Figure 3** Comparison of road traffic injuries caused by perpetrators: Migrant workers versus the control group Note: (A) The perpetrators among four-wheeled vehicle drivers, (B) The perpetrators among motorcycle drivers. Among them, 4848 road traffic injuries (injuried perpetrators and road traffic victims) were caused by four-wheeled vehicle drivers among migrant workers, accounting for 27.82% of the total road traffic injuries in Guangzhou. The injuries caused by motorcycle drivers among migrant workers were 3650 (injuried perpetrators and road traffic victims), accounting for 20.94%.

perpetrators of RTIs. Migrant workers accounted for the vast majority of both.

# DISCUSSION

Guangzhou is one of the four first-tier cities in China, attracting a large number of migrant workers. They generally have low education, poor awareness of traffic regulations, lack of medical protection and are more likely to violate traffic regulations. The number of migrant workers in Guangzhou reached more than 8 million in 2022, accounting for 46% of the total population. However, both the number of RTCs and RTIs suffered by migrant workers were far greater than those of the control group, and they had a significant impact on the road safety.

Overall, RTIs have declined in many countries as they have adopted strict lockdown measures during the COVID-19 pandemic.<sup>29</sup> Although RTIs in China have also declined, the number of RTIs of e-bikes has increased despite strict control of public transportation.<sup>30</sup> There is no obvious downward trend of RTIs in Guangzhou in 2020 and 2021, which indicates that the road safety problem in Guangzhou is still serious.

Transportation has become an important issue for migrant workers. Compared with four-wheeled vehicles, motorcycles are a low-cost means of transportation that can meet the requirements of shorter commutes and have become a suitable choice for migrant workers. Although the government issued the Regulations on the administration of non-motor vehicles and motorcycles in Guangzhou in 2017,<sup>31</sup> which banned motorcycles in central urban areas, it still failed to prevent the frequent occurrence of motorcycle crashes, especially in outer urban areas. Regarding the types of crashes, motorcyclists mainly collided with four-wheeled vehicles (especially cars and heavy goods vehicles), and the results of the logistic analysis also showed that collision with four-wheeled vehicles was an important risk factor. In Southeast Asia and the Western Pacific Region, two wheelers and three wheelers are the leading sources of RTIs,<sup>32</sup> which is consistent with our findings. Reducing collisions between motorcycles and four-wheeled vehicles in outer urban areas is a key measure to reduce motorcyclists' injuries.

Approximately, 48.96% of motorcycle drivers among migrant workers in Guangzhou were driving without a licence, and approximately one-third of the those were combined with drunk driving. Driving without a licence was an important risk factor for RTIs (OR 1.990, 95% CI 1.391 to 2.848), which was consistent with the results of Wu,<sup>33</sup> Chang<sup>34</sup> and Martin-delos Reyes.<sup>35</sup> In other low/middle-income countries, there are also reports of motorcyclists driving without a licence. For example, approximately 67.5% of motorcyclists in Benha city, Egypt<sup>36</sup> and 41% in Ho  $\chi$  Minh City, Vietnam do not have a motorcycle licence.<sup>37</sup> In contrast, the proportion of motorcyclists driving without a licence in developed countries is much lower, as shown in a survey in Ohio, USA, which showed that it was only 14.7%.<sup>38</sup> Since 84% of motorcycle drivers in Guangzhou driving without a licence were migrant workers, it is important to strictly implement training and assessment for them to drive motorcycles with a licence.

In Guangzhou, there are many migrant workers who drive taxis and work for online ride-hailing apps.

We found that four-wheeled vehicle occupants were most involved in RTCs, but their HD was much lower than that of vulnerable road users. Four-wheeled vehicle drivers among migrant workers accounted for approximately 28% of RTIs, and the vast majority of RTIs involved other road users, not themselves. Therefore, we proposed to focus not only on RTIs among vulnerable road users but also on four-wheeled vehicle drivers, especially migrant workers.

The most important illegal behaviour of the four-wheeled vehicle driver was 'other unsafe driver behaviour', which was also a risk factor for RTIs. According to Article 22 Paragraph 1 of the Law of the People's Republic of China on Road Traffic Safety, motor vehicle drivers shall abide by the provisions of road traffic safety laws and regulations and drive safely and in a civilised manner in accordance with operational norms.<sup>39</sup> This is a vague legal provision that does not accurately indicate the driver's illegal behaviours. When the driver's violation was not determined or the driver's violation did not accurately correspond to other provisions of the law, the crash was often handled in accordance with Article 22 Paragraph 1 and recorded as 'other unsafe driver behaviour'. Because lots of illegal behaviours of them were not clear, it was difficult to determine the cause of the crash and make effective recommendations for injury prevention. A study in Shenzhen<sup>7</sup> also noted that 53.2% of RTCs were caused by 'other unsafe driver behaviours' and stressed the importance of police reporting to identify the cause of the crash. In summary, the government should conduct an in-depth investigation and revision the traffic law and further refine 'other unsafe driver behaviours' so that the traffic police can effectively identify drivers' illegal behaviours and the causes of crashes.

Drunk driving is an important common illegal behaviour of motorcycle and four-wheeled vehicle drivers, and the number of migrant workers is much higher than that of the control group (motorcycle drivers: 1055 vs 251; four-wheeled vehicle drivers: 875 vs 405). Studies<sup>40 41</sup> have also confirmed that drunk driving is an important risk factor. There were two important findings on drunk driving: (1) In terms of quantity alone, there was not much difference among four-wheeled vehicle drivers and motorcycles (four-wheeled motor vehicles: 1280 vs motorcycles: 1306), but the proportion of motorcycle drivers who drove while intoxicated was higher than that of four-wheeled vehicle drivers (motorcycles: 19.40% vs four-wheeled vehicles: 8.90%). Some studies have found that compared with motor vehicles, drunk driving on motorcycles is more likely to cause traffic crashes, but motorcycle drivers often receive lighter penalties.<sup>42</sup> (2) Approximately two-thirds of motorcycle drivers were drunk and driving without a licence. This problem is particularly prominent among migrant workers and the control group. Similar studies also indicate that approximately 62% of motorcycle drivers drive without a valid licence while under the influence of alcohol/drugs, which is approximately 14 times the rate of sober drivers.<sup>43</sup> Therefore, the government must take stricter measures and greater efforts to control drunk driving and driving without a valid licence of motorcycle drivers.

There were some limitations to this study: we classified the degree of injury according to the Criteria for the Identification of Human Injuries, which differs from the criteria of other countries, and did not take participants with mild injuries in RTCs into account. This may have led to more RTIs being overlooked. We did not analyse the economic losses experienced by migrant workers from RTIs, which is actually an important factor in encouraging the government to focus on improving road safety. In addition, Guangzhou has a large migrant population, and there are some unregistered migrant workers,<sup>44</sup> which may also affect the results of this study.

#### CONCLUSION

This study systematically elaborated the role of migrant workers in RTIs in Guangzhou from 2017 to 2021. Migrant workers were both the leading source of RTIs and the main perpetrators of RTCs. To improve road safety in Guangzhou, a first-tier city in China, we propose the following suggestions:

- 1. Fully understand and attach importance to the major impact of migrant workers on road safety.
- 2. The transportation means of migrant workers in Guangzhou should be comprehensively investigated, and greater use of

public transportation, such as buses and subways, should be encouraged, especially in outer urban areas.

- 3. Strictly implement a system of driving motorcycles with licences after training and assessment and increase the punishment for motorcycle violations. Punishment measures should also include compulsory education.
- 4. Revise the Law of the People's Republic of China on Road Traffic Safety, especially the relevant provisions on motor vehicle traffic regulations, so that the front-line traffic police can clearly identify the illegal behaviours of drivers.
- 5. Increase the intensity of investigation of drunk driving and driving without a licence, especially motorcycle drivers.

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