

# Occupational Safety and Health of Riders Working for Digital Food Delivery Platforms in the City of Milan, Italy\*

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## ABSTRACT

**Background:** *The rapid growth of the digital economy has transformed various labor markets, including the food sector. The transient nature and the peculiar work environments of food delivery workers raise concerns about occupational safety and health (OSH). This study aims to better understand these issues by conducting a comprehensive exploratory survey on OSH among food delivery riders in Milan, Italy.* **Methods:** *The study employed structured interviews based on a validated questionnaire developed through a literature review, expert interviews, and input from riders and health and safety professionals. The survey was performed from July to November 2022 by interviewing riders at their main gathering points.* **Results:** *We interviewed 240 riders, 97% males, 81% less than 35 years old, and 83% with extra-European origin. Delivery was performed mainly by traditional bicycles (40%) and e-bikes (46%), with 44% working seven days per week and 23% working more than 8 hours daily. Overworking was significantly influenced by the type of contract, citizenship, and platform. Road accidents were reported by 39% of riders, influenced by type of vehicle, fatigue, and number of daily deliveries. Physical and verbal assaults (12% and 28%, respectively) were reported, as well as health-related issues, particularly musculoskeletal disorders.* **Conclusions:** *The findings underscore food delivery riders' complex challenges, emphasizing the need for targeted interventions. The study calls for collaborative efforts between policymakers, employers, OSH professionals, and stakeholders to enhance OSH standards and promote decent working conditions, aligning with the 2030 Agenda for Sustainable Development.*

## 1. INTRODUCTION

The rise of the digital economy has transformed the labor market, presenting new opportunities and challenges for workers globally [1]. Recently, the spotlight on the food delivery sector, enhanced by the COVID-19 pandemic, has favored public

discussions about the well-being of “riders”, workers employed by digital platforms to transport and deliver goods using various modes of transportation. In Italy, on-demand food delivery is increasing, with a workforce of approximately 60,000 riders, marking a five-fold surge since 2019 [2]. This growth has been even higher in urban centers

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like Milan, Italy, where approximately 8,000 riders are employed.

Given work's transient and dynamic nature in the platform economy, the research has focused mainly on employment relationships [3]. Food delivery platforms have adopted various work organization structures in response to numerous legal complaints and evolving legislation. One standard model is the "free login" system, which offers flexible work schedules without fixed shifts, allowing riders to choose their availability. This is the case for Deliveroo, Wolt, and Uber Eats [4-5], which mostly employ riders as autonomous or temporary workers. In contrast, Just Eat [6] uses a shift-oriented model with subordinate employment, organizing riders in local teams weekly. Glovo and Foodora also use a shift-like model, but they rely on self-employed or temporary workers, with shifts booked in advance by riders according to the so-called "excellence scores" [7-8]. The score is determined by an algorithm that evaluates riders' performances based on availability during high-demand slots, shift cancellations, customer reviews, and total orders delivered. In Italy, riders are classified as self- or para-subordinate employees, with minimum protection levels typical of subordinate employment recently extended to these workers by legislative changes (Legislative Decree 81/2015; Law 128/2019). Differences between contracts affect minimum wage standards and the availability of benefits like sick leave and holidays.

Riders face occupational safety and health (OSH) risks similar to contingent work risks [9]. While the sector offers job opportunities and flexibility, recent research has highlighted issues such as labor control, overworking, and psychosocial implications [10-14]. Riders performing their tasks in urban environments on bicycles, e-bikes, and other poorly protected means of transportation are at risk of road accidents and injuries [15-19]. Besides, there is growing concern about health issues such as musculoskeletal disorders (MSD) [20].

The OSH landscape for food delivery riders is complex, involving multiple factors, including vulnerabilities associated with the transient nature of gig economy work and the prevalence of migrant workers [21]. Despite the increasing interest in rider health and safety, only some studies have systematically investigated this

topic [22]. This study aims to fill this gap by examining OSH risks among 240 riders working for food delivery platforms in Milan, one of Europe's most populated (1.4 million people) metropolitan areas.

## 2. METHODS

### 2.1. Questionnaire Definition and Evaluation

The survey was conducted in a group of riders working for food delivery platforms in Milan through structured interviews administered by a team of researchers. This investigation, performed between July and November 2022, used a questionnaire developed through a detailed process. Initially, a bibliographic review was conducted using the SCOPUS database, focusing on road accidents [15-18, 23] and OSH in platform and gig economy [9-11, 24]. The research extended to "gray" literature, collecting institutional documents [2, 12, 25-27]. Additionally, one food delivery rider and a bike courier, both acting as experts, were interviewed to identify critical topics. Their input informed the draft questionnaire, which was evaluated for content validity and clarity [28-29] by eight experts, including health and safety professionals, labor law experts, and academic researchers. Experts rated each item's relevance and clarity, suggesting modifications as needed. Details on the evaluation method and results are available as Supplemental materials (S1). After the evaluation, changes were made to improve the questionnaire's clarity, simplify its structure, and incorporate new topics. Two previously interviewed workers reviewed the draft questionnaire for additional recommendations. The final version included 38 mandatory items plus 11 optional items (S2), the latter submitted only to riders available to extend the interview owing to the generally tight timeframes for field interviews. Two versions were prepared: paper-based and online using Google Forms. In July 2022, a pilot test with 30 riders ensured the timing and evaluated any ambiguous questions. Following this, a debriefing increased confidence and produced the first feedback; the main was to create an English version of the questionnaire to minimize language misunderstandings with foreign workers. This paper focuses on a subset

of the data related to sociodemographic information, work organization, and OSH risks. The project and the questionnaire were approved by the Ethics Committee of the University of Milan (approval n. 42/22).

## 2.2. Administration Phase

A team of 10 researchers and students from the University of Milan was selected as interviewers. Two preparatory meetings were held to discuss the questionnaire, interview techniques, and administration methods, including targeting meeting points where riders usually gather (e.g., near restaurants or rail or metro stations). The supplemental material contains a map and a list of these points (S3). The items were not modified. The core survey was performed from mid-September to the end of November 2022. Recruitment and administration took place in the field, with the research team conducting 165 interviews and collecting 75 self-administered questionnaires during four formal Confederazione Generale Italiana del Lavoro (CGIL) trade union meetings, all under the supervision of a researcher. In all cases, the project aims and questionnaire contents were presented before asking for the workers' availability.

## 2.3. Data Management and Analysis

All the answers to the questionnaire were registered on the Google Forms platform. The probabilities of overworking (defined as working seven days per week or for more than 8 hours per day), road accidents, and health outcomes (e.g., back pain and shoulders/neck pain) are quantified using crude odds ratios (OR) and 95% Confidence Intervals (CI) computed through logistic regression. After univariate analysis, we focused on variables with substantial effect sizes and those relevant to prevention strategies. Multiple imputations addressed missing data, and adjusted O.R.s (AORs) were computed through multivariable logistic regression. Potential confounders for selected exposure variables were identified using directed acyclic graphs (DAG). Descriptive statistics and regression analyses were conducted in R studio [30]. Imputation analysis was conducted using the Mice package [31].

## 3. RESULTS

### 3.1. Sociodemographic and Work Information

The study group consisted of 240 riders who were interviewed; their main characteristics are summarized in Table 1.

Most of the interviewed subjects were males of foreign origin without Italian citizenship. The mean age was 30, with about half in the 25-34 age category. The regions of origin were Asia, followed by Africa, with Pakistan and Nigeria the most represented countries. Forty-two percent had a middle or primary school education, and a similar proportion had a high school degree, with a small minority being students. A significant number (34%) reported having difficulties understanding Italian. About 40% of respondents lived outside the city.

Work characteristics are summarized in Table 2.

Our sample consisted of riders with limited experience, with a mean job duration of about years. Most were self-employed with a VAT number or employed under precarious contracts. One of the interviewees, a 17-year-old, reported working under a contract that was not in his name. All major active platforms in Milan were represented: 30% worked exclusively for Platform A, which employs autonomous or precarious contract workers and embraces a 'free login' type of organization. Riders working for Platform B, a more classical shift-based organization that extensively uses permanent contracts, comprise 23% of the sample. Riders working for Platform C, which employs a shift-based work organization, precarious or autonomous contracts, and a reward system that enables them to pick new shifts, represented 12% of the total.

Additionally, 25% of respondents worked for more than one company (multi-account workers). One of the riders reported working without a proper contract through an intermediary. Most respondents owned their working vehicle, mainly e-bikes or traditional bicycles, and used backpacks. Only 13% of riders sought trade union support; the main reason for not seeking support was a lack of knowledge. Regarding work schedules, about 23% worked more than 8 hours per day, and 44% reported working seven days a week.

**Table 1.** Personal characteristics of the interviewed riders. Data are reported as count (%).

Variable	Categories	No. (%)
<b>Sample size</b>	<b>Total</b>	240 (100)
<b>Sex</b>	Male	233 (97)
	Female	3 (1)
<b>Age (years)</b>	<25	47 (20)
	25-29	69 (29)
	30-34	46 (19)
	>=35	69 (29)
	Overall mean±sd	30 ± 7
<b>Origin country/continent</b>	Italy	39 (16)
	Europe (other than Italy)	3 (1)
	Asia	118 (49)
	Africa	69 (29)
	Central-South America	7 (3)
<b>Italian citizenship</b>	Yes	53 (22)
	No	184 (77)
<b>Italian comprehension</b>	Well	73 (30)
	Quite well	83 (35)
	With many difficulties	52 (22)
	Do not understand	29 (12)
<b>Student</b>	Yes	30 (13)
	No	207 (86)
<b>Education</b>	Degree/master's degree or higher	28 (12)
	High school	97 (40)
	Middle school or primary school	102 (43)
	Other	3 (1)
<b>Residence</b>	Milan	142 (59)
	Province of Milan	60 (25)
	Other areas of the region	36 (15)

*N.B.: N.A.s not reported but covered by % computation.*

Riders typically traveled more than 20 km per day and delivered between 5 and 15 orders daily.

### 3.2. Determinants of Overworking

Table 3 reports the probability of working seven days per week and more than eight hours per day in relation to various variables of interest.

The probability of overworking was higher for autonomous workers and riders without Italian

citizenship, increasing with age. It was also higher for those employed by platforms with non-traditional shift-work organizations (Platforms A and C) or those working for multiple platforms (multi-account). In contrast, students had a lower risk of overworking. Multivariate regression analysis (S4) confirms that platform type, citizenship, and contract type were associated with overworking. Due to the lower impact of Platform B on overworking, a sensitivity analysis was performed by

**Table 2.** Work-related information. Data are reported as count (%).

<b>Variables</b>	<b>Categories</b>	<b>No. (%)</b>
<b>Job duration</b>	<12 months	47 (20)
	12-36 months	151 (63)
	>36 months	37 (15)
	Months (mean±sd)	26 ± 20
<b>Type of contract</b>	Permanent	88 (37)
	Autonomous (VAT)	98 (41)
	Precarious	36 (15)
<b>Platform</b>	Platform A	71 (30)
	Platform B	56 (23)
	Platform C	28 (12)
	Multi-account	60 (25)
	Others	17 (7)
<b>Number of active accounts for different platforms (multi-account)</b>	1	172 (72)
	2	45 (19)
	> 2	14 (6)
<b>Ownership of the vehicle</b>	Rider	205 (85)
	Platform	20 (8)
	Other	4 (2)
<b>Working vehicle</b>	E-bike	111 (46)
	Traditional bicycle	96 (40)
	Moped/motorcycle	21 (9)
	Other	6 (2)
<b>Use of backpack</b>	No	35 (15)
	Yes	117 (49)
<b>Use of a smartphone sport</b>	No	32 (13)
	Yes	121 (50)
<b>Riders who have asked for support from trade unions</b>	Platform A	6 (19)
	Platform B	15 (47)
	Platform C	4 (13)
	Multi-account	5 (16)
	Others	1 (3)
<b>Reasons for not having asked for trade unions' support</b>	Never heard about them	93 (39)
	NeverI never taught about/Never needed	55 (23)
	I talk with colleagues and don't trust them	35 (15)
	I ask the company	3 (1)
<b>Working hours per day</b>	<3	10 (4)
	3-4	47 (20)
	5-6	60 (25)
	7-8	61 (25)
	>8	56 (23)

Table 2 (Continued)

Variables	Categories	No. (%)
Working day per week	<3	8 (3)
	3-4	32 (13)
	5-6	90 (38)
	7	105 (44)
Deliveries per day	<5	7 (3)
	5-10	90 (38)
	11-15	77 (32)
	16-20	41 (17)
	>20	19 (8)
Km per day	>20	147 (61)
	16-20	42 (18)
	11-15	22 (9)
	5-10	17 (7)
	<5	3 (1)

*N.B.: N.A.s not reported but covered by % computation.*

excluding the platform from the dataset. The results remained consistent, showing no significant differences compared to the full dataset.

### 3.3. Occupational Safety and Health Information

Table 4 shows the primary information on OSH, including road accidents, assaults, and possible work-related issues.

Thirty-nine percent of riders reported at least one road accident in the past year, with e-bike riders being the most affected. Accidents mainly occurred during the evening (5-7 pm). Common accidents included collisions with vehicles and falls due to wet cobblestones and poor road conditions. Most victims reported health consequences, primarily back and knee injuries, with 35% requiring hospital assistance. Moreover, 29 riders reported physical assaults, and 67 reported verbal assaults. Over half of the riders suffered from work-related health issues, mainly musculoskeletal disorders (MSDs) and fatigue.

### 3.4. Determinants of Road Accidents and Work-Related Health Issues

Table 5 shows the probability of being a victim of a road accident and suffering from back pain and fatigue in relation to selected variables.

The probability of road accidents was higher for e-bike riders and those experiencing fatigue, which increased with traveled distance and number of deliveries. This probability was lower for students and precarious workers. Multivariate regression analysis (S6) confirms strong associations with vehicle type and fatigue and suggests likely associations with backpack use and the number of deliveries. Regarding work-related health issues, back pain probability increases with age, job duration, daily traveled distance, backpack, and e-bike use. This probability was lower among those with lower education and autonomous or precarious riders working for platforms A and C or using multiple accounts. Similar trends were observed when considering fatigue, except for vehicle type influence. Multivariable logistic regression analysis confirms important roles for backpack use and daily travel distance, with a suggestive association for vehicle type (S8).

## 4. DISCUSSION

### 4.1. Safety Concerns for an Evolving and Vulnerable Workforce

Our results shed further light on the vulnerability of individuals working as riders within the digital food delivery sector. Our sample was predominantly

**Table 3.** Crude odds ratio (OR) of the occurrence of overworking. The number (%) of cases belonging to each subgroup and the total number of respondents (Total) are reported, along with OR estimates and 95% Confidence Intervals (CI).

Variables		Days/week = 7			Hours/day > 8		
		n. (%)	Total	OR (95% CI)	n. (%)	Total	OR (95% CI)
Age (yr)	<25	15 (32)	47	1.00 (Ref)	6 (13)	45	1.00 (Ref)
	25-29	33 (50)	66	2.13 (0.99-4.74)	14 (21)	66	1.79 (0.66-5.45)
	30-34	23 (50)	46	2.13 (0.93-5.03)	11 (24)	45	2.10 (0.72-6.63)
	>=35	34 (49)	69	2.07 (0.97-4.57)	25 (36)	69	3.79 (1.49-11.05)
Citizenship (Italian)	Yes	8 (16)	50	1.00 (Ref)	6 (12)	50	1.00 (Ref)
	No	96 (52)	184	5.73 (2.67-13.77)	50 (38)	133	2.76 (1.18-7.56)
Student	Yes	3 (10)	30	0.11 (0.03-0.33)	1 (3)	30	0.09 (0.01-0.45)
	No	101 (50)	204	1.00 (Ref)	55 (27)	203	1.00 (Ref)
Education	Degree/higher	12 (43)	28	1.00 (Ref)	8 (29)	28	1.00 (Ref)
	High school	39 (42)	94	0.95 (0.40-2.26)	20 (21)	94	0.68 (0.26-1.83)
	Middle school or lower	51 (50)	102	1.33 (0.58-3.2)	26 (26)	101	0.87 (0.35-2.30)
Job duration (yr)	<1	24 (51)	47	1.00 (Ref)	14 (30)	47	1.00 (Ref)
	1-3	66 (45)	148	0.77 (0.40-1.49)	34 (23)	148	0.70 (0.34-1.49)
	>3	14 (38)	37	0.58 (0.24-1.39)	7 (19)	36	0.57 (0.19-1.57)
Type of Contract	Permanent	23 (26)	88	1.00 (Ref)	14 (16)	88	1.00 (Ref)
	Autonomous	65 (66)	98	5.57 (2.99-10.66)	37 (38)	97	3.26 (1.64-6.76)
	Precarious	10 (28)	36	1.09 (0.44-2.56)	2 (6)	36	0.31 (0.05-1.20)
Platform	Platform A	51 (72)	71	68.85 (18.97-445.91)	29 (41)	70	19.10 (5.33-122.45)
	Platform B	2 (4)	56	1.00 (Ref)	2 (4)	56	1.00 (Ref)
	Platform C	13 (46)	28	23.40 (5.68-160.74)	4 (14)	28	4.5 (0.82-34.1)
	Multi-account	33 (52)	63	29.70 (8.24-191.24)	19 (28)	67	10.80 (2.91-70.27)

composed of a foreign workforce without citizenship, working under precarious or autonomous contracts, and possessing limited knowledge of Italian. These findings are consistent with the literature, mainly focusing on the urban gig economy [21]. Cultural and language barriers represent the most pressing issues as they contribute significantly to health and safety risks and social vulnerabilities [24]. Riders with limited knowledge of the local language are more prone to discrimination, hostility, and exploitation, often unaware of their rights and the possibility of receiving union support [22]. These considerations align with our results, which indicate a high prevalence of overwork and a lower

likelihood of reporting work-related health issues among riders with precarious contracts and without union support.

Additionally, a rider working with a contract not in his name confirms that non-transparent intermediation practices still occur in the Italian labor market, further exacerbating job insecurity and exploitation. Nonetheless, the widespread ownership of working vehicles, including motorcycles and e-bikes, indicates a high level of rider commitment and investment, suggesting a shift towards long-term employment rather than transient gig work. Compared to Fasano & Natale's 2019 survey in Milan, our study involved an older, ethnically different

**Table 4.** Occupational safety and health information of the 240 interviewed riders. Data are reported as count (%).

Variables	Categories	No. (%)
Riders reporting road accidents	Total	91 (38)
	E-bicycle	54 (59)
	Bicycle	27 (30)
	Moped/motorcycle	8 (9)
	Evening (17-19)	36 (40)
	Lunchtime (12-15)	21 (23)
	Dinner time (19-22)	17 (19)
	Collision with other vehicles	29 (32)
	Fall by wet cobblestones/road	26 (29)
	Road conditions (e.g., road potholes/holes)	25 (28)
Sequelae after road accidents	Total	81 (34)
	Knees/pelvis/legs or feet pain	39 (48)
	Back pain	28 (35)
	Wrists or arms or hand pain	25 (31)
Hospital assistance after road accidents	Total	32 (13)
	Collision with other vehicles	17 (53)
	Fall by wet cobblestones/road	11 (34)
	Road conditions (e.g., road potholes/holes)	6 (19)
Physical assault	Total	29 (12)
	Fearing for health	14 (48)
Verbal assault	Total	67 (28)
	Fearing for health	12 (18)
Possible work-related health issues	Total	150 (63)
	Back pain	89 (59)
	Fatigue	73 (49)
	Shoulders/neck pain	48 (32)

population. In particular, fewer riders were under 25 years old (20% vs. 57%), and the Asian component increased from 15% to 49% [25]. This reflects recent immigration trends [32] and indicates the significant turnover of an evolving workforce. African workers were more reluctant to be interviewed, possibly leading to their underrepresentation.

#### 4.2. Health and Safety Consequences of Algorithmic Management

Researchers have focused on the algorithm-rider relation in the last years, arguing that making riders

free to connect/disconnect from the system does not go together with more control over the labor process [13] but leads them to work overload and burnout [14]. In our study, we observed a similar trend with riders employed with permanent contracts and in traditional shift-work organizations not experiencing overwork. At the same time, those working in a free-login modality were more exposed. Nevertheless, riders employed by Platform C were also more likely to overwork despite using a shift-work organization. A possible explanation is that these riders are employed as autonomous workers within a national collective agreement framework that does



**Table 5.** Crude odds ratio (OR) of the occurrence of road accidents, back pain, and fatigue. The number (%) of cases belonging to each subgroup and the total number of respondents (Total) are reported, as well as OR and 95% Confidence Intervals (CI).

Variables	Health issues											
	Road Accidents						Back pain			Fatigue		
	n. (%)	Tot	OR (95% CI)	n. (%)	Total	OR (95% CI)	n. (%)	Total	OR (95% CI)	n. (%)	Total	OR (95% CI)
Age (yr)												
	<=25	16 (35)	46	1.00 (Ref)	11 (23)	47	1.00 (Ref)	9 (19)	47	1.00 (Ref)	47	1.00 (Ref)
	26-30	24 (39)	62	1.18 (0.54-2.65)	25 (25)	69	1.86 (0.82-4.41)	27 (39)	69	1.86 (0.82-4.41)	69	2.71 (1.17-6.78)
	31-35	22 (49)	45	1.79 (0.78-4.22)	22 (48)	46	3.00 (1.25-7.51)	18 (39)	46	3.00 (1.25-7.51)	46	2.71 (1.09-7.18)
	>35	28 (47)	60	1.64 (0.75-3.67)	27 (39)	69	2.10 (0.93-4.97)	18 (26)	69	2.10 (0.93-4.97)	69	1.49 (0.62-3.81)
Citizenship (Italian)												
	Yes	19 (39)	49	1.00 (Ref)	21 (40)	53	1.00 (Ref)	21 (40)	53	1.00 (Ref)	53	1.00 (Ref)
	No	72 (43)	166	1.21 (0.63-2.35)	68 (37)	184	0.89 (0.48-1.69)	52 (28)	184	0.89 (0.48-1.69)	184	0.60 (0.32-1.15)
Student												
	Yes	11 (39)	28	0.37 (0.37-1.93)	12 (40)	30	1.13 (0.50-2.44)	8 (27)	30	1.13 (0.50-2.44)	30	0.79 (0.32-1.81)
	No	80 (43)	187	1.00 (Ref)	77 (37)	207	1.00 (Ref)	65 (31)	207	1.00 (Ref)	207	1.00 (Ref)
Degrees												
	Higher	11 (44)	25	1.00 (Ref)	15 (54)	28	1.00 (Ref)	10 (36)	28	1.00 (Ref)	28	1.00 (Ref)
	High school	37 (44)	84	1.00 (0.41-2.50)	35 (36)	97	0.49 (0.21-1.14)	30 (31)	97	0.49 (0.21-1.14)	97	0.81 (0.34-2.01)
	Middle or lower	39 (40)	98	0.84 (0.35-2.08)	33 (32)	102	0.41 (0.17-0.97)	29 (28)	102	0.41 (0.17-0.97)	102	0.72 (0.30-1.78)
Job duration (yr)												
	<1	-	-	-	-	47	1.00 (Ref)	12 (26)	47	1.00 (Ref)	47	1.00 (Ref)
	1-3	-	-	-	-	151	1.47 (0.74-3.05)	46 (31)	151	1.47 (0.74-3.05)	151	1.28 (0.62-2.77)
	>3	-	-	-	-	37	1.80 (0.73-4.48)	13 (35)	37	1.80 (0.73-4.48)	37	1.58 (0.62-4.10)
Contract												
	Permanent	36 (48)	75	1.00 (Ref)	39 (44)	88	1.00 (Ref)	32 (36)	88	1.00 (Ref)	88	1.00 (Ref)
	Autonomous	41 (44)	94	0.84 (0.45-1.54)	38 (39)	98	0.80 (0.44-1.43)	29 (30)	98	0.80 (0.44-1.43)	98	0.74 (0.40-1.36)
	Precarious	11 (31)	35	0.50 (0.21-1.14)	8 (21)	39	0.32 (0.13-0.76)	8 (21)	39	0.32 (0.13-0.76)	39	0.45 (0.18-1.06)
Working hours												
	<5	17 (33)	51	1.00 (Ref)	28 (49)	57	1.00 (Ref)	17 (30)	57	1.00 (Ref)	57	1.00 (Ref)
	5-8	56 (48)	117	1.84 (0.93-3.71)	42 (35)	121	0.55 (0.29-1.04)	46 (38)	121	0.55 (0.29-1.04)	121	1.44 (0.74-2.89)
	>8	18 (38)	48	1.20 (0.53-2.75)	19 (34)	56	0.53 (0.25-1.13)	10 (18)	56	0.53 (0.25-1.13)	56	0.51 (0.20-1.23)
Working days												
	<5	16 (41)	39	1.00 (Ref)	13 (33)	40	1.00 (Ref)	12 (30)	40	1.00 (Ref)	40	1.00 (Ref)
	5-6	32 (39)	82	0.92 (0.42-2.02)	39 (43)	90	1.59 (0.74-3.55)	35 (39)	90	1.59 (0.74-3.55)	90	1.48 (0.68-3.38)
	7	43 (45)	95	1.19 (0.56-2.56)	37 (35)	105	1.13 (0.53-2.50)	26 (25)	105	1.13 (0.53-2.50)	105	0.77 (0.35-1.76)
Daily traveled distance (km)												
	<15	10 (26)	38	1.00 (Ref)	9 (21)	42	1.00 (Ref)	9 (21.4)	42	1.00 (Ref)	42	1.00 (Ref)
	15-20	17 (41)	42	1.90 (0.75-5.05)	16 (36)	44	2.26 (0.87-6.12)	12 (28.6)	44	2.26 (0.87-6.12)	42	1.47 (0.54-4.06)
	>20	62 (47)	132	2.48 (1.15-5.74)	61 (42)	147	2.60 (1.20-6.14)	50 (34.0)	147	2.60 (1.20-6.14)	147	1.89 (0.87-4.48)

Table 5 (Continued)



not include time restrictions or fixed working hours. Besides, Platform C embraces the so-called “badge system” [14], which aims at ranking workers according to their performances (e.g., likelihood to accept shifts, canceling or not going to shifts, etc.), precluding or favoring the opportunity to participate to the most profitable shifts. This appraisal system may reduce workers’ autonomy, leading them to pick shifts regardless of their schedules, thereby increasing the risk of overwork and the likelihood of risky behaviors [33-34]. Still, work organization remains a crucial factor to consider when analyzing OSH in the gig economy and also when referring to road safety. The intensive working schedules reported by riders, with almost 44% working seven days a week (23% for more than 8 hours/day) and fatigue among the most reported occupational health disorders, generate concerns, especially in light of the higher probability of accidents emphasized by both our findings and the recent literature [17, 35-37].

### **4.3. Underreported Issues: Road Safety Challenges**

We reported a high prevalence of road accidents (~40%), consistent with the literature [15-17, 19], though not reflected in institutional records. For instance, the 2021 dataset from the National Institute for Statistical Analysis (ISTAT) shows only ten road accidents involving two-wheel riders during work in Milan, while the National Institute for Insurance against Accidents at Work (INAIL) reports 84 injuries for the entire Lombardy region, where Milan is located. Underreporting of occupational accidents is a known issue linked with cultural barriers, job precarity, and social vulnerability [38, 39]. Our study found that the leading causes of road accidents were poor road conditions (e.g., holes and potholes), inattention, inadequate driving skills (e.g., the ability to ride in wet conditions), and possibly heavy and destabilizing loads on precarious vehicles. However, 53% of riders cited collisions with other vehicles as the primary cause when hospital visits were required, indicating the most significant health risk.

Additionally, 24% of riders reported collisions with opened vehicle doors, a common hazard for

urban cyclists [40]. These findings align with the literature. For instance, Dennerlein and Meeker (2002) found high crash injury rates in 113 urban bicycle couriers in Boston [15]. Heyer et al. (2015) reported that 21.9% of commercial bicycle rider accidents in New York involved open car doors [16]. Christie & Ward (2019) found that 80% of bicycle riders in their study reported road accidents, often due to fatigue and violation of speed limits due to rush [17]. Recent studies highlight behaviors and external factors influencing rider risk. Perkio (2023) found that financial pressure led delivery workers in Sweden to take risks [22]. Bonifacio (2022) identified contradictions between algorithmic management, piecework payment, and safety behaviors among riders in Milan [41]. Our results also show a link between the number of daily deliveries, the distance traveled, and the likelihood of road accidents, with higher numbers increasing the risk. In our study, many e-bikes were traditional bicycles modified with electric batteries (likely failing to meet safety standards), increasing the risks for excessive speed, weight, inadequate braking systems, and instability [16]. The widespread ownership of vehicles (85%) further increases safety risks, as maintenance responsibility falls on riders; in addition, financial strain may discourage vehicle maintenance, exacerbating health and safety risks [42].

### **4.4. Violence and Physical Strain: Critical Issues Not to Be Underestimated**

Violence and aggression at work during delivery have been reported in the literature. For instance, Dennerlein & Meker (2002) reported that 1% of work-related injuries were due to on-road assaults/violence [15]. Lachapelle et al. (2021) noted road rage and harassment among many of the 35 interviewed commercial cyclists, while Perkio et al. (2023) reported experiences of violence and aggression in different situations, such as attempted theft of vehicles [18, 22]. Given the significant prevalence of both physical (12%) and verbal (28%) assaults we found in our investigation, we recommend placing more emphasis on this issue. Working as a rider exposes individuals not only to safety and psychosocial risks but also to physical strain.

For example, Li et al. (2022) investigated musculoskeletal disorders (MSD) among 657 bicycle riders working in Shanghai (China), finding a high prevalence (55%) of MSD, particularly associated with shoulder, neck, knee, and forearm, with longer job duration increasing symptoms likelihood [20]. These results align with our findings, where using backpacks and job duration are possible determinants of MSD.

#### 4.5. Possible Scenarios to Improve Working Conditions

Based on our findings, intervention should adopt a multi-level approach, including policy changes, technological innovations, and work, as well as place culture shifts involving various stakeholders such as employers, communities, and city councils. Empowering riders with knowledge of their rights and union support will enable them to advocate for safer and more supportive work environments. Policymakers should ensure that algorithmic management processes are transparent and incorporate parameters to reduce OSH risks and limit physical and mental strain [43-44]. These factors should be monitored by an effective worker health surveillance system and prevented through improvements in the working environment, safety culture, and technologies. For instance, creating rider-friendly urban environments, such as providing hubs for rest and essential services, can enhance well-being, alleviate mental and physical strain, and promote social interactions. The Vision Zero plan embraced by the European Union in 2021, which promotes safer urban environments and effective speed and traffic control policies [45], can significantly reduce road accidents for food delivery riders.

Additionally, mandatory safety training and ergonomic guidelines for load management, including correctly using well-designed backpacks, can alleviate daily physical strain. Moreover, the high prevalence (40%) of riders commuting from outside the city can be seen as an alarm sign for social inequality, such as the lack of affordable housing options and discrimination in housing markets. Housing policies that promote inclusivity for a broad spectrum of socio-economic groups can improve the living

conditions and well-being of migrant workers, including food delivery riders. Finally, establishing a reporting system for violence and harassment, along with accessible support services, can address critical psychosocial risks.

#### 4.6. Study Limitations and Strengths

While this study provides valuable insights into the OSH of food delivery riders, it is essential to acknowledge its methodological limitations. In particular, the findings may be of limited generalizability due to the local scale and the selection bias, as recruitment relied on casual involvement and voluntary participation. Moreover, for health outcomes, the survey is subject to self-report bias, and the cross-sectional design allows us to find associations but limits the possibility of establishing a causal link between determinants and outcomes. These factors highlight the need for experimental studies and objective measures in future research. Despite these limitations, the study's strengths lie in its empirical results, which cover a broad range of OSH topics, offering a vast understanding of the phenomenon. Additionally, although not representative of the entire workforce, the relevant number of subjects employed by different platforms and directly recruited in the field without employer mediation likely provided a deeper and more genuine understanding of the issues faced by food delivery riders.

### 5. CONCLUSION

Our study reveals that food delivery riders in Milan, predominantly foreign and employed under precarious conditions, face significant vulnerabilities, including high rates of overwork, road accidents, and health issues like musculoskeletal disorders and fatigue. The findings, aligned with recent literature, emphasize the need for improved regulatory measures and support systems to enhance rider safety and working conditions. Integrating decent work conditions and social protection principles from the 2030 Agenda for Sustainable Development [46] into public policies and platform practices will foster a safer and more supportive working environment for riders.

**SUPPLEMENTARY MATERIALS:** The following are available online: Supplemental material S1–S8.

**INSTITUTIONAL REVIEW BOARD STATEMENT:** The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of the University of Milan (approval n. 42/22).

**INFORMED CONSENT STATEMENT:** Informed consent was obtained from all subjects involved in the study.

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