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Intensification of app-based deliveries and the frequency of motorcycle accidents in the São Paulo metropolitan region

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Abstract

The expansion of platform-mediated work has reshaped labor relations and urban mobility dynamics, particularly in the motorcycle delivery sector. In this context, the present study analyzes the association between the intensification of app-based delivery activity and the incidence of motorcycle accidents in the city of São Paulo. This is an observational, ecological, longitudinal time-series study covering the period from 2015 to 2025. Secondary public-domain data were used, including information on traffic accidents (DETRAN), population (IBGE), and the motorcycle fleet (SENATRAN) in the city of São Paulo, in addition to delivery volume data obtained from institutional and media sources to construct an index of activity intensification in the region. Generalized Linear Models (GLM) were applied to estimate the effect of the activity intensification index on motorcycle accidents in São Paulo. An increasing trend in delivery activity intensification was observed, accompanied by a rise in both the absolute number and the proportion of motorcycle-related accidents. The intensification of delivery activity showed a significant positive correlation with the total number of accidents (Rho = 0.736; p = 0.013) and with the percentage of accidents (Rho = 0.991; p < 0.001). In the model adjusted for the city's total population, the association with the number of accidents remained statistically significant (p = 0.021). These findings indicate that the expansion of platform-mediated work is associated with an increased incidence of motorcycle accidents, possibly due to greater occupational risk exposure, prolonged working hours, and productivity pressures. It is concluded that the growth of this work modality constitutes a relevant factor in the dynamics of urban traffic accidents, with implications for road safety policies and occupational health.

Keywords: Delivery, Delivery app, Motorcycle accidents.

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Resumo

A expansão do trabalho mediado por plataformas digitais tem reconfigurado as relações laborais e a dinâmica da mobilidade urbana, especialmente no setor de entregas por motocicletas. Levando isso em consideração, a presente pesquisa analisa a associação entre a intensificação da atividade de aplicativo de entrega e a incidência de acidentes por motocicleta na cidade de São Paulo. Trata-se de estudo observacional, ecológico, longitudinal, do tipo série temporal, abrangendo o período de 2015 a 2025. Foram utilizados dados secundários de domínio público, incluindo informações sobre acidentes de trânsito (DETRAN), população (IBGE) e frota de motocicletas (SENATRAN) na cidade de São Paulo, além de dados de volume de entregas obtidos por fontes institucionais e midiáticas para a construção de um índice de intensificação da atividade na região. Foi realizada análise de Modelos Lineares Generalizados (GLM) para cálculo do efeito estimado do índice de intensificação da atividade sobre os acidentes com motocicletas na cidade de São Paulo. Observou-se tendência crescente da intensificação da atividade de entrega, acompanhada pelo aumento do número absoluto e da proporção de acidentes envolvendo motocicletas. A intensificação da atividade de entrega apresentou correlação positiva significativa com o total de acidentes (Rho = 0,736; p = 0,013) e com o percentual de acidentes (Rho = 0,991; p < 0,001). No modelo ajustado pela população total da cidade, manteve-se associação estatisticamente significativa com o número de acidentes (p = 0,021). Os achados indicam que a acentuação do trabalho mediado por plataformas digitais associa-se ao aumento da incidência de acidentes envolvendo motociclistas, possivelmente em decorrência da ampliação da exposição ao risco ocupacional, jornadas prolongadas e pressão por produtividade. Conclui-se que a expansão dessa modalidade de trabalho constitui fator relevante na dinâmica dos acidentes de trânsito em ambiente urbano, com implicações para políticas públicas de segurança viária e saúde do trabalhador.

PALAVRAS-CHAVE: Delivery, Aplicativo de entregas, Acidentes de motocicleta

Introduction

From the 1980s, the rapid development of information and communication technologies and its incorporation in the global economy inaugurated a new phase of capitalism, characterized by the digital economy. This process has recently culminated in the transformation of labor relations, which have largely become mediated by digital platforms (GROHMANN; SALVAGNI,

2023). In Brazil, the Administrative Council for Economic Defense (CADE) reported revenues of 4.25 billion USD from platform-based companies in 2022, consolidating them as relevant agents in the national economy.

The so-called "uberization" of labor is a neologism that gained prominence in Brazil from 2017 onwards, referring to the impact of technology companies on the labor market by mediating employment relationships and connecting service providers to consumers. With the growing "uberization" of the labor market, a type of employer–employee relationship based on flexible contracts has strengthened, characterized by formally independent workers lacking the labor rights guaranteed under contracts governed by the Brazilian Consolidation of Labor Laws (CLT). Among the most relevant expressions of this model in the Brazilian context are motorcycle drivers who deliver goods and food through apps, an activity that has expanded rapidly in recent years (ABÍLIO, 2021).

More than 1.7 million people engage in platform-mediated labor activities in Brazil, of which approximately 485,000 work specifically in food delivery applications (IBGE, 2025). Between 2022 and 2024, there was a significant increase in the number of motorcyclists linked to digital platforms, alongside a reduction among those not using this type of intermediation. Although the use of platforms is associated with an average monthly income 28% higher than that of non-platform workers, this gain occurs at the expense of longer working hours, low social security coverage, and high productivity pressure. A substantial proportion of workers report extending their working hours due to fear of account blocking or deactivation, with approximately 30% reporting increased workloads for this reason.

Thus, working conditions on digital platforms are characterized by long working hours and low social protection. A study conducted in New York involving 1,650 delivery workers found that approximately 22% re-

ported having suffered injuries and 21% assaults at work, with workers dependent on this income showing significantly higher prevalence of these adverse events (LASKARIS; HUSSEIN; STIMPSON et al., 2024). Similarly, motorcyclists linked to platforms show a higher likelihood of collisions and risk behaviors compared to delivery workers directly employed by commercial establishments, as they are constantly exposed to more stressful conditions (CHRISTIE; WARD et al., 2022; CIDREIRA, 2023). In the Brazilian context, studies indicate that a substantial proportion of app-based delivery workers have already experienced traffic accidents or other work-related incidents, reinforcing concerns regarding road safety and occupational health in this category (Ação da Cidadania, 2025; Fundacentro/UFBA, secondary data).

More than 1.7 million people engage in platform-mediated labor activities in Brazil, of which approximately 485,000 work specifically in food delivery applications (IBGE, 2025). Between 2022 and 2024, there was an increase of approximately 140,000 motorcyclists linked to digital platforms, alongside a reduction of 53,000 among those not using such intermediation. In 2019, although motorcycles represented 22% of the total vehicle fleet in the country, motorcycle accidents accounted for 52% of hospitalizations due to traffic accidents in Brazil. Furthermore, depending on the sample, 50% or more of the analyzed accidents are work-related (GANEM, 2020; RIOS, 2019). In addition, motorcyclists are the main fatal victims in work-related transport accidents, representing 21.2% of total records between 2011 and 2020 (MINISTRY OF HEALTH, 2022). Therefore, beyond the human cost, there is a significant economic and social impact associated with motorcyclists.

In the municipality of São Paulo, the largest urban center in the country, characterized by intense traffic flow and high demand for delivery services, this phenomenon is particularly relevant. The city concentrates

one of the largest motorcycle fleets in Brazil and has a history of high morbidity and mortality related to motorcycle accidents, especially among young men of working age. The expansion of app-based delivery services, intensified in recent years, particularly after the COVID-19 pandemic, has contributed to the increased presence of professional motorcyclists on São Paulo's urban roads (OLIVEIRA; CORROCHANO, 2023). Specifically in the urban context of São Paulo, motorcycle-related accidents represent a substantial proportion of hospitalizations and deaths due to transport accidents. Although motorcycles do not constitute the majority of the municipal fleet, they are among the main vehicles involved in severe incidents, with significant impact on the healthcare system and social security. Therefore, considering the high circulation of professional motorcyclists in São Paulo, the expansion of platform-mediated labor, and the burden of motorcycle accidents on urban morbidity and mortality, it is essential to analyze this phenomenon at the municipal level within the Brazilian context, in order to support local public policies on road safety and worker health protection.

The objective of this study is to analyze the relationship between the intensification of app-based delivery activity and the incidence of motorcycle accidents in the city of São Paulo, under the hypothesis that there is a positive correlation between these two variables, even after controlling for population size and the local motorcycle fleet.

Methods

We conducted an observational, longitudinal, ecological time-series design, analyzing data related to the city of São Paulo between 2015 and 2025.

Secondary data from official public databases were used. Information on the number of motorcycle-related accidents and the proportion of motorcycle accidents relative to total traffic accidents was obtained from the State Departments of Traffic (DETRAN). Population and demographic data were collected from the Brazilian Institute of Geography and Statistics (IBGE) (https://www.ibge.gov.br), while data on the total motorcycle fleet were obtained from the National Traffic Secretariat (SENATRAN).

Annual data on the number of delivery orders performed by motorcycle couriers across Brazil, from the largest company in the sector, were obtained from official company announcements and journalistic sources. Based on these data, a "National Intensification Index" was calculated to quantify the extent to which the company's activity expanded each year relative to its operations in 2015, the baseline year of the study. This index was calculated by dividing the number of deliveries in each year by the number of deliveries performed in 2015.

Motorcycle accident rates were calculated per 100,000 inhabitants using IBGE population estimates. A multicollinearity test was applied among the independent variables (Spearman's rho > 0.7). Using non-collinear variables, Generalized Linear Models (GLM) were performed to assess the significance of correlations and estimate the effects between variables after controlling for the influence of others. Statistical significance was set at $p < 0.05$ to ensure analytical reliability. All analyses were conducted using JAMOVI software, version 2.6.44.

As this study was based exclusively on secondary, publicly available data without individual identification, ethical approval by a Research Ethics Committee was not required, in accordance with Resolution No. 510/2026 of the National Health Council.

Results

Between 2015 and 2025, a consistent increase was observed in indicators related to motorcycle-based logistics: the intensification of app-based motorcycle deliveries (red curve) and the percentage of accidents involving motorcycles (blue curve). Both exhibited an upward trend, with slope coefficients of 12.07 and 1.74, respectively. In contrast, the estimated population of the municipality (green curve) did not follow this pattern, showing a negative slope coefficient (Figure 1). This pattern is further supported by the scatter plot analysis of these variables (Figure 2).

In the Spearman correlation matrix, app intensification showed a significantly positive correlation with the number of registered motorcycles (rho = 0.988; $p < 0.001$). App intensification was also significantly positively correlated with the annual total number of motorcycle accidents (rho = 0.736; $p = 0.013$) and with the percentage of accidents involving motorcycles (rho = 0.991; $p < 0.001$). The number of registered motorcycles showed a significantly positive correlation with the annual total number of accidents (rho = 0.867; $p = 0.003$) and with the percentage of accidents (rho = 0.976; $p < 0.001$). In contrast, the estimated population did not show statistically significant correlation with any of the other variables (Table 1).

In the Generalized Linear Model (GLM), the annual total number of motorcycle accidents was considered the dependent variable, while the estimated population of São Paulo and app intensification were included as independent variables, after excluding other variables due to collinearity. The estimated population did not show a statistically significant association with the annual total number of accidents ($p = 0.519$; 95% CI = −0.0252/0.015). In contrast, app intensification showed a positive and statistically significant association with the response variable ($p = 0.021$), with an estimated average effect of approximately 308 accidents per year

for each unit increase in the app intensification index, while holding the population effect constant in the model (Table 2).

Figure 1: Temporal variation of app-based motorcycle delivery intensification index (red) and the percentage of accidents involving motorcycles (blue) in the city of São Paulo (primary axis), along with the estimated total population of the city (green) (secondary axis). Trend lines for each variable are represented by dashed lines in their respective colors.

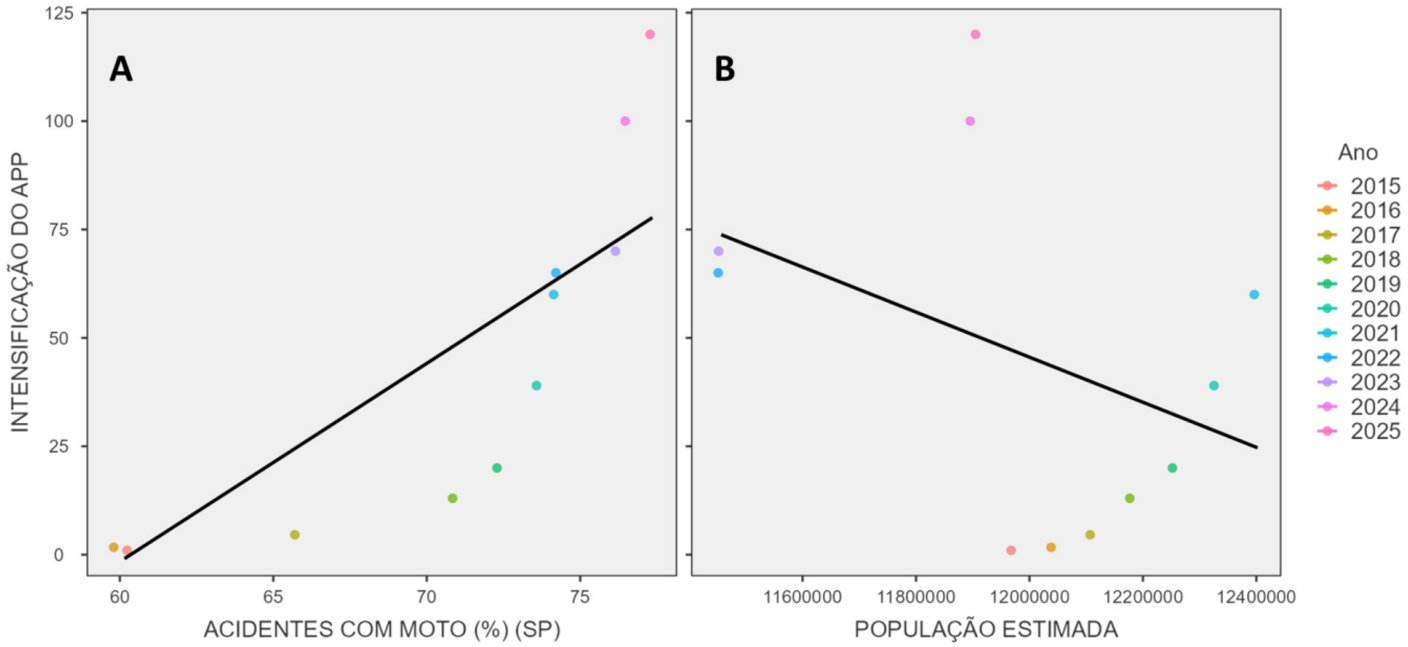

Figure 2: Scatter plots showing the relationship between the intensification of app-based motorcycle delivery services in São Paulo and the percentage of motorcycle accidents relative to total traffic accidents (A), and the estimated population in São Paulo (B).

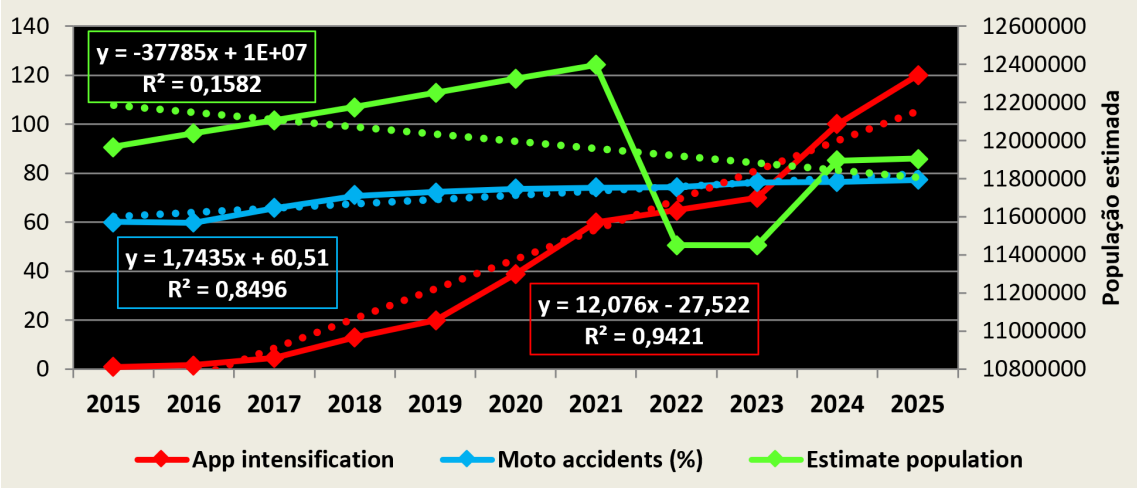

Table 1: Spearman correlation matrix of annual values from 2015 to 2025 for variables related to the city of São Paulo.

		App intensification index	Registered motorcycles	Motorcycles accidents (total)	Motorcycles accidents (%)
App intensification index	**Rho**	—			
	p	—			
Registered motorcycles	**Rho**	0,988	—		
	p	<,001	—		
Motorcycles accidents (total)	**Rho**	0,736	0,867	—	
	p	0,013	0,003	—	
Motorcycles accidents (%)	**Rho**	0,991	0,976	0,755	—
	p	<,001	<,001	0,01	—
Estimated population	**Rho**	-0,273	-0,067	-0,188	-0,285
	p	0,448	0,88	0,608	0,427

Table 2: Explanatory model (GLM) for the annual total number of motorcycle accidents in the city of São Paulo between 2015 and 2025.

				Confidence interval (95%)	
Covariates	**p**	**Estimate**	**SE**	**Inf.**	**Sup.**
Estimated population	0,519	-0,00339	0,005	-0,0252	0,015
App intensification index	0,021	308,43245	107,613	159,0312	641,6425

Discussion

The results obtained are consistent with the hypothesis that there is a positive correlation between the intensification of app-based motorcycle delivery activity and the incidence of traffic accidents involving motorcycles. Temporal analysis demonstrated parallel growth among the proxy variable for app intensification, the percentage of accidents involving motorcycles, and the number of registered motorcycles, while the estimated population

of the municipality remained relatively stable and did not proportionally follow this dynamic.

The correlation between app intensification and the percentage of motorcycle accidents (rho = 0.991) suggests temporal alignment between the expansion of this activity and the increasing contribution of motorcycles to the overall burden of traffic accidents. Additionally, the association with the absolute number of accidents (rho = 0.736) reinforces that the phenomenon is not limited to a proportional shift in accident composition but is also related to an absolute increase in the outcome. Within the context of the obtained results, it was not possible to include the effect of the motorcycle fleet size in the city of São Paulo, as these data were collinear with the intensification of app-based delivery activity (rho = 0.988). Although it prevented its inclusion in the GLM analysis, this strong correlation reinforces the impact of motorcycle-based digital platforms on urban traffic dynamics by increasing the local fleet size (WADUD, 2020). Thus, the strong positive correlation between app intensification and the number of registered motorcycles suggests that the expansion of platform-mediated labor causes fleet growth or, alternatively, that both reflect the same process of intensification of motorcycle activity in the urban environment. This pattern highlights the need for public planning to accommodate the additional fleet within local traffic dynamics (DE OLIVEIRA et al., 2024).

In the explanatory model (GLM), app intensification remained significantly associated with the annual total number of accidents, even after adjusting for the estimated population. The estimated coefficient indicates that, within the analyzed time window, increases in the proxy variable are associated with a substantial average increase in the annual number of accidents. This finding strengthens the interpretation that the observed phenomenon is not explained by demographic growth, but rather by structural changes in urban mobility dynamics and in the occupational

profile of motorcyclists. Our results indicate that the intensification of app-based motorcycle delivery activity is associated with an increase in traffic accidents in urban settings. Productivity pressure leads many delivery riders to work more than 10–12 hours per day, often without weekly rest (FIORAVANTI et al., 2023). In this context, informality combined with productivity pressure contributes to the adoption of behaviors aimed at increasing earnings, even at the cost of elevated risk of traffic accidents (SILVA, ANDRADE, SOARES, SOARES, MATHIAS, 2008). An international study demonstrated that the prevalence of accidents involving motorcycle couriers is associated with the number of trips performed and daily working hours, suggesting that greater exposure to urban traffic increases the risk of incidents in a deregulated environment without limits on weekly working hours (PRAKOBKARN et al., 2024).

It is important to distinguish between fleet growth and risk exposure growth. The risk of accidents does not depend solely on the number of registered vehicles but also on circulation volume, intensity of use, time of exposure on the roads, and working conditions. App-based delivery workers tend to have prolonged working hours, task-based remuneration, algorithmic incentives for speed and reduced delivery time, and predominantly operate in high-density traffic areas (ZENG and WU, 2022). In this sense, app intensification may influence not only the number of workers but also the cumulative exposure to risk associated with each individual's activity.

The precarization and occupational vulnerability characteristic of platform-mediated workers include long working hours, occupational stress, fatigue, and income insecurity, all of which increase the likelihood of risk-taking behavior in traffic. According to a study by Bajwa et al. (2018), gig economy workers constitute a high-demand, low-cost labor force subjected to algorithmic pressure for productivity, lack of social protection, and economic instability. Although this model offers apparent flexibility,

such structural conditions may indirectly contribute to increased exposure to occupational accidents.

A study conducted in two municipalities in the state of Paraná reinforces this scenario, showing that most motorcycle couriers are subjected to exhaustive working hours to compensate for low remuneration. This strategy is used to increase productivity despite negative impacts on mental health, quality of life, and increased risk of traffic-related incidents (SILVA, ANDRADE, SOARES, SOARES, MATHIAS, 2008).

This new organization of work, promoted by platform-based companies, constitutes a profit-generation model that directly benefits from worker productivity. As demand for platform use increases, the number of registered workers and completed deliveries also grows, intensifying performance pressure and expanding the profits of gig economy companies, whose logic is based on task-based payment. Due to the informal nature of this labor relationship, companies reduce labor costs, further favoring profit maximization (ALOISI, 2020; DE STEFANO et al., 2021). Thus, the digital economy, mediated by platforms, links economic incentives to the intensification of working hours and productivity, which may encourage risk-taking behavior and contribute to an increased probability of traffic accidents (MORAES et al., 2024).

The absence of a significant association between estimated population and accidents in the adjusted model reinforces that population growth does not explain the variation in the outcome during the analyzed period. In large metropolitan areas such as São Paulo, annual demographic changes tend to be modest compared to economic and technological transformations that rapidly alter mobility patterns. This finding supports the hypothesis that a structural phenomenon related to the reorganization

of urban labor is occurring, beyond the mere increase in population demand for mobility.

Conclusion

The intensification of app-mediated delivery activity represents a disruption of the traditional "employer–service provider–consumer" relationship, increasing perceived autonomy while reducing economic and social protections for service providers. This new arrangement increases the risks associated with motorcycle delivery work by requiring longer working hours under more stressful conditions, which is reflected in our data as a strong direct correlation between delivery activity and the incidence of traffic accidents involving motorcycles.

Despite the observed statistical consistency, it is essential to acknowledge that the ecological design and aggregated time-series analysis do not allow for individual-level causal inference. The "app intensification" variable constitutes an aggregated proxy and may simultaneously capture multiple aspects, such as the actual increase in the number of delivery workers and motorcycles, as demonstrated, as well as the growing informality of the activity, the expansion of delivery demand, and local macroeconomic transformations. Furthermore, potentially relevant variables were not included in the model, such as municipal road safety policies, changes in enforcement, urban infrastructure, and variations in accident underreporting. Therefore, the results should be interpreted as evidence of a robust temporal association and should encourage similar studies in other Brazilian metropolitan areas, rather than as proof of direct causality.

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