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Analyzing Traffic Violations through e-challan System in Metropolitan Cities (Workshop Paper)

Ritwik Mishra*,
Ponnurangam Kumaraguru,
and
Rajiv Ratn Shah
IIT, Delhi
{ritwikm, pk, rajivratn}@iitd.ac.in
*These authors contributed equally to work

Aanshul Sadaria*, Shashank Srikanth*,
Kanay Gupta*, Himanshu Bhatia*,
and Pratik Jain*
IIT, Hyderabad
{aanshul.sadaria@students, shashank.s@research,
kanay.gupta@students, himanshu.bhatia@students,
pratik.jain@students}.iit.ac.in

Abstract—Given that India is now moving towards automated solutions to curb traffic violations and road accidents, we focus our efforts on characterizing these violations in Indian cities. In this work, we present our characterization of the traffic violations via an Automated e-challan (electronic traffic-violation receipt) issuance system of Ahmedabad and New Delhi. To explore this, we collected an exhaustive dataset of over 6 million e-challans. Characterizing the fine payment behavior, we find that 57% of unique vehicles in Ahmedabad are involved in repeat offenses. The temporal analysis shows a significant difference in e-challans issued during the festivals. Spatially, different violation types are distributed differently with the existence of certain unique hotspots. Finally, we also demonstrate how e-challans can act as a proxy measure to analyze the efficacy of the Motor Vehicles (Amendment) Act 2019. Our work suggests that high penalties may not have a long term impact on decreasing traffic violations.

Keywords—big data; traffic violations; e-challan; transport systems; state policy; surveillance;

I. INTRODUCTION

In 2004, fatal injuries from road accidents were predicted to become the third leading cause of death by the end of 2020, and the trend shows that middle-income developing countries (like India) are going to get the hardest hit [1, 2]. At the beginning of 2020, road accidents accounted for the most number of deaths in the world, among the age group of 5 to 29 years old, with more than 90% of the mortalities coming from low- and middle-income countries [3].

Previous research in the field of behavior studies regarding traffic rule violations has shown that in more than 70% cases, the role of human behavior is one of the causes [4]. Most of these accidents can be prevented if the traffic rules are properly followed. In India, the traffic police across states have started adopting the automated traffic management systems to promote adherence to traffic rules [5]–[7]. Such automated systems vary in their functioning and usage across the states. Some systems are capable of tasks like capturing violations and issuance of e-challan without any human intervention. At the same time, others can also generate e-challans along with photo evidence and send it to violators

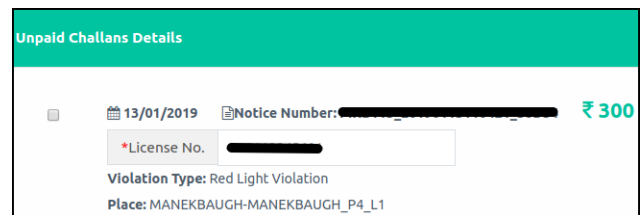


Figure 1: A sample e-challan in Ahmedabad.

through SMS [5].

We curate a dataset of e-challans from the traffic-violations-portal of two metropolitan cities of India: Delhi and Ahmedabad since their e-challan portals directly respond to HTTP requests. Moreover, both are tier-1 cities in terms of house rental allowance [8] and population [9]. The Ahmedabad traffic police launched their second leg of automated traffic management system in April 2018, and it leverages a network of 1,300 video surveillance cameras installed across 87 traffic junctions [10]. Delhi traffic police launched their intelligent traffic management measures in 2016. It included HD CCTV cameras in eminent locations, 50 cameras mounted on traffic police vehicles, and 200 body-worn cameras for traffic constables [11]. Figure 1 shows an example of an e-challan generated in Ahmedabad. An e-challan consists of several details of a given traffic violation like the date/time, place of violation, violation type, and corresponding fine amount.

In this paper, we carry out a detailed study of traffic violations in the cities of Ahmedabad and Delhi. Our analysis would be particularly useful for the government and other law enforcement agencies such as police, who are responsible for making the roads safer for citizens. Unlike some earlier works [12, 13] that focused on road accident data, we focus only on traffic violations.

A. Research Questions

The existence of large scale digital data such as traffic violations in a city can be utilized to derive a lot of information and characterize such violations in detail. Law

enforcement agencies can get valuable insights from the distribution of violation types in a city. Moreover, an analysis of user behavior towards paying a violation penalty could be useful in drafting future legislation. Thus, we address our first research question:

RQ1: *How can e-challan data be used to characterize the distribution of traffic violations and e-challan payment patterns as well?*

We are also interested in analyzing the spatial and temporal patterns in traffic violations across cities. It can help in designing more robust and effective intervention measures for traffic regulatory bodies. For example, the variation of traffic violations across different areas and localities would allow law enforcement agencies and policymakers to design more violation-specific intervention measures for each region. Similarly, the temporal patterns in traffic violations across the days of the year can be used to deploy surveillance resources effectively. We thus, address:

RQ2: *What are the spatial and temporal patterns in traffic violations across the cities being studied?*

Finally, we are interested in understanding how such data can be used to understand public compliance and making informed policy decisions. Thus, we show a possible application of our dataset for measuring the people’s conformity to certain policies such as the Motor Vehicles (Amendment) Act 2019 [14] through the number of traffic violations. Thus, we address the following research question:

RQ3: *Can traffic violations data in the form of E-Challans serve as a proxy for measuring the effectiveness of government regulations?*

B. Contributions

We describe a method to collect e-challans from traffic regulatory portals and present relevant insights from a large-scale dataset of 6 million e-challans, that were issued in Delhi and Ahmedabad. For spatial analysis, 98% of the e-challans are geotagged with the corresponding latitude and longitude of their offense location.

C. Privacy and Ethics

We collect data from Ahmedabad and Delhi traffic police’s e-challan portal for research purposes only. Additionally, we do not use any personally identifiable information in our analysis.

II. RELATED WORK

We structure the discussion of related work into two main themes: related work on road accidents and work concerning the spatial and temporal analysis of traffic accidents and social media data.

Traffic Accidents and Violations: Traffic accidents account for more than a million deaths each year across the world, according to WHO [15], and a lot of research has been conducted on data concerning road accidents. Sanjay

Description	Ahmedabad	Delhi
Number of e-challans	2,628,116	1,238,144
Number of paid e-challans	896,140	NA
Number of unpaid e-challans	1,731,976	NA
Number of unique vehicles	931,338	548,233
Total amount owed	588,756,200	NA
Total amount paid	185,684,000	NA
Total amount unpaid	403,072,200	282,664,000
Number of violations	18	29
Number of locations	111	54,335
Number of denominations	12	6

Table I: A brief description of the e-challans collected in the first phase

et al. [16] analyze the road accident data across India at a national, state, and metropolitan city level and show that the distribution of road accident deaths and injuries varies according to age, gender, month and time. It has also been shown that more than 50% of the cities face higher fatality risks as compared to their rural counterparts. Iglesias et al. [17] explored the relationship between anger and traffic violations to characterize men as a more prone gender to commit a traffic violation. Jayatilleke et al. [18] showed the negative correlation between traffic fines and traffic violations along with fatal road accidents. Leekha et al. [19] indicated that attentiveness of a driver can be inferred from their posture on the driving seat.

Another set of approaches to model road accidents involve identifying road accident hotspots using GIS (Geographical Information System) technologies. Choudhary et al. [12] geocoded 5 years of road accident locations over the digital map of Varanasi and clustered accidents using a spatial heatmap. Qiqi et al. [20] demonstrated that traffic violations amongst bus drivers are associated with the date, weather, and presence of traffic cameras at bus stations. Analysis done by Qiqi et al. [20] is the most similar to our work, but their analysis was limited to buses only. Unlike the previous works which focus mainly on correlating user behavior with road accidents and traffic violation, our work investigates the effect of government policies on these violations and also suggests measures that can help manage traffic and ensure order.

Spatio-temporal analysis: A lot of research has been done on the spatial and temporal patterns in social media such as Twitter, Foursquare, and Snapchat [21]. For example, Lamba et al. [22] find that for most cities, distracted driving content posted on Snapchat is geographically concentrated to a few locations of the city. Several studies have also performed temporal analysis on social media websites by analyzing posting behavior amongst Snapchat users [23] and Twitter users [24]. We aim to use similar techniques to analyze traffic violations and gain unique insights. Some works have also studied spatio-temporal patterns in traffic accidents across cities in the world. F. Jegede analyzed road traffic accidents in Oyo State, Nigeria, and identified six

traffic zones (Black Spots) that required special attention by any road safety programs or law enforcement agencies [25]. Similar studies on spatio-temporal analysis of accidents have also been done in India [26], the Czech Republic [27], and other countries. Unlike the previous works, which deal mostly with traffic accidents or social media data, our work deals with the spatio-temporal patterns in traffic violations.

III. DATASET COLLECTION AND DESCRIPTION

For this work, we collect traffic violation receipts (e-challan) from the e-challan portal of Ahmedabad traffic police¹ and Delhi traffic police².

A. Data collection

We pinged the e-challan portal with vehicle number in the body of POST requests to obtain the e-challan of the given vehicle number. This is in contrast to various other cities like Hyderabad, Mumbai, etc., where filling a Captcha or login credentials is mandatory.

For the city of Ahmedabad, a typical vehicle number has the following format (without hyphens): GJ-R-XX-dddd, where GJ is the code for Gujarat state, $R \in \{01, 27\}$ is the code for one of the two RTOs in Ahmedabad city, $X \in \{A, B, \dots, Z\}$, and $d \in \{0-9\}$. To ping the e-challan portal, we used all the possible combinations of vehicle numbers i.e. $2 \times 26 \times 26 \times 10^4$ ($\approx 10m$) possible combinations.

In the case of Delhi, possible combinations of vehicle numbers are nearly 1 billion. Since it is not feasible to check all possible combinations of vehicle numbers, we begin enumerating in a lexicographic manner and pruned our search space by breaking the loop when we find no e-challan in any of the 10,000 previously searched vehicle numbers.

For example, if we find no e-challans in the range DL1-CHA-0000 - DL1-CHA-9999, then we stop querying for vehicles with vehicle number DL1-CXX-XXXX onwards. We observed that once an entire series of vehicle number do not yield any e-challan, no e-challan is seen further in the subsequent series i.e. DL1-CHB-0000 - DL1-CZZ-9999. Therefore, we believe that it is safe to assume that vehicles further in this series have not been registered yet.

In this fashion, we checked 4 million combinations of vehicle numbers when the total number of valid vehicles (registered after 2005) on the roads of Delhi is 6 million [28, 29]. Thus, while the dataset collected in the case of Ahmedabad can be assumed to be complete, it cannot be claimed for Delhi.

In the first phase of data collection, we collected over 3 million e-challans from 15 April 2018 (launch date of Ahmedabad automated traffic management system) to 31 August 2019. Table I provides a quantitative description of our dataset from first phase. For analysis of The Motor Vehicles (Amendment) Act 2019 (MVA), we again collected

Ahmedabad		Delhi	
Violation Type	# e-challans	Violation Type	# e-challans
Red light	2,535,623	Red light	532,441
Stop line	49,660	Over speed	321,239
Improper parking	27,167	Improper Parking	184,349
Driving in BRTS	4,348	Stop line	117,774
Wrong lane	3,725	No Helmet	40,343
Total violation	2,628,116	Total Violation	1,238,144

Table II: Top 5 violations in Ahmedabad and Delhi

e-challans for all the unique vehicles from the first phase. Only those e-challans were taken into consideration that were issued after the act was implemented i.e., 1st September 2019. For Delhi, e-challans as far as 6th June 2020 are collected in the second phase, whereas for Ahmedabad the end date was 13th July 2020. This marks the end of the second phase of data collection. All the analysis before section 6 is done on the data collected in the first phase because MVA significantly changed the patterns in traffic violations after its launch date. Therefore we believe that data collected in the second phase cannot be used to analyze the general trends in traffic violations.

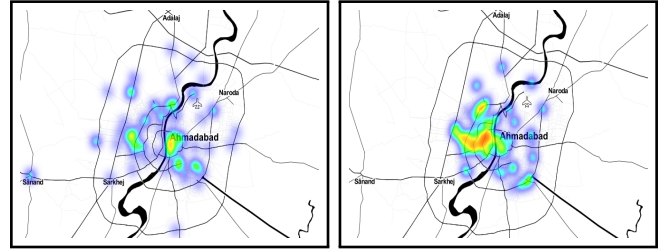


Figure 2: Heatmaps for *Improper Parking* (left) and *Red Light Violation* (right) in Ahmedabad.

B. Dataset description

The final dataset, for Delhi and Ahmedabad, contains a total of over 6 million e-challans. For each unique e-challan in our dataset, we have five major attributes - (i) Date/Time of the violation, (ii) Location of the violation, (iii) Type of violation, (iv) Fine amount, (v) Paid or unpaid e-challan (only in case of Ahmedabad). In the final dataset, the total unpaid amount from e-challans tallies to 4 billion INR.

Though the data collected in both these cities are similar in most aspects, they differ in certain attributes. In Ahmedabad, we have access to both paid and unpaid e-challan for each vehicle, unlike Delhi where the portal deletes paid e-challan in some time. There is a difference in the granularity of temporal data in both the datasets with e-challans in Delhi containing the exact timestamp of the violation. In contrast, e-challans in Ahmedabad contain only the date of violation. The nomenclature of Delhi vehicle numbers contains the type of vehicle as well. For example, DL9CA1234 is vehicle

¹<https://payahmedabadchallan.org>

²<https://delhitrafficpolice.nic.in/notice/pay-notice/>

number of a car registered in RTO number 9 (*Dwarka*)³. Such nomenclature is not available in Ahmedabad vehicle numbers. Since there are a lot of dissimilarities in the data of both the cities, a standardized way of reporting traffic violations in e-challan traffic portals would benefit further research in this domain.

C. Data Preprocessing for Geocoding

Due to the presence of multiple cameras in a single location of Ahmedabad, two cameras may have the same geographical location but a different name in the location field of the e-challan. Thus, we cleaned the data by updating the location field of all e-challans to a specific geographic location to perform the spatial analysis. In Delhi, the number of unique locations was above 50 thousand. The location description contained spelling variations, abbreviations, and unwanted details. For example, one such description was ‘*COD ring road. Towards Naraina eating kachori by causing traffic obstruction*’. Central locations were extracted by checking noun entities in an exhaustive (curated) list of known places in Delhi. After the cleaning process, 98% of e-challans in the final dataset were successfully geotagged.

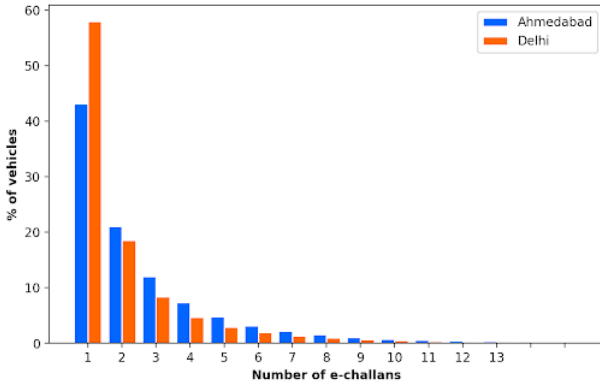


Figure 3: Percentage of unique vehicles with given number of e-challan receipts.

IV. CHARACTERIZING TRAFFIC VIOLATIONS AND FINE PAYMENTS

In this section, we characterize the different types of violations and incidents of repeated violations in the two cities. We also analyze the trends and patterns in fine payments for the city of Ahmedabad. We restrict the latter analysis to Ahmedabad, as the dataset of Delhi e-challans does not consist of both paid and unpaid e-challans.

A. Distribution of violation types

The number of e-challans issued for the top 5 most common violation types in Ahmedabad and Delhi is presented in Table II. We can infer from Table II that the top 2

violations in both cities account for 68.94% and 98.37% of all the e-challans issued in the city respectively. Thus, specific targeted measures can be taken to reduce the number of such violations committed compared to general measures that target all violations equally. We also analyze the violation types from a spatial perspective, as shown in Figure 2. From Figure 2, we can see that the hot-spots of different violation type varies according to the location. Furthermore, the *Red Light Violations* are more concentrated in West Ahmedabad as compared to *Improper Parking*, which are scattered in few regions across the city. The implication of the above analysis is that the location of a violation type is a specific function of that violation type and is likely to be clustered in certain regions of the city.

B. E-Challan Payments

We analyze the payment behavior for the city of Ahmedabad only due to the unavailability of the payment status in the Delhi e-challan dataset. From Table I, the ratio of unpaid to paid e-challans is calculated to be 1.93, and the ratio of fine amounts of unpaid to paid e-challans is 2.17. This suggests that the majority of paid e-challans consist of lower fine amounts as the fine payment ratio is 1.12 times the issued e-challans ratio. We further analyze the distribution of paid e-challans ratio with respect to the e-challan fine amount and found that 34.11% fines with denominations less than 1000 INR are paid whereas 18.91% fines are paid of those more than 1000 INR. This shows that the fine amount is likely to affect the payment behavior of users in Ahmedabad. However, we find that the e-challans of overspeeding violations have a drastically higher ratio (0.62) of paid e-challans compared to 0.17 for BRTs lane violations where their average fine amount is 1017.8 INR and 1251.2 INR respectively, which is relatively similar.

C. Repeat violations

Identifying repeat violations and its prevalence across cities will be useful for law enforcement agencies. In Figure 3, we show the percentage distribution of unique vehicles in our dataset for the number of e-challans issued to each one of them. From the plot, it is clear that a significant portion of the unique vehicles has more than 1 violations (57% in Ahmedabad and 42% in Delhi). We further computed that the median number of e-challans issued to all the users was 2 and 1 for Ahmedabad and Delhi, respectively. Thus, we notice a city-wise difference wherein a vehicle is more likely to be involved in repeat offenses in Ahmedabad as compared to Delhi. We also find that there are vehicles with more than 100 e-challans issued in both Ahmedabad and Delhi. This suggests that many of them might not be aware of the e-challans being issued to them or simply decline to pay up until required.

³<https://www.policybazaar.com/rto-delhi/>

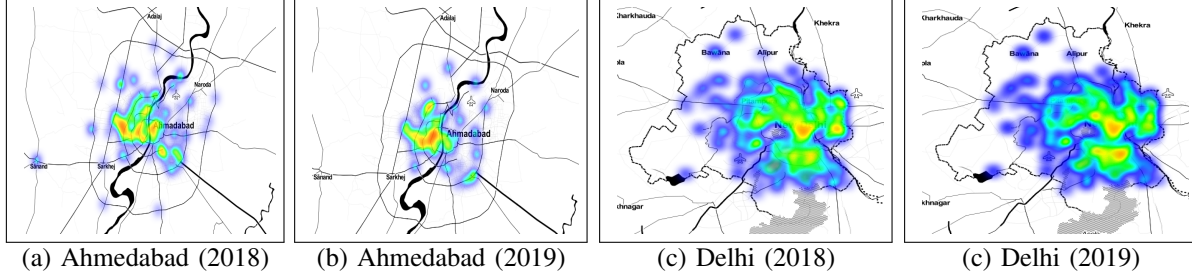


Figure 4: Heatmaps for year 2018 (a,c) and 2019 (b,d) in our e-challan dataset.

V. CHARACTERIZING TEMPORAL AND SPATIAL PATTERNS

In this section, we characterize the spatial and temporal patterns in the datasets. Spatial analysis is useful for understanding the presence of geographical clusters that account for most traffic violations. On the other hand, temporal analysis allows us to analyze the general trends in the occurrence of traffic violations and when it is more prevalent.

A. Spatial analysis

We use spatial analysis to investigate the presence of certain hotspots where traffic violations are more likely to occur. In Table III, we show that for Ahmedabad, the top 5 locations (in terms of the number of e-challans issued) account for approximately 32% of all the e-challans collected for the city. However, in Delhi's case, the top 5 locations contribute to only 13% of Delhi's e-challan data. Delhi being a larger city than Ahmedabad, has a wider spread of e-challans, which is also captured by the numbers mentioned.

Shyamal region of Ahmedabad and *JNU to Neela Hauz* road of Delhi have the most number of e-challans in our datasets and by itself accounted for approximately 8% and 4% of all the e-challans in the respective datasets. Thus, the data reveals that most traffic violations are concentrated in only a few regions of the city.

We can infer from Figure 4 that traffic violations are concentrated in a few regions across Ahmedabad whereas, for Delhi, it is much distributed across the city. One explanation for this observation could be since Delhi has a much longer road-length per vehicle (2.8 meters) as compared to Ahmedabad (0.5 meters) [30]. Most of the violations occurred in the central regions of the Ahmedabad and were more concentrated on the left side of the *Sabarmati river*.

These insights can be used to take targeted intervention measures for different regions of the city.

B. Temporal Analysis

Temporal analysis of the data allows us to find patterns about the occurrence of traffic violations with respect to time. Figure 5 shows the distribution of all the e-challans issued during the period of the first phase of data collection in both the cities. We analyze the plots to see if there are any spikes around the festival days. In general, there is a steep drop or increase in the number of e-challans issued during festival days for Ahmedabad. We observe that 2 – 3 days before *Rath Yatra* (Chariot Procession) - July 14, 2018, and July 4, 2019 - the number of e-challans issued is zero as the police personnel was on security duty. This suggestion is further strengthened by another observation that during a few other festivals like *Muharram*, *Eid-ul-Fitr*, and *Diwali*, there is a dip in the number of e-challans issued. However, on some other popular festivals in Ahmedabad, such as *Navratri*, *Rakshabandhan*, *Janmashtmi*, and *Ganesh Chaturthi*, there is a notable rise in the number of e-challans issued. This is because there is a higher rush of vehicles due to gatherings, and people are prone to be less sensitive towards traffic rules.

The highest number of e-challans (16,500) issued on a single day in our dataset for Ahmedabad was on January 13, 2019, a day before *Makar Sakranti*, one of the most widely celebrated festivals in Ahmedabad. The underlying trend of the high number of e-challans issued a few days before certain festivals continues during the day of the festival as well. Similar trends were observed for the city of Delhi as well. On 15th August (Independence Day) 2018, the drop in traffic violations was highest (85%) compared to the previous day. Subsequently, 16th August 2018 witnessed the sharpest

Ahmedabad		Delhi	
Location	Number of e-challans	Location	Number of e-challans
Shyamal	213,491	JNU to Neela Hauz Near IIMC	52,043
Sashtrinagar	160,375	Sarai Kale Khan From ITO Straight	48,036
Sardarpatelstatue	159,762	Mayapuri From Kriti Nagar	23,326
Nfd	155,883	Moolchand From Dhaulakuan	22,214
Girish colddrinks	150,537	Andrews Ganj From JLN Stadium	21,584
Total Violations	2,628,116	Total Violations	1,238,144

Table III: Distribution of e-challans with location.

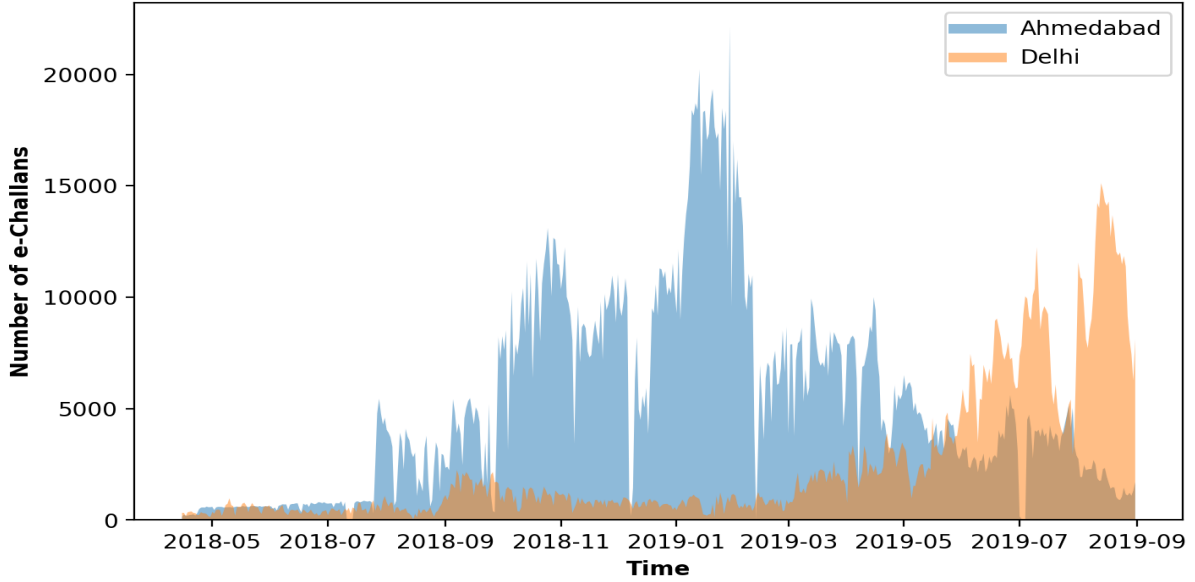


Figure 5: Time series plot of all the e-challans in our dataset for both the cities

increase (850%) in the number of fines. On Diwali, we see a similar drop in Delhi as well as in Ahmedabad. This shows that both cities show similar behavior around festivals, which can then be used to resource traffic personnel better.

Another trend that can be discerned from Figure 5 is that the number of e-challans is continuously increasing with time in Delhi whereas in Ahmedabad, the maximum number of e-challans issued during early 2019 after which it starts to decrease. This shows that there have been concrete efforts from the Delhi traffic department to effectively use this system and capture more violations through the system.

Due to the availability of the exact time of violation in the Delhi dataset, we analyze the temporal trends with respect to the hour of the day in Figure 6(a) and Figure 6(b). From Figure 6(a), we observe an increasing trend in the number of violations during the morning hours of 7 am to 10 am, which gradually decreases till noon and then again starts rising to attain maxima at 5 pm. The violations reduce drastically after 7 pm. Hence, most of the traffic violations are committed from 7 am to 7 pm of the day. We also plot the hourly trends of stop-line violations in Figure 6(b) for two-wheelers and private cars. We can see that during peak traffic hours i.e., 10 am - 12 pm and 5 pm - 7 pm, the percentage of two-wheelers is higher. This could be because it is relatively easy for a two-wheeler (like scooter or motorbike) to navigate through the traffic and break the queues during peak hours. We posit that this insight would be useful for the law enforcement agencies as they can pay special attention to two-wheelers during these times compared to the other times of the day.

In summary, spatial-temporal trends in the traffic violations of a city could give relevant insights into the flow of traffic

inside the city. Insights from such trends would benefit the traffic police to adopt specialized measures for some violations or vehicle types. Moreover, e-challans could also serve as an (indirect) indication to measure the effectiveness of some government regulations, which directly affects the flow of traffic in a city.

VI. E-CHALLANS AS A PROXY

Several studies in the past have used traffic violation data as a proxy for traffic crashes [31, 32]. In this section, we try to answer if the traffic violations data in the form of e-challans can serve as a simplistic proxy for measuring government regulations' effectiveness. Specifically, we look at the effect on the main government regulation on traffic violations i.e., The Motor Vehicles (Amendment) Act 2019 [14]. Since we intend to assess the impact of MVA, subsequent analysis takes into account the same vehicles that committed traffic violation before the implementation of MVA, as explained in second phase of data collection in section III.

Threats to validity: Evaluating the effect of any one decision or regulation on complex matters such as societal issues is a complex issue as multiple competing explanations could be provided for a given observation. Moreover, like any other dataset, even a dataset consisting of e-challans could be prone to implicit and explicit biases. The results described below should not be used in isolation to evaluate the effectiveness of regulations. However, they should be part of a set of holistic measures that take into account several other societal and correlated data. With this analysis, we only show a possible application of similar data for the evaluation of such policies or regulations.

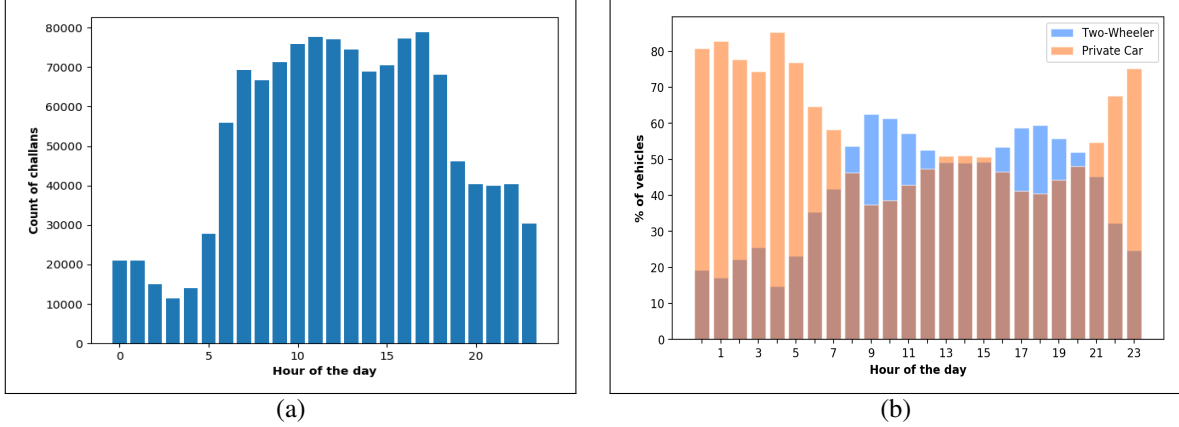


Figure 6: (a) Hourly trends of committing traffic violations and (b) Hourly trends of committing stop-line violations, in Delhi.

A. Effects of The Motor Vehicles(Amendment) Act 2019 on e-challans

The recent amendments to the Motor Vehicle Act in 2019 have enhanced the penalties for several traffic violations [14]. In some cases, the penalties have even doubled or quadrupled, depending on the type of violations. Assuming strict and uniform implementation, we try to understand if the increase in awareness about violations, coupled with the increased fines, caused any significant change in the number of e-challans issued.

In Delhi and Ahmedabad, the new Motor Vehicles Act was implemented on 1st September 2019. As compared to August of 2019, Delhi data shows 45% decrease in average e-challans that were issued in September as seen in Table IV. This is contrary to the data of 2018, where September saw a 250% increase in average e-challans compared to August 2018. Moreover, September 2019 witnessed negative growth in the average number of e-challans issued per day (wrt previous day) and became the only month in our dataset to have negative growth. The number of e-challans issued per day fell till 2nd October 2019, and reached an all-time low of 89 traffic e-challans issued in one day since 15th August of 2018. Effect of the act was seen until November 2019, where average e-challans per day decreased by 57%, but the average growth rate in November climbed to 8% per day. After three months of the new act, December saw the highest average e-challans per day in 2019. The first week of January 2020 broke the record of average e-challans per day from December 2019.

For Ahmedabad, an unexpected 14.89% rise is seen in average e-challans in September with respect to August with an average daily growth of 8.1% in September. The average e-challans in October is 3.70% less with respect to August and 16.18% less with respect to September. Over a two month time-window before and after the implementation of the act, there was an average drop of 28.97%. We considered a two month time-window due to the non availability of

e-challans in the month of November 2019 for the city of Ahmedabad. Hence, for the sake of uniform comparison, e-challans between July and October (both inclusive) are taken into account to study the effect of the act. After the implementation, September had higher average e-challans compared to any other month. News reports suggest that traffic penalties in Ahmedabad were not raised as much as this act was supposed to raise [33]. On comparing these numbers with respect to Delhi, we can say that the impact of the act in Delhi was immediate but not long-lasting, whereas the effect persisted in Ahmedabad but took time to take effect. It corroborates the findings of [34, 35], which claims that raising the penalty amount for a traffic violation doesn't necessarily decrease the violation frequency in the long run.

Month	Delhi	Ahmedabad
September	-45%	+14.89%
October	-89%	-3.7%
November	-57%	NA

Table IV: Change in average number of e-challans with respect to August 2019

We further calculated average e-challans per day, in the window of 2 months, for top 100 violators (by the count of issued e-challans) in our dataset and found that for Delhi, there was an average decrease of 64% whereas in Ahmedabad this was just 34%. This can be attributed to the fact that in Delhi, the changes in fine amount [36] were more drastic compared to Ahmedabad. This led to a greater effect on Delhi people as they were bound to pay greater fines and thus resulted in a higher decrease. This was also supported by the fact that for certain violation types for which fines were increased manifolds like stop-line violation (increased 10 times), there was a decrease of 58% in Delhi whereas, in Ahmedabad for red light violation (increased 4 times), a drop of 31% is observed.

For Ahmedabad, we analyze the ratio of paid to the total e-challans before and after the act and found that this ratio

decreased for different violation types. The ratio reduced from 0.34 to 0.14 and from 0.22 to 0.10 for red light violation and improper parking, respectively. This tells us that more people used to pay their e-challans before the act, and there was a less significant drop in the number of e-challans than Delhi due to the lesser increase in the fine amount.

We also calculated the frequency in which e-challans are issued to the top 100 violators, again in a window of 2 months before and after MVA i.e. from July to September and then from September to October. For these, we calculated the average time between two consecutive violations by these vehicles. In the case of Ahmedabad, this average time increases from 8.81 days before MVA to 15.11 days after MVA. In Delhi, we found that before MVA, this number was 3.78 days which increases to 5.25 days after the MVA was implemented. However, for December 2019 to the first week of 2020, the average time gap between consecutive fines reduced to 1.36 days. Nevertheless, in the first two months of implementation, we can see that the average time between successive traffic violations by top-100 violators in both cities increases. This signifies that, in the short-run, MVA was effective in its purpose for both the cities. However, the effects of the same might not be long-lasting and more detailed study needs to be conducted on the same.

This result has several implications. It suggests that a holistic approach involving increased enforcement, higher fines and targeted intervention measures is required in order to decrease the number and frequency of traffic violations. For example, studies such as [37] have shown that in the case of overspeeding violation, social marketing and public education are vital measures in reducing traffic injuries in addition to strict enforcement of speed limits. The variations in the temporal and spatial patterns of different types of traffic violations as mentioned earlier can thus be utilized by the law enforcement agencies for social marketing in a targeted manner. For example, the law enforcement agencies can put up more educational billboards or speed limit traffic signs in areas that have higher incidences of overspeeding. Moreover, the system can be used to identify the egregious offenders and specific messages or reminders could be sent to them via mobiles or letters. Research suggests that timely reminders to pay fines help in reducing the violation frequency [38].

VII. CONCLUSION

As time progresses, the number of vehicles on road in addition to traffic violations in metropolitan cities of India rises. In this work, we propose a method to collect the electronic receipts traffic violations (e-challans) from the Ahmedabad and Delhi traffic police portal. We collected over 6 million such e-challans and characterized the distribution of various fine payment patterns and repeat offense of violations. We observed that top-2 violations in a city account for the majority of violations in the city. We further analyzed the data for spatial and temporal patterns and found the

presence of unique spatial and temporal clusters for different violation types. We believe that these insights can be used by law enforcement agencies to design targeted intervention measures and awareness campaigns. Finally, we also show an application of traffic violations, which act as a proxy measure, to measure the effectiveness of government regulations by taking a case study of the Motor Vehicles (Amendment) Act 2019. Our analysis shows that higher traffic fines have an immediate reducing effect on traffic violations, but the effect need not be long-lasting.

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