ORIGINAL ARTICLES: VARIOUS TOPICS

Traffic Injury Data, Policy, and Public Health: Lessons from Boston Chinatown

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ABSTRACT *We note that long-standing land use and transportation policy are critical factors in creating traffic conditions and will have to play a role in reducing injuries. We present the historical progression of events that created current traffic conditions in Boston Chinatown* and an analysis of traffic-related injuries at the community level for the years 1996–1998. Injuries were found to be as likely on weekends as on weekdays and frequently occurred late at night. Nighttime occupant injuries were found to be more likely on Friday, Saturday, and Sunday nights (relative risk = 2.26; confidence interval = 1.35–3.78, $P = .0014$). Injuries varied significantly by location for occupant ($P < .001$) and for pedestrian injuries ($P = .039$). There were no peaks of injuries at traditionally defined commuter hours, which have been the standard time for assessing “worst case” traffic impacts by developers and government agencies. There was, however, a strong association between injuries and vehicle volume at 9 intersections with simple configurations for AM and PM commuter hours ($R^2 = 0.589$, $P = .010$), resulting in a calculated increase of 3–5 injuries per year for each increase of 1,000 vehicles. There was no such association at 10 intersections with complex configurations ($R^2 = 0.104$, $P = .397$). The 24-hour weekend patterns of vehicle volumes showed that traffic abated only between 3 and 7 AM, and the patterns appeared qualitatively to mirror the 24-hour pattern of injuries, suggesting that they were also indicative of injury risk. We suggest that there is a need for both long-term changes in policy and more immediate interventions. We also conclude that researchers should be cautious about assuming that traffic patterns conform to naive expectations such as rush hour peaks.*

KEYWORDS *Asian American, Community, Injuries, Traffic, Transportation Policy.*

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*On May 7, 1998, a pedestrian was struck and seriously injured just outside the boundaries for this study (South Station). A legal settlement for \$6 million was reported on August 2, 2000, between the Central Artery Project and the driver of the car.¹

INTRODUCTION

Chinatowns are some of the most vibrant ethnic neighborhoods in America's landscape. Home to recent immigrants and old-timers alike, a Chinatown is the heart of many urban Asian American communities. However, Chinatowns are often found in city centers and in crowded and polluted environments.²⁻⁴ Boston's Chinatown (Chinatown, hereafter) is no exception. While this small but densely populated community is for many purely a commercial district of "exotic" shops, markets, and restaurants to be toured on weekend excursions, it is also a residential community and home to more than 5,000 people.

The causes of the current day traffic patterns in Chinatown lie in the history of the community's development. In the 1950s and 1960s, Chinatown lost one half of its land and one third of its housing to two new highways: the Central Artery and the Massachusetts Turnpike Extension.⁵ Built between 1953 and 1959, the Central Artery destroyed over 50 multiunit housing structures, as well as half the celebrated On Leong Merchant Association building. Built in 1963, the Massachusetts Turnpike extension destroyed 60 more multiunit housing structures.⁶ As a result, Chinatown lost one half of its land base and over 1,000 units of housing.⁷ Cutting off potential routes of expansion, these highways eliminated much affordable housing, reduced the number of commercial venues, and added to traffic congestion, noise, and pollution.⁸ The Boston Redevelopment Authority has conceded that Chinatown suffers from "chronic traffic congestion [and that] pedestrian safety in the heavily concentrated residential areas has been threatened."⁹

In more recent years, Tufts University School of Medicine and New England Medical Center (NEMC) have expanded in the heart of Chinatown, further squeezing space for housing and business.¹⁰ In 1993, NEMC proposed building a 455-car garage next to a community day-care facility in Chinatown. The garage would generate over 3,000 daily vehicle trips circulating within a block of an elementary school and elderly and family housing and would stand within 4 feet of a community day-care facility.¹⁰⁻¹² The Chinatown community organized to oppose the garage; undertook its first traffic study, which challenged developer traffic volumes by counting vehicles at intersections near the proposed garage; and urged the state's Secretary of Environmental Affairs to review the cumulative impacts of all the developments in a longitudinal and cumulative manner.

Within 2 years of defeating the medical center garage, the community rallied to oppose a more formidable foe. The state's Highway Department revived a plan to build a permanent exit ramp (Ramp DD) into Chinatown, and the Central Artery/Tunnel project planned to build an additional temporary detour ramp (Albany Street detour) into Chinatown.¹³ If constructed, either of these would generate 25,000 additional daily vehicle trips into the already overloaded roadways of the community. The Chinatown community launched another traffic and transportation study and worked with the Boston Transportation Department to eventually come up with alternatives that led to neither ramp being constructed.

In 1997, a private developer proposed building a complex with a hotel, condominium, theater, and mall—now under construction.^{14,15} The community quickly learned that this was only the first in a wave of up to 30 proposed developments slated for the Chinatown area. It became obvious to community activists that they could no longer address the cumulative impacts of all these developments by relying on volunteer-driven, small-scale traffic studies. Representatives from the Chinatown

community, using political pressure and the findings of preliminary studies,¹⁶ pressured the city to conduct a comprehensive transportation study of Chinatown.

The City of Boston responded by commissioning a consultant to undertake a study in 1998.⁹ The study produced an extensive set of recommendations that focused both on interventions such as roadway and sidewalk modifications and enforcement of traffic laws and on more rigorous assessment of the impact of new development. It did the latter by summing expected traffic increases from all known future development, whereas previously developers had measured their traffic impact against existing conditions and ignored the combined impact of other projects. However, despite the fact that the study incorporated input from community representatives in terms of scope and methodology, it failed to address injuries.

Traffic-Related Injuries

Injuries are, however, one of the most tangible and immediate consequences of traffic. In the 1990s, motor vehicles were the leading cause of death from injury nationally and one of the top four causes of emergency department visits.^{17,18} The literature with respect to traffic-related injuries focuses on children,^{18,19} pedestrians,²⁰ and especially pediatric pedestrians.^{21–24} Studies of injuries to motor vehicle occupants have tended to place greater emphasis on fatalities, the role of alcohol in causing crashes, and safety features in the design of automobiles.²⁵ In contrast, we chose to look at all injuries to pedestrians and occupants on low-speed streets in an urban setting.

Parts of the literature are, however, relevant, if not entirely comparable to our focus. For pedestrians, factors reported to be associated with injuries include traffic volume, high density of parked vehicles, high speeds of travel, inadequate sidewalks, total number of pedestrians, and living in multifamily dwellings.^{21,23,26,27} Many elderly are unable to cross intersections during the time allotted by signals,²⁸ and injury rates for children increase if the children have to cross more streets to walk to school.²⁹ Geographical mapping of pedestrian injuries suggests more injuries closer to downtown,³⁰ and temporal analysis suggests higher fatalities on the weekends and at night.^{20,31}

Massachusetts and Chinatown

In 1998, Massachusetts was reported to have rates of traffic fatalities (6.6/100,000 population) that were less than half the national average (15.34/100,000).³² However, the state had the highest rate of automobile injury claims (2.29/100 insured cars), which was more than twice the US national average (1.17/100 insured cars).³³ The state also had the fourth highest proportion of deaths of pedestrians.³²

Previously reported¹⁶ was an analysis of Chinatown traffic injury data for 1 year, 1996. The relatively small sample size (110 injuries) precluded elucidation of temporal or geographic patterns with adequate statistical clarity. Nevertheless, late night and weekend injuries were apparent. It was also observed that injuries rose and fell with commuter traffic peaks during weekdays. A pilot environmental health survey also asked questions about Chinatown residents' experience with traffic.³ Difficulty crossing intersections on the green or walk signal was reported by 54.8% of respondents, and 9.5% reported having been in a motor vehicle accident in Chinatown.

We report here analysis of 3 years of traffic-related injuries in Chinatown and comment on their relevance to land use and transportation policy and to public

1996

(a)

1997

(b)

FIGURE 1. Distribution of pedestrian and vehicle occupant injuries by geographic location for (a) 1996, (b) 1997, and (c) 1998. Diamonds indicate occupant injuries, stars indicate pedestrian injuries reported in both the BTS and 911 databases, and circles indicate pedestrian injuries reported in only the 911 database. X indicates locations at which 24-hour vehicle volume measurements were made. Arrows indicate intersections at which more than five injuries were recorded in one year, but not the other two.

FIGURE 1. Continued.

health interventions. Our primary goal was to analyze injury and vehicle volume data in an exploratory manner that could prompt changes in policy with respect to traffic-related injuries. Our secondary goal was to contribute to general knowledge about the relationship of traffic to injuries.

METHODS

Study Area

The study area was defined as the area south of Boylston/Essex Streets and north of East Berkeley Street. On the eastern side, the boundary line ran from Atlantic Avenue to Kneeland Street to the John Fitzgerald Highway (“Central Artery”) and Albany Street. In the west, the division was set along Tremont Street (see Fig. 1).

Traffic Injury Report Databases

Traffic-related injury report data for the Chinatown area was requested in writing from the Boston Police Department (BPD) Office of Research Analysis. Data were provided for the period from January 1, 1996, through December 31, 1998, in two databases as described in the Table. One data set consisted of calls for service to 911 and the other of records on file with BPD. The 911 data identified motor vehicle accidents involving a pedestrian (MVAPED). The BPD report data included the set of all reports listed as motor vehicle accidents with injuries (M/V ACC.

TABLE. Data used in the study

	Data	Coded as
911 Calls	Pedestrian injuries	Pedestrian injuries
Boston Police Department reports	All traffic injuries	All traffic injuries
Study data set	All traffic injuries	Pedestrian and occupant injuries

INJURIES). Each data set consisted of information on the location of the reported injury (street number or intersection), the time (displayed by the hour and minute, AM or PM), date, and day of the week. The data were also indexed according to police-designated reporting areas, which are areas of several square blocks.

The two data sets were cross-referenced to identify overlapping of service responses and to separate pedestrian from vehicle occupant injuries. Reports deemed to be the same incident in the 911 and BPD data sets were those that occurred at the same location, on the same date, within 1 hour of each other. In most cases, the reports counted as a single injury were within 10 minutes of each other. The overlapping data, those incidents listed in both databases, were defined as confirmed pedestrian injuries. These were combined with the 911 calls without a BPD report to constitute all pedestrian injuries. The remaining BPD reports were defined as injuries to motor vehicle occupants (see Table).

Traffic Volume Databases

The only 24-hour traffic volume data available to us were provided by TAMS Consulting of Boston. These data describe 24-hour traffic volume at six locations and intersections during Friday, Saturday, and Sunday, which were June 19–21, 1999. They were collected as part of the Chinatown Transportation Study⁹ commissioned by the Boston Transportation Department in 1999. Traffic volumes were assessed under a subcontract by a commercial firm (Accurate Counts) using Jamar Technologies Trax II[®] automatic tube recorders (ATRs), which use pneumatic tubes to record the passing of vehicles. The recordings were downloaded to a computer in 15-minute intervals using the software Tasplus 4[®].

Adequate intersection traffic volume data were not available for the years in which we analyzed injuries, so we used data from the closest years for which it was available. Two sources were used to generate estimations of traffic volume at intersections in Chinatown. The preferred source of data was a model reported by the Chinatown Transportation Study, which was based on combined data from several studies by developers; these studies overlapped with the time period for our injury data.⁹ Although not included in the official report, from their supporting materials we were provided by the Boston Transportation Department with a map of intersection vehicle volumes. Unfortunately, this study did not investigate all of the intersections of interest to us since it concentrated primarily on the northern parts of Chinatown. As a supplement, we used NEMC's 1994 draft impact report on traffic in the southern section of Chinatown.³³ Both data sets reported vehicle volumes for 7–9 AM and 4–6 PM.

The data used were generated by similar modeling methods that were comparable and should give an accurate relative sense of traffic volume. The data do not reflect day-to-day variation in traffic that limits the quality of information on which the study was based. Nevertheless, the data for Boston Chinatown are better than

for most communities because of the large number of development impact studies that are available. For each intersection for which data were available, the number of cars driving into the intersection was totaled. If the intersection was shown on both the Chinatown Transportation Study and the NEMC draft report, we used the values from the Chinatown Transportation Study.

The configuration of roadways at intersections was divided into three categories. The first was defined as *simple* and consisted of intersections in which 2 one-way streets intersected cleanly. The second was defined as *complex* and included combinations of one-way and two-way streets in nonconflicting configurations and intersections of two-way streets. The third category was defined as *confusing* and consisted of two intersections that had one-way streets that met two-way streets head-on.

Analysis of the Injury Data

The injury data were analyzed for variation based on the time at which injuries occurred to determine whether there were any temporal patterns to injury risk. Data were stratified along the variables year, month of the year, day of the week, and hour of the day for the complete data set and for both pedestrian and vehicle occupant injury reports. We chose these time parameters both because the data was coded this way and because they are standard units of time. For grouping of weekend days (Friday, Saturday, and Sunday) or commuter hours (AM, noon, and PM), we chose days and times that fit both our sense of traffic flow from observation of the community and those that corresponded to those frequently used by developers to analyze traffic impacts.

Most of the injury reports provided a location for injuries designated with either two streets (an intersection) or a single street name and address number (occasionally also an intersection). This allowed straightforward mapping of injuries by location for a large majority of injuries. However, there were 29 reports listed only by street name and reporting area. In the case of these injury reports, a cross-reference with reporting area numbers was necessary to provide a reasonable estimation of injury location. In these instances, the incident was mapped to a location on the street listed, within the designated reporting area, at the center point of the street as it passed through the reporting area. This method provided accuracy to within two blocks or less.

In 1987, the Boston Redevelopment Authority (BRA) published two physical area maps that included most street numbers. These were used as a reference when plotting injury data. Tiger line files for Boston were obtained from the US Geological Survey and were used as base maps in the computerized mapping system, Map Info, Professional®. The BPD and 911 data were layered on top of these maps for geographic analysis.

Statistical Analysis

Patterns of injuries with time and location were examined using χ^2 goodness-of-fit analysis, while the relation between location and type of injury was analyzed with χ^2 contingency table analysis. The dependence of traffic volume on site and time was analyzed using analysis of variance, followed by Newman-Keuls post hoc testing. The relationship between traffic volume and number of injuries was estimated with Spearman rank correlation. All data were entered into MS Excel® and transferred to SPSS® for analysis.

RESULTS

Temporal Analysis

Over the 3-year period encompassed by the study, there were 92 pedestrian injuries and 236 vehicle occupant injuries reported in the BPD databases. The total number of vehicle occupant injuries was 71 in 1996; it was 87 in 1997, and it was 78 in 1998. The total number of pedestrian injuries was 39 in 1996; in 1997, it was 26 in 1997, and it was 27 in 1998.

Injury reports did not differ statistically by day of the week ($P = .496$, $P = .163$) or month ($P = .369$, $P = .440$) for vehicle occupants or pedestrians, respectively. The lowest and highest numbers of injuries did not form a pattern (Fig. 2). The ratio of pedestrian injuries to occupant injuries also did not differ significantly with day of the week ($P = .309$) or with month ($P = .643$).

Assessment of the pattern of injuries by hour of the day revealed that, while the majority of injuries were reported between 8 AM and 6 PM, there were also appreciable injuries reported during night hours from 10 PM to 3 AM (Fig. 3). Statistical analysis of occupant injuries showed no significant association ($P = .481$) between injuries and commuter hours (7–9 AM, 11 AM–2 PM, 4–6 PM) compared to the intervening hours (9–11 AM, 2–4 PM). Nighttime occupant injuries were found to be more likely on Friday, Saturday, and Sunday nights (relative risk = 2.26, confidence interval (CI) = 1.35–3.78, $P = .0014$). Pedestrian injuries were not significantly associated with either commuter hours ($P = .776$) or weekend nights ($P = .950$).

Geographic Analysis

Maps of injuries by location in Boston Chinatown suggest from visual inspection that injuries were not evenly distributed, and that the pattern of injury distribution was relatively consistent from year to year (Fig. 1). Most injuries occurred along major roadways running through the community, with some intersections exhibiting “clusters” of injury reports in one or more years. A single intersection along the Massachusetts Turnpike (I-90) had the most reported injuries of any intersection in all 3 years. Three intersections, marked with arrows in Fig. 1, had two or fewer injuries in 2 years and clusters of five or more injuries in 1 year. Other intersections were more stable across the study period. Statistical analysis for the reporting areas designated by the BPD confirms that occupant injuries ($P < .001$) and pedestrian injuries ($P = .039$) were significantly associated with location. The pattern of injuries was similar year to year ($P = .261$), and the ratio of pedestrian to occupant injuries did not vary significantly between reporting areas ($P = .271$).

Video and personal observations were conducted on six occasions at three intersections between June 17, 1997, and October 6, 1997, within the study area.^{34,35} The intersections were the ones marked with an arrow in Fig. 1a, the intersection immediately north of that intersection (toward the top of the map), and the intersection immediately west of the second. The videotape study revealed a range of 2 to 37 illegal turns per 2-hour observation period per intersection. “Near-miss” events happened from 8 to 76 times at the intersections. Potentially hazardous behaviors and infrastructure included vehicles traveling at high speed, left turns from the far right lane, pedestrians crossing against the light, U-turns, bicyclists and vehicles running red lights, vehicles caught in the intersection during the red cycle of the light, confusing walk signals, lack of lane demarcation, lack of any walk signal

(a)

(b)

FIGURE 2. Distribution of pedestrian (open bars) and vehicle occupant (closed bars) injuries by (a) day of the week and (b) month of the year.

unless activated by pedestrians, and walk times as short as 15 seconds. We have not yet been able to associate causes such as these with the injuries analyzed.

24-Hour Vehicle Volumes

For six locations, marked X in Fig. 1, uninterrupted 24-hour vehicle volumes were available for a consecutive Friday, Saturday, and Sunday in 1999. There were a few records of traffic volume that contained evidence of interruption of counts (i.e., sudden drops to zero) (Fig. 4). This could have been due to tampering, damage to

FIGURE 3. Distribution of pedestrian (open bars) and vehicle occupant (closed bars) injuries by hour of the day.

the tube, or vehicles parking on the instrumentation. The recorded traffic volumes reveal that there was considerable traffic late into the night, dropping off only after 3 AM and rising again by 7 AM. Indeed, for some of the nights measured for the Beach Street location, peak traffic volume was at 2 AM. The circadian traffic patterns at the six sites differed statistically from each other ($P < .001$). This was found to be resolvable into two statistically similar subsets consisting of three locations each ($P = .148$ and $P = .213$, open and closed points in Fig. 4). It was not apparent to us what caused these two patterns.

Association Between Vehicle Volumes and Injuries

Nonparametric correlations were examined between vehicle volume, available for most major intersections, and injuries reported within the intersection. Figure 5 shows the relationship between total injuries and estimated vehicle volume in the 6–8 AM and 4–6 PM periods for 9 intersection configurations defined as simple (2 one-way streets intersecting at right angles) and 10 that were complex (most other configurations). The correlation coefficients were $R^2 = 0.589$ ($P = .010$) for simple configurations and $R^2 = 0.104$ ($P = .397$) for complex intersections. For simple intersections, this translates into an increase of between 3 and 5 injuries per year for each increase of 1,000 vehicles. Two intersections that were coded as particularly confusing (one-way streets emptying into each other combined with two-way streets) are not shown; however, one of the intersections defined as confusing greatly exceeded all other intersections in terms of injuries normalized by vehicle volume and is the intersection in Fig. 1 with the largest cluster of injuries in each year.

FIGURE 4. Twenty-four hour vehicle volumes, normalized to percentage total for six locations in Chinatown (locations marked X in Fig. 3). Closed circles are three of the locations with statistically similar patterns; open squares are the other three locations with a different statistically similar pattern.

DISCUSSION

This exploratory study was undertaken with the assumption that it would be possible to use available quantitative data about traffic injuries and vehicle volumes to inform future land use and transportation policy in the community and to prompt more immediate safety interventions. Further, it was hoped that our findings would generate avenues of research that could further elucidate the relationship of traffic volume to injuries, and that the results for one community would be instructive to other communities. It is necessary first to say something about the limitations to our approach.

Limitations of the Study

The injury databases used were likely to have a number of limitations. First and foremost, it is unlikely that 911 and/or the BPD have a report on every vehicle-related injury that occurred over the span of the 3-year period investigated. For example, the authors are personally aware of one pedestrian hit by a car within the study area and time frame. This person left the scene and did not report the injury or seek medical assistance despite painful bruises and scrapes. Others with injuries may also have been transported to emergency rooms without placing a call to 911

(a)

(b)

FIGURE 5. Association of modeled vehicle volume at intersections for weekdays at 4–6 PM and 7–9 AM with total injuries at (a) simple intersections and (b) complex intersections from 1996 to 1998.

and without involvement of police. The availability of an emergency room (marked “ER” on Fig. 1) in Chinatown could encourage non-emergency medical transport of injured persons. If this occurred, it would have also led to undercounting of traffic-related injuries. It is possible that those with injuries that occurred closer to the emergency room would be less likely to need to seek 911 or police assistance.

Another possible problem is that the data may have included reports that were erroneously recorded due to inaccurate reporting or data management errors within

the responsible agencies. The larger database kept by the BPD contains, for example, information on motor vehicle property damage accidents without injury, which could be miscoded in either direction. In addition, those 911 calls that had no corresponding BPD report could have been false or could also have resulted from calls that were inaccurately coded. We were unable to estimate the degree to which these errors occurred, but assume that they were small given the need for accurate record keeping within the police and emergency medical services.

For Chinatown, there were considerable data about traffic available because of the relatively large number of environmental impact reports filed, something that is lacking for many communities.³⁶ The modeled vehicle volumes at intersections for commuter hours that we used, however, still fail to reflect variation on different days or times of the year, and they were based on commuter hour measurements that did not necessarily reflect 24-hour traffic patterns. Further, while the traffic volume data overlapped with the years for which we analyzed injuries, they were not specific to those years, and there could have been factors other than the traffic volume in effect during the time in which injury data were collected. The study is limited in accuracy by sample size and design, as well as by the lack of information on causes of injury-producing crashes.

The limitations discussed above do not undermine, in our opinion, the practical/applied use of the analysis with respect to policymaking or preparing public safety interventions. It is our contention that the analysis presented is inherently more accurate with respect to injuries than other methods commonly used in Boston and Massachusetts since these rely only on vehicle volumes.³⁷ The study also attempted to contribute to theoretical understanding of traffic injury causation. Our findings in this regard are preliminary, but we think they suggest future areas of research and are suggestive of possible underlying causal factors.

THE MEANING OF FINDINGS FOR CHINATOWN

There are several conclusions that we feel we can draw with respect to Chinatown. First, this study was an initial response to the community concerns that there had been and continued to be a historical progression toward worse traffic and more injuries. The construction of the highways, the siting of theater and red light districts, and the building of garages, businesses, and luxury housing that attract motor vehicle traffic all likely contributed to create the current traffic conditions in the community, and rapid new construction currently under way may exacerbate things further still.

Second, the high traffic volume that extends into the weekends and late night hours appears to be a contributor to the injuries that follow the same pattern. The lack of statistically significant associations of injuries with most temporal frameworks that we tested (time of day, day of week, month) supports the idea that injuries cannot be assessed at limited “peak” times. We find it intriguing that the pattern of traffic volume over 24-hour periods in Chinatown appears to mirror injury distribution over 24-hour periods on the weekend (compare Figs. 3 and 4). In this regard, it is also noteworthy that injuries were significantly more likely on weekend nights when there are likely more drivers (perhaps young men) who have been drinking and/or involved in illegal activities associated with drugs and/or prostitution in the red light district. Since environmental impact studies in Chinatown have frequently used Friday PM commuter hours (4–6 PM) as worst case scenarios,

they may have failed to account for impacts at other times of the week, day, or night when injuries are just as likely to occur.^{14,15}

Third, certain intersections (see Fig. 1) had greater numbers of injuries consistently over multiple years when compared to other intersections. Together with the almost 24 hours per day, 7 days per week temporal distribution of injuries, these patterns suggest locations and times (including the weekend and late at night) for expansion of intervention efforts (e.g., posting a police detail) and for consideration during policy/development decision making (e.g., redesign of confusing intersections). Added information about causes of crashes would be helpful in designing interventions.

Fourth, there is a need to integrate assessment of transportation impacts from individual developments or other traffic-generating sources. The history of Chinatown shows that individual developments and transportation projects frequently contribute only incrementally to traffic volume, but combined they add to greater impact. The city's study of Chinatown acknowledged this, and it recommended that new traffic impacts be assessed against all planned or approved developments.⁹

Negative traffic impacts need to be addressed at the level of both land use and transportation policy and public safety interventions. In the policy arena, both vehicle volume and configuration of intersections need to be addressed. This will be challenging in today's development "boom." Safety measures, such as education or police enforcement of traffic laws, are easier to implement and are worthwhile, but likely have only moderate impacts and do not address underlying causes. Interventions such as those proposed by the Boston Transportation Department in 1999, including roadway and sidewalk redesign, changes in signage and signals, and improved enforcement, should be ranked by priority and implemented. Long-term planning is needed minimally to prevent increases in vehicle volume and preferably to reduce traffic.

Generalizability of Findings

This study contains lessons for academicians, community activists, and municipal policymakers. These are as follows:

1. Analysis of total traffic-related injuries allows for microscale assessment that would not be possible looking only at fatalities and their relationship to vehicle miles traveled, vehicle speed, seat belts, or population and economic demographics, the most commonly assessed parameters for macromodels.³⁸ Fatalities^{27,39} are too infrequent to generate the types of patterns that we documented for the microanalysis necessary at the community level.
2. Analysis of injuries provides information not available when vehicle volumes at intersections for limited hours of the day are the sole data. This is mostly relevant to municipal planners and enforcement staff since most studies in the literature already focus on injuries.^{20,23,26,27,31} Yet, at least in Massachusetts, decision making with respect to transportation policy rests on vehicle volumes and, in particular, delays to motorists rather than on injuries.³⁷
3. Our results suggest that it is not reasonable to assume that traffic patterns are "typical" or that they match naive assumptions. Chinatown may or may not reflect the situation in other urban communities as the move toward "24-hour" cities accelerates. At the very least, it provides a cautionary lesson against assuming that traffic volume or injury risk is maximum or repre-

sentative at certain times or locations. Despite being situated in a high commuter district (downtown Boston), we found that commuter hours on weekdays were not the peak times for traffic injuries. Indeed, our finding that weekend nights provided increased risk for traffic-related injuries confirms earlier reports.^{20,31}

4. Many studies^{23,26,27} have been case-control approaches that are effective at generating information about the relationship of factors such as density of parked cars, neighborhoods with multifamily dwellings, and speed limits to traffic injury risk. We feel that such studies are less well adapted than the method that we used as a practical approach to inform municipal policy about highly specific risk factors at the microscale of individual communities in a way that could effectively target resources to particular sections of roadway.
5. The relationship of vehicle volume to numbers of injuries at intersections is not simple. Pooling all intersections led to a relatively weak association. However, categorizing intersections by level of complexity resulted in a strong association for simple intersections and little association for more complex intersections. We think that it is possible that vehicle volume is a significant factor at simple intersections, while the configuration of the intersection dominates for more complex configurations. It would be interesting to test whether this finding holds for other communities and larger data sets.
6. Traffic volumes for 24-hour periods may be informative, even if available for limited locations in a community. In our study, 24-hour traffic patterns at a few locations and at very limited times (Fig. 4) largely mirrored the injury patterns over 24 hours for the whole community (Fig. 3). Given our limited 24-hour vehicle volume data, we feel that this point is in need of validation before a firm conclusion can be reached.

CONCLUSION

This study has confirmed that weekend nights are times of increased risk, and that Friday commuter hours are not the worst case scenario for injury risk in Chinatown. We also showed that vehicle volume was strongly associated with risk at simple intersection configurations, while intersection configuration may be the primary factor at more complex intersections. These conclusions appear to have immediate implications for land use and transportation policy and for public health and safety interventions. We conclude that communities, city agencies, and others would better serve the interests of injury prevention if they included vehicle injury analysis in their decision-making processes.

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