# Bicyclist Fatalities in New York City

Hannah C. Jarvis, James R. Gill

**ABSTRACT**
New York City has over 700 miles of bicycle lanes and over half a million residents use a bicycle several times a month. We searched the electronic death certificate database on all bicycling fatalities between April 2006 and August 2012 to study the autopsy findings, toxicological results, and the epidemiological patterns. Of the 146 bicyclists studied, most were male (n=134). The main ethnic group was white (n=48). Recreational use accounted for 40 fatalities. A survival interval occurred in 72 bicyclists (two hours to 33 years). Manhattan had the highest number of bicyclist fatalities per 100 000 population (2.65). Most fatalities occurred during the summer (n=62), or on a Saturday (n=28). Fifty-five cases reported clear weather. The most frequent motor vehicle involved was a four-door sedan (n=34). Fifteen decedents were documented to be wearing a helmet. Postmortem examination included 116 autopsies and 30 external-only examinations. All causes of death were due to blunt trauma and all manners of death were accident. The most commonly injured body region was the head (n=121). Fractures most commonly involved the skull (n=89). Toxicological analysis detected ethanol (n=22), cannabinoids (n=15), cocaine (n=11), and methadone (n=3). Similar to fatalities in motor-vehicle-only collisions, bicyclists also die from blunt injuries and drug/ethanol intoxication is not unusual. The overwhelming male predominance may be a reflection of a higher number of male bicyclists and/or related to increased risk taking among males. This information may be useful for public health considerations when looking for ways to prevent these deaths. *Acad Forensic Pathol. 2015 5(4): 667-675*

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## INTRODUCTION

In New York City, people are more likely to ride a bicycle or walk to work than in any other major U.S. city (1). Bicycling is an increasingly popular recreational pursuit and according to the Department of Transportation, New York City has over 700 miles of designated bicycle lanes, of which 250 miles have been created since 2006, with over half a million residents using a bicycle at least several times a month. Since the 1980's, ridership has increased considerably as the bicycle offers an environmentally friendly and inexpensive method of transportation that also provides exercise.

Bicyclists share the busy and congested roadways with motorists including buses and trucks, and although there have been various public safety campaigns, the number of bicyclist deaths in New York City remains at a constant level. On average, 611 bicyclists are killed in the United States every year (2). In 2012, there were 45 bicyclist fatalities in New York City (3). For some of these vulnerable road users, their deaths may have been preventable.

There are several reasons to study these fatalities. Foremost is the prevention of future bicycle fatalities. This can be related to the equipment (e.g., model of bicycle, safety equipment such as helmets) and the geographic location of fatalities to identify high-risk areas. These data can be useful for bicycle and equipment manufacturers as well as the Department of Transportation, in attempts to improve safety. The information obtained at autopsy helps to understand how the injuries cause death, which may help to develop or modify bicycle or safety equipment. It also provides information on the typical injury patterns seen at postmortem examination. One can also study the frequency in which ethanol and illicit drugs are potential contributing factors in these deaths. This type of information can be used to target public health and safety campaigns.

This study examined the medical examiner case files on all bicycling fatalities in New York City over a six-year period and describes the autopsy findings, toxicological results, and the epidemiological patterns of these fatalities in this large metropolitan area.

## METHODS

The electronic death certificate database was searched for all fatalities involving a bicycle that occurred between April 2006 and August 2012. There were a total of 156 fatalities. Ten decedents were excluded from the study: five were pedestrians that were struck by a bicycle, one was an adult who was riding a child's tricycle, one fell onto a bicycle, and three accidents occurred outside of New York City.

Bicyclist fatalities in New York City typically undergo autopsy examination. In instances with an objection and there are no suspicious circumstances, an external-only examination may be performed. At autopsy, specimens collected for toxicological analysis include vitreous humor, blood, urine, bile, gastric contents, brain, and liver. Postmortem blood was collected, preserved with sodium fluoride, and stored at 4°C prior to analysis. The Forensic Toxicology Laboratory performed toxicologic analysis on all decedents. Ethanol concentrations were determined in blood using headspace gas chromatography. Specimens were routinely screened for opioids, barbiturates, amphetamines, benzoylecgonine, and benzodiazepines by enzyme or radioimmunoassay. Confirmation and quantitation of morphine, codeine, and benzoylecgonine were performed using gas chromatography/mass spectrometry (GC/MS). Urine or blood also was analyzed by gas chromatography for basic drugs, including cocaine, phencyclidine (PCP), and methadone with confirmation by GC/MS.

All documents in the medical examiner case files of all 146 fatalities were reviewed and the following information was manually extracted: age, gender, and ethnicity of the bicyclist; reason for cycling; helmet use; survival interval; New York City borough; time and place; environmental conditions; accident circumstances; type of bicycle and motor vehicle if involved; autopsy findings (body injury locations and fracture sites); and toxicological results.

The data were compiled on a Microsoft Excel spreadsheet for analysis.

## RESULTS

Between April 2006 and August 2012, the Medical Examiner's Office investigated 146 bicyclist fatalities. There were 134 males and 12 females (male to female ratio 11:1). The age ranged from 8 to 83 years (average was 40 years). The distribution of ethnicities was White (n=48, 33%), Hispanic (n=43, 29%), Black (n=32, 22%), Asian (n=19, 13%) and unknown (n=4, 3%). Recreational bicycle use accounted for 40 fatalities and work commuting for one. There were five work-related deaths, and 100 were unspecified. A survival interval occurred in 72 bicyclists (from two hours to 33 years). Within the five boroughs of New York City, the fatalities were distributed as follows: Brooklyn, 52; Manhattan, 42; Queens, 33; Bronx, 19;

and Staten Island, 0. Most fatalities occurred on the street or sidewalk (n=136). Other locations included a bike path (n=6), a bridge (n=2), Central Park (n=1) or unknown (n=1). Among those that were known, the most frequent time of day when the fatalities occurred, was between 18:00-19:00 (n=11) and 22:00-23:00 (n=11), with 62% (n=86) occurring between 13:00 and midnight (**Figure 1**). The day on which the accident occurred was mainly on a Saturday (n=28) or Thursday (n=27) (**Figure 2**).

The environmental conditions reported in 80 instances were: clear (n=55), raining (n=7), cloudy (n=6), cold (n=2), and hot (n=1). Most fatalities occurred during the summer months (n=62) with 24 of these occurring in the month of August. The fewest number of fatalities was recorded during winter months (n=19) (**Figure 3**). The most common circumstance was collision with a motor vehicle (n=124) and the most frequent
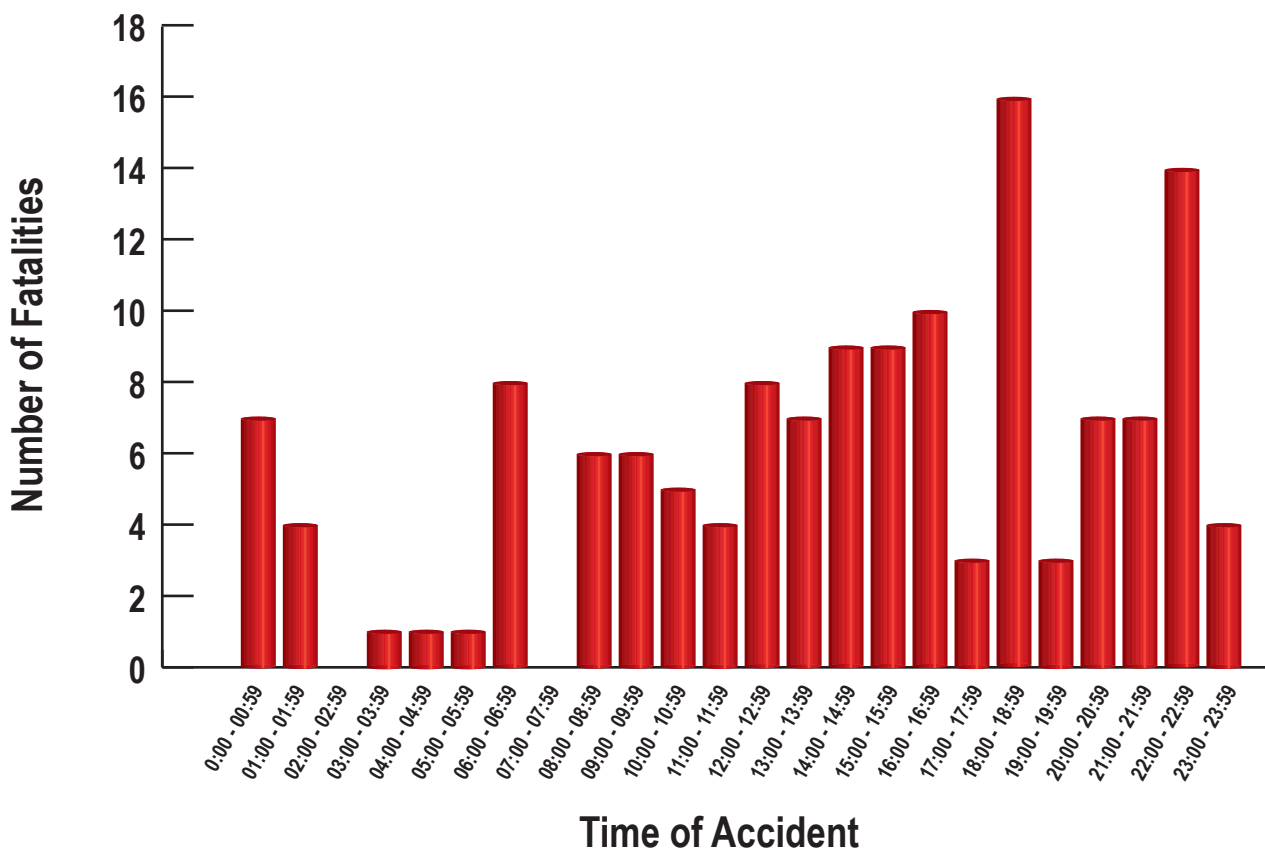


**Figure 1:** Fatalities by time.

motor vehicle involved was a four-door sedan (n=34) or truck (n=18). The other circumstances of death were falling off the bicycle (n=9), collision with an open car door (n=4), collision with a fixed object (e.g., a pole (n=3)), collision with a motorcycle (n=3), collision with another bicycle (n=1) or unknown (n=1). In four cases, the motor vehicle involved fled the scene. The type of bike involved was recorded in only 11 instances (four were mountain bikes). For helmet use, 15 decedents were wearing a bike helmet and 67 were not (64 cases did not document this information).

Postmortem examination included 116 autopsies and 30 external-only examinations. All of the caus-es of death were due to blunt trauma and all manners of death were accident. The most commonly injured body region was the head (n=121) and 91% of fatali-ties that did not wear a helmet sustained a head injury. The nature of the head injury included skull fractures (including extrusion of brain matter in crushing in-juries), epidural hemorrhage, subdural hemorrhage, subarachnoid hemorrhage, and cerebral contusions.

Other body regions that sustained significant injuries included: thorax (n=72), abdomen and pelvis (n=54), and upper/lower extremities (n=51). The types of injuries sustained included lacerations to solid and hollow organs, aortic transection or laceration, and
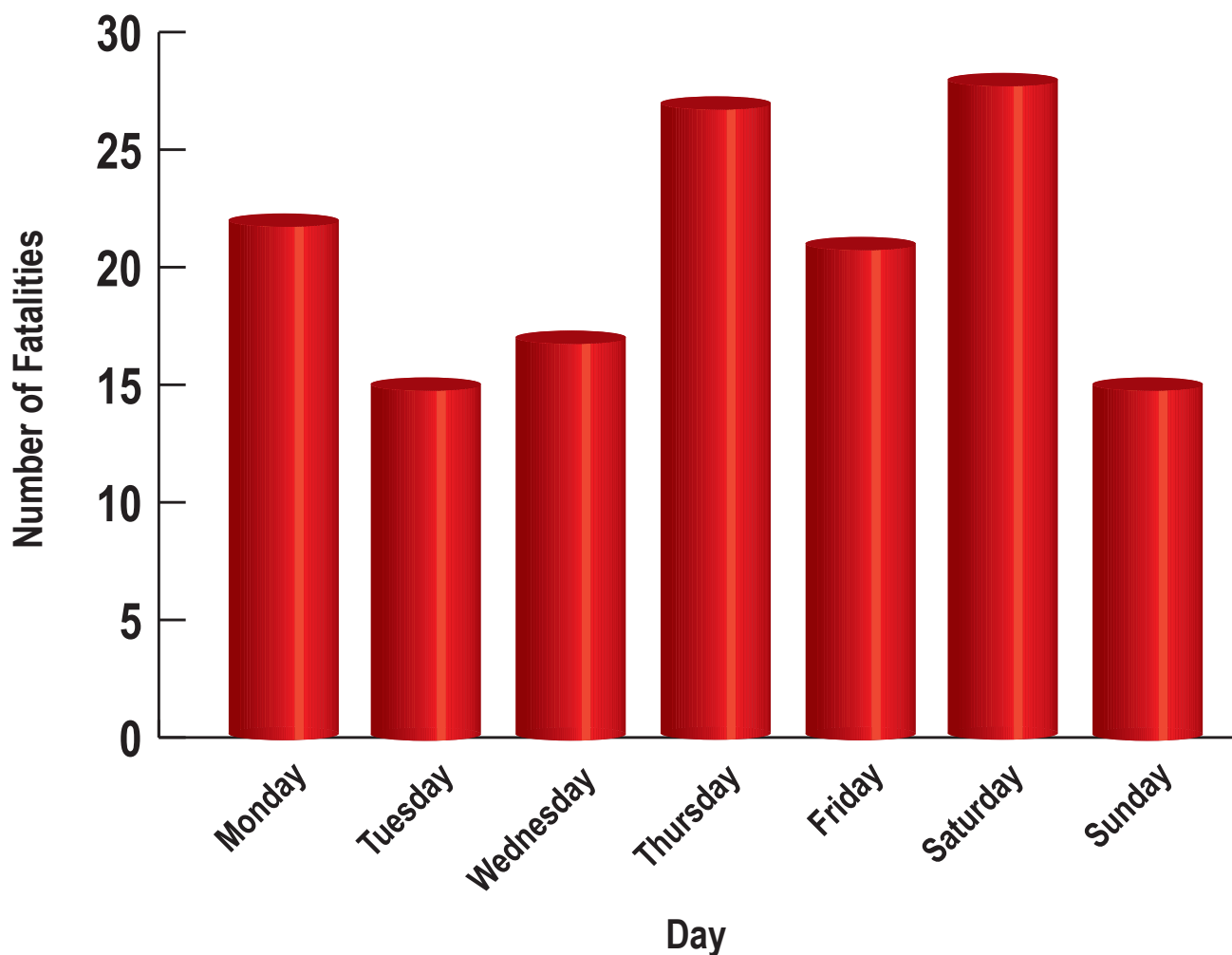


**Figure 2:** Fatalities by day.

visceral contusions. Vertebral injuries occurred in 37 instances. The most common injured spinal level was cervical in isolation (n=17), of which 82% had an associated head injury. Overall, fractures were detected in 132 fatalities and most commonly involved the skull (n=89) and/or ribs (n=64).

Toxicological analysis of blood detected drugs or ethanol in 39 cases, ten of whom were positive for more than one. Ethanol was detected in 22 instances, with an average blood concentration of 0.13 g/dL. Cannabinoids were detected in 15 fatalities, cocaine and/or benzoylecgonine in 11, and methadone in three. Nicotine or cotinine were detected in three. Diphenhydramine, caffeine, and oxycodone were each detected in

one. Ethanol was detected in two of the methadone–positive fatalities.

## DISCUSSION

This study examined various characteristics of bicycling fatalities observed over a six-year period in New York City, the most densely populated large city in the United States, with a population of 8 491 079 as of 2014 (4, 5). The public transportation system runs 24 hours a day and 365 days a year. The subway system is the most extensive in the world (6) and is supported by other modes of transportation such as buses, ferries, taxies, and pedicabs. New York City introduced the Citi Bike bike share program in May 2013, which
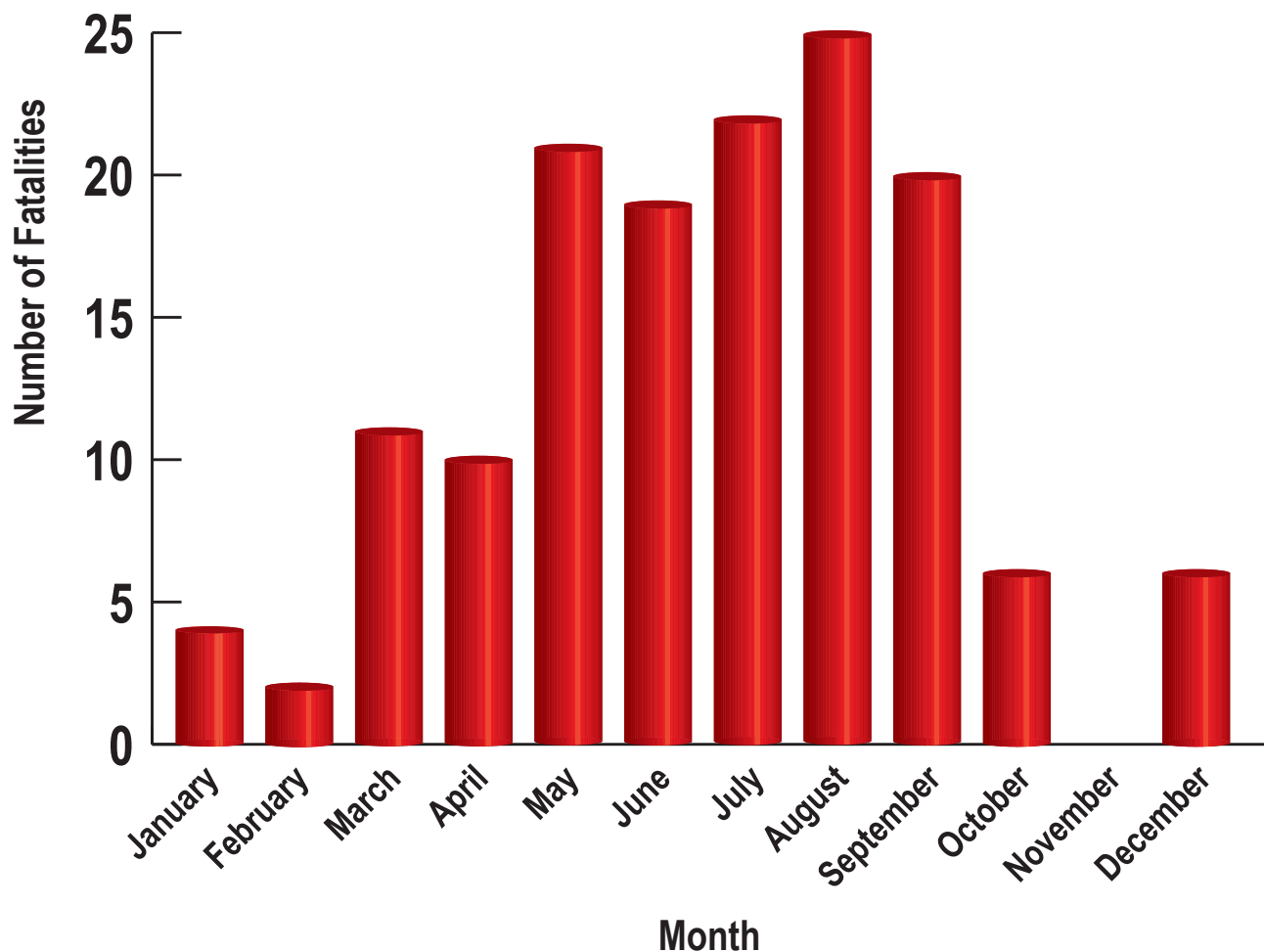


**Figure 3:** Fatalities by month.

is already in place in many cities around the world, including London and Paris. During the first 200 days of the program, Citi Bike users took 5.8 million trips for more than 11 million miles (7).

Amongst the five boroughs of New York City, the highest absolute number of fatalities occurred in Brooklyn (36%), which is the borough with the largest population of 2 621 793 (5). A study examining bicycling in different cities in the state of California showed that cities with higher bicycling rates were associated with lower fatality rates, suggesting safety in numbers (8). Brooklyn, however, has the highest numbers of bicyclist commuters in New York City (9). In addition to the size of the population, the traffic environment in Brooklyn is different than Manhattan as there tend to be more open roads that move faster, in comparison to the congested and slower moving streets of Manhattan. Given that most of these fatalities involved a collision with a motor vehicle, the increased absolute number of fatalities in Brooklyn also could be a reflection of the behavior of the drivers in these different locations. However, comparing all five boroughs, the number of deaths per 100 000 population based on the 2010 census in each borough, are as follows: Manhattan, 2.65; Brooklyn, 1.98; Queens, 1.48; Bronx, 1.37; and Staten Island, 0 (5). This suggests an increased risk for the bicyclists of Manhattan.

Most of the fatalities occurred in the summer during the month of August and on Saturdays, which may be a reflection of the greater appeal of outdoor activities in the warmer months, and people participating in recreational bicycling outside the typical workweek. Of the 80 instances in which the weather conditions were recorded, the weather was described as "clear" in 38%, suggesting that the weather is often not a factor as the visibility was good and the road surface was not wet or icy. In addition, people are less likely to ride their bicycle in poor weather. The vast majority (92%) of all fatalities occurred on the street or sidewalk and 85% were due to a collision with a motor vehicle (27% of which were four-door sedans). Only 4% of fatalities occurred on a bike path suggesting that the use of such paths that provide distance between the bicyclist and motor vehicles may afford some protection.

There were 11 pediatric fatalities involving bicyclists below the age of 18 years, the youngest being eight years old. Similar to the adult bicyclist fatalities, the circumstances of the accident involved collision with a motor vehicle on the road, in all but two cases. In one case, a car jumped the curb and struck a 9-year-old boy on the sidewalk; in another case, a truck hit an 8-year-old boy on a bicycle path.

Ethanol was detected in 15% of fatalities. In New York, a blood ethanol concentration greater than 0.08 g/dL is classified as a "Driving While Intoxicated (DWI)" violation of the law (10). This law, however, does not extend to people riding bicycles (nor operators of horse-drawn carriages) (11). Bicyclists who are intoxicated with ethanol are more likely to sustain fatal injuries than sober bicyclists (12). The consumption of alcohol also may lead to higher risk-taking behavior. In our study, 68% of bicyclists in whom ethanol was detected did not wear a helmet. Interestingly, the time of day of the accidents that occurred in intoxicated bicyclists was distributed throughout the day and the only interval not registering any deaths was between 2:00 am to 6:00 am. Under New York State law, establishments with liquor licenses must stop serving alcohol at 4:00 am (13)—which coincides with the middle of this time window when no deaths were observed. Establishments can remain open after this, serving nonalcoholic beverages until 7:00 am, when they may start serving alcohol once more. Intoxicated people leaving New York City's bars at 4:00 am may be utilizing other modes of transportation.

Cannabinoids were detected in 10% of fatalities. Several studies have examined the ability to safely operate a motor vehicle while under the influence of cannabinoids, and found that the intoxication impaired driving performance, especially when combined with ethanol (14). It also increases the risk of involvement in a motor vehicle collision (15). Similar effects may be observed in bicyclists. Interestingly, all 15 bicyclists who were positive for cannabinoids in our study wore a safety helmet. However, 93% of them died instantly, which is a higher proportion when compared to fatalities without cannabinoid detection, where 54% died instantly.

The ethnicity of the fatalities was representative of the ethnic diversity found in New York City. The overwhelming male predominance (11:1 male to female ratio) may be a reflection of a higher number of male bicyclists and/or related to increased risk taking among males. Similarly, motor vehicle collisions involve three times as many male fatalities as female (16). Data from motor vehicle collisions also reveal that drivers under the age of 25 had the highest rate of involvement in fatal crashes of any age group. Younger drivers are generally more inexperienced and, demonstrate risk-taking behavior and immaturity. They expose themselves to greater risk, for example, driving at nighttime, not wearing seatbelts, and are more prone to driver error (17). In our study, 28% of fatalities occurred in bicyclists 25 years and younger. In addition, only 10% of this group wore a bicycle helmet and 40% of them were positive for cannabinoids.

Certain case information was not available in some deaths, especially if there was prolonged survival interval. For example, some unknown factors included whether the decedent had a visual or hearing deficit and was wearing the appropriate aids, or if they were performing secondary tasks such as listening to music or talking on their cell phones. Data from studies of motor vehicle collisions have shown that tasks that distracted drivers are risk factors for crashes or near-crashes (17). For bicycle accidents occurring at nighttime, it would be interesting to know whether the cyclist was using front and/or rear lights, or reflective clothing. These data were missing from the case file and police report for all fatalities in our study. However, the implications of a significant association could bring about legislation, such as that with motor vehicles, to prevent cell phone usage while operating a bicycle, or mandatory usage of bicycle lights.

More thorough documentation of the circumstances of the incident would be helpful in answering some of these questions. Investigative focus on the use of bicycle helmets, reasons for bicycling (e.g., work, recreation), and type of bike (e.g., wide handle bars that may increase the likelihood of a collision) could be improved, as this information was frequently missing from the case file and police report. In one fatality, a 67-year-old bicyclist was riding along the street when the frame of the bike suddenly fractured, resulting in a fall and a spinal injury. The type of bike was recorded in this instance, and any trends in mechanical failure of certain makes and models may be discernable on a national level if this information is collated and recorded. This type of information could be used to improve the safety design of bicycles.

The factors determining which party is at fault in each case are complex. Information available to us from the case files included the initial police report, which described the circumstances of the accident – for example, "bicyclist collided with car/bus/truck" or "bicyclist struck open car door" – but they do not assign blame. Bicyclists must follow the same traffic laws as any other vehicle on the road, and there were many incidences of bicyclists breaking traffic laws such as cycling through a red traffic light or cycling against the flow of traffic. This does highlight the potential for preventative interventions, such as a public health educational campaign. Other circumstances included bicyclists striking fixed objects after being ejected from their bicycle due to hitting a pothole or riding over a metal plate on the road. This raises the question of whether any fault could be placed on the authorities responsible for repairing or maintaining the roads. There are therefore multiple factors at play. It is not possible to determine which party was negligent and at fault from the information available to us without a complete investigation and a definitive legal outcome. We must also consider that both parties could have been negligent and both shared some degree of fault for the accident.

Similar to fatalities in motor-vehicle-only collisions, bicyclists most frequently die as a result of blunt impact injuries. Other studies have demonstrated that the main cause of death in motor-vehicle-associated fatalities is from head injury. Our study shows that head injuries were the most common injuries in bicyclist deaths as well. The majority of bicyclists who did not wear a helmet sustained a head injury. Given the relatively lower speed of bicycle collisions, the benefits of wearing a helmet are likely greater for bicyclists than for high-speed motorcyclists who are in a collision. In

addition, we have no data on helmet use among non-fatal bicyclist collisions. The effectiveness of wearing a bicycle helmet, however, has been shown in prior studies to be effective in reducing head injuries (18). New York law states that all children under the age of 14 years must wear a helmet when bicycling (19). In our study, three fatalities were sustained in children under the age of 14 years who were not wearing a helmet. The importance of public education, as well as targeting parents and children at schools, could be effective in reducing the number of head injuries through increasing use of safety helmets.

The typical autopsy findings from all fatalities were head injuries (83%), with an underlying skull fracture (in 82% of head injuries); injuries to the thorax (49%); injuries to the abdomen and pelvis (37%); upper extremity (19%); and lower extremity (16%). The distribution of injuries appears to affect the more superior zones of the body. This could be explained by the seated position of the rider or by secondary impacts with the ground, or other parts of the motor vehicle after the initial contact. It also is possible that some of the injuries sustained to the abdomen and pelvis are as a direct result of the body impacting the handlebars or saddle, for example.

## CONCLUSIONS

This study has reviewed the epidemiological, toxicological, and autopsy findings of bicyclist fatalities in New York City over a six-year period. Risk factors include the male gender, cycling in the summer months, and cycling on the streets, with the majority of fatalities caused by collision with a motor vehicle. The head was the most commonly injured body region and the lack of helmet use was noted. Within the five boroughs, Manhattan had the highest number of bicyclist fatalities per 100 000 population. The use of ethanol and drugs is known to lead to increased risky behavior and was associated with instantaneous death. This information may be useful for public health considerations when looking for ways to prevent these deaths.

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