Special Article

INJURIES DUE TO FIREARMS IN THREE CITIES

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ABSTRACT

Background To describe the incidence and outcome of injuries due to firearms, we conducted a population-based study of fatal and nonfatal gunshot wounds in three cities: Memphis, Tennessee; Seattle, Washington; and Galveston, Texas.

Methods Records of the police, medical examiners, ambulance crews, and hospital emergency departments and hospital admissions were monitored to identify all injuries caused by firearms that were severe enough to prompt emergency medical treatment. These records were linked to generate a complete picture of each event. Census data were used to calculate rates of injury for various population groups.

Results A total of 1915 cases of injury due to firearms were identified between November 16, 1992, and May 15, 1994. The crude rate of firearm injury per 100,000 person-years was 222.6 in Memphis, 143.6 in Galveston, and 54.1 in Seattle. Approximately 88 percent of the injuries were incurred during confirmed or probable assaults; 7 percent were sustained in the course of suicide or attempted suicide; unintentional injuries accounted for 4 percent of the cases. Handguns were used in 88 percent of the cases in which the type of weapon was recorded. Five percent of the 1677 victims who were brought to a hospital emergency department could not be resuscitated; 53 percent were hospitalized, and 42 percent were treated and released. Ninety-seven percent of the deaths occurred within 24 hours of the injury. Emergency department and inpatient charges exceeded $16.5 million.

Conclusions Injuries due to firearms, most involving handguns, are a major cause of morbidity and mortality in U.S. urban areas. The incidence varies greatly from city to city. (N Engl J Med 1996;335: 1438-44.)

INJURIES due to firearms are a major health problem in the United States.[1-4] Although several studies have documented the impact of firearm-related deaths,[5-15] little is known about the epidemiologic characteristics of nonfatal gunshot wounds.[16-18] Hospital records have been used to study patients who have been admitted,[19-23] but they do not contain information about patients who do not survive to admission or who are treated and released. Emergency departments treat hospitalized and nonhospitalized patients, but they have no data on victims who die at the scene of an injury. Medical examiners' reports can be used to document deaths, but nonfatal injuries are necessarily excluded. Health care records often lack important details about the events surrounding an injury,[24-27] which can only be obtained from police records.[28,29] In order to describe more clearly the epidemiologic characteristics of injuries caused by firearms, we used all these sources of data to study such injuries in three cities: Memphis, Tennessee; Seattle; and Galveston, Texas.

METHODS

The Three Cities

Memphis and Seattle are the largest cities in the states of Tennessee and Washington, respectively, but they differ in important respects (Table 1). In contrast to Memphis, which has a majority black population and a relatively high rate of poverty, Seattle has a population that is predominantly white and a high standard of living.[30,31] The rates of violent crime in the two cities differ as well. Seattle has one of the lowest rates of homicide among major U.S. cities. The rate of homicide in Memphis is more typical of cities of its size.[33]

Galveston, an island city on the coast of Texas, has a population that is approximately 48 percent non-Hispanic white, 29 percent black, 21 percent Hispanic, and 2 percent Asian.[32] In 1990, 24 percent of Galveston's citizens lived below the federal poverty line. In 1993, Galveston's rate of homicide and other violent crimes was similar to that of Memphis[33] (Table 1).

Definition of Cases

A case was defined as any injury resulting from the discharge of a powder firearm that was severe enough to prompt emergency medical attention. Threats with a firearm, discharge without injury, and injuries due to the use of a firearm as a club were excluded. Only injuries to permanent residents of each city were counted. Injuries that occurred outside the city limits were included if the victim was transported back to the city for emergency care. Identification of cases was initiated on November 16, 1992, and terminated in Memphis 12 months later. In Seattle and

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Galveston, efforts were continued for six additional months and concluded on May 15, 1994.

Primary Sources of Data

Four major sources of information were used to identify cases and obtain data: police reports, records of the emergency-medical-services departments, records of hospital emergency departments and trauma centers, and medical examiners' records.

Police Reports

Police investigate every reported case of firearm-related injury to determine whether a crime has been committed. We screened all reports in each city to identify every eligible case.

Records of Emergency Medical Services

In each city, emergency calls to 911 are answered by a single emergency-medical-services provider. We contacted these agencies periodically to obtain reports on all persons who underwent evaluation or were transported to a hospital with a gunshot wound.

Hospital Records

In all three cities, trauma centers and emergency departments are required to report all cases of gunshot injury to the police.[34-36] As a backup to immediate telephone notification, we asked emergency department personnel to complete a one-page report and send it to the study team or the police.

Medical Examiners' Records

The records of medical examiners were reviewed periodically to identify every death caused by a gunshot injury.

Secondary Sources of Data

To supplement these sources of information, we periodically reviewed the log book of each public hospital's emergency department and all level 1 trauma centers to identify cases that might otherwise have been missed. Every effort was made to link medical records to the corresponding police reports. If no report could be found under a patient's name or any known alias, the police department's files were scanned to detect misspelled names, mismatched dates, or other data-entry errors.

Information about surgical procedures, length of stay, and outcome was obtained from inpatient charts. Level 1 trauma centers and university-affiliated institutions supplied financial information as well. In Memphis, the state's trauma registry served as a supplemental source of data.

Management of Data

A coding hierarchy was established to ensure that the best source of information was used to complete each item. For example, inpatient records were preferred for information about nonfatal injuries, and data from the medical examiner were considered best for information about deaths. Police records were considered authoritative for information about the incident resulting in injury. When one source was missing, the best alternative source was used. When no source contained information about a specific variable, it was listed as missing.

Statistical Analysis

Data from the 1990 U.S. Census were used to calculate community-specific rates of injury and death.[30-32] The rates were adjusted for age, sex, and race or ethnic group with use of a standard population derived by summing the 1990 populations of all three cities. Poisson regression was used to calculate rate ratios and 95 percent confidence intervals.

Deaths were classified as occurring at the scene, in the emergency department, or in the hospital. Emergency department and hospital charges were tabulated according to the cause of injury. Private hospital charges were estimated on the basis of the median daily charge for inpatient care in the city in question.

RESULTS

Incidence of Injury

A total of 1915 cases were identified. The crude rate of injuries due to firearms per 100,000 person-years was 222.6 in Memphis, 143.6 in Galveston, and 54.1 in Seattle. After adjustment for age, sex, and race or ethnic group, the rates were 155.6 in Memphis, 160.0 in Galveston, and 110.2 in Seattle. A total of 365 of the victims (19 percent) died.

The discrepancy between crude and adjusted rates arose because the three cities differ markedly in demographic makeup and because the incidence of firearm injury is strongly related to race or ethnic group, sex, and age. Blacks and Hispanics were shot at far higher rates than non-Hispanic whites (age- and sex-adjusted rate ratios, 13.5 and 2.6, respectively). Males were shot 8.2 times as often as females. The rates of firearm injury rose sharply among people over 10 years of age, peaked at 20 to 29 years, and declined thereafter.

Certain subgroups had extraordinarily high rates of injury. Black males 15 to 29 years of age were wounded by firearms 25 times as often as non-Hispanic whites of similar age (1708.4 vs. 67.1 per 100,000 person-years). Black men 30 to 44 years of age had the second-highest rate (783.7 per 100,000 person-years). Non-Hispanic white girls up to 14 years of age had the lowest rate of injury due to firearms (4.7 per 100,000 person-years) (Table 2).

TABLE 1. DEMOGRAPHIC CHARACTERISTICS OF THE STUDY LOCATIONS.*

CHARACTERISTIC	MEMPHIS	SEATTLE	GALVESTON
Population	610,337	516,259	59,070
Race or ethnic group (%)†			
Non-Hispanic white	43.7	73.7	47.8
Black	54.8	10.1	29.1
Hispanic	<1	3.6	21.4
Asian, Pacific Islander, or Native American	<1	13.1	2.3
Median household income (1990 dollars)	22,674	29,353	20,825
Persons below federal poverty level (%)	23.0	12.4	24.2
High-school graduates 25 and older (%)	70.4	86.4	70.0
Murders/100,000 (1993)	32.0	12.6	39.5
Violent crimes/100,000 (1993)	1,634	1,387	1,745

*Data are from the U.S. Bureau of the Census[30-32] and the Federal Bureau of Investigation.[33] Each city's rate of violent crime was calculated by dividing the number of violent crimes (murder, forcible rape, robbery, and aggravated assault) reported to the Uniform Crime Reports program[33] by the city's population.

†Because of rounding, percentages do not always total 100.

TABLE 2. FIREARM-RELATED INJURIES IN THREE CITIES, ACCORDING TO AGE, RACE OR ETHNIC GROUP, AND SEX.

GROUP	AGE (YR)			
	0–14	15–29	30–44	≥45
	cases/100,000 person-yr			
Non-Hispanic white				
Male	6.7	67.1	61.3	52.7
Female	4.7	17.1	8.6	5.2
Black				
Male	62.0	1708.4	783.7	163.0
Female	27.5	165.4	82.9	25.3
Hispanic or other				
Male	16.4	318.4	64.4	22.8
Female	16.8	31.2	9.9	23.9

TABLE 3. ACCIDENTAL FIREARM-RELATED INJURIES IN THREE CITIES.*

VARIABLE	VALUE
Incidence — no./100,000 person-yr	
Race or ethnic group	
Non-Hispanic white	2.4
Black	12.7
Hispanic	6.3
Asian	1.6
City	
Memphis	5.5
Seattle	8.7
Galveston	13.5
Shooter's relationship to victim (86 cases) — no. (%)	
Self	67 (78)
Nonintimate acquaintance	8 (9)
Boyfriend	2 (2)
Spouse, family member, or relative	6 (7)
Other or unknown	3 (3)
Location of shooting (74 cases) — no. (%)	
Victim's home	48 (65)
Shooter's or another person's home	6 (8)
Street or parking lot	5 (7)
Motor vehicle	8 (11)
Other or unknown	7 (9)
Type of firearm (71 cases) — no. (%)	
Handgun	63 (89)
Rifle	4 (6)
Shotgun	4 (6)
Site of injury (86 cases) — no. (%)†	
Head	7 (8)
Face	4 (5)
Neck	1 (1)
Chest	6 (7)
Abdomen	5 (6)
Pelvis or perineum	2 (2)
Arm	7 (8)
Leg	30 (35)
Hand or fingers	18 (21)
Foot or toes	10 (12)
Back or buttocks	4 (5)
Outcome (85 cases) — no. (%)	
Died at scene	2 (2)
Died in emergency department or hospital	3 (4)
Treated and released from emergency department	50 (59)
Discharged from hospital alive	30 (35)

*There was a total of 86 cases. Rates for racial or ethnic groups have been adjusted for age and sex; rates for the three cities have been adjusted for age, sex, and race or ethnic group. Percentages in each category are based on the total number of cases with available data.

†Individual wounds exceeded the total number of cases.

Circumstances of Injury

Different circumstances were associated with different patterns and outcomes of injury. Unintentional shootings (n=86) accounted for 4.5 percent of the cases but only 1.4 percent of the deaths. The incidence of unintentional injury, adjusted for age and sex, differed somewhat among non-Hispanic whites, blacks, and Hispanics (Table 3). Ninety percent of the victims were males. Sixty-seven people (78 percent) accidentally shot themselves; the rest were shot by someone else. Almost two thirds of unintentional shootings took place in the home of the victim. Five victims (6 percent) died; nonfatal injuries outnumbered deaths by 16 to 1. In 83 percent of the cases, the type of weapon was noted. In 89 percent of these cases, it was a handgun.

Suicide attempts (n=138) accounted for 7.2 percent of the cases but 33 percent of the deaths. Age- and sex-adjusted rates were similar among non-Hispanic whites, blacks, and Hispanics (Table 4). Males attempted suicide with a gun 6.5 times as often as females (95 percent confidence interval, 4.1 to 10.2). Seventy-seven percent of the suicide attempts took place in the home of the victim. In five cases, the shooter killed someone else before shooting himself. Four of these shootings were the result of domestic violence. The fifth followed an argument between the shooter and a female acquaintance.

Almost three fourths of those who attempted suicide shot themselves in the head. Seventeen percent shot themselves in the chest. Eighty-six percent of suicide attempts (n=119) were successful; the ratio of deaths to nonfatal injuries was 6.3 to 1. A handgun was used in 85 percent of the cases.

Assaults (n=1496) accounted for 78 percent of the injuries due to firearms and 65 percent of the deaths. A total of 238 victims (15.9 percent) died. In 195 additional cases, the circumstances were unclear or conflicting reports were received. Three of these incidents resulted in death. Most were probably assaults as well. Annual age- and sex-adjusted rates of confirmed assault were 15.6 per 100,000 for non-Hispanic whites, 42.8 per 100,000 for Hispanics, and 308.3 per 100,000 for blacks. Males were shot eight times as often as females.

Thirty-one percent of documented assaults were the result of an argument or altercation. Twenty percent occurred during the commission of another felony, such as a robbery. Police classified 15 percent of the assaults as "drive-by" shootings and 3 percent as "drug-related." In 25 percent of the cases, the victim claimed that the shooting was unprovoked (Table 5).

TABLE 4. SUICIDE AND ATTEMPTED SUICIDE BY FIREARMS IN THREE CITIES.*

VARIABLE	VALUE
Incidence — no./100,000 person-yr	
Race or ethnic group	
Non-Hispanic white	9.3
Black	10.0
Hispanic	11.6
Asian	3.1
Other	9.2
City	
Memphis	10.6
Seattle	9.2
Galveston	7.1
Location of shooting (136 cases) — no. (%)	
Victim's home	105 (77)
Another person's home	13 (10)
Motor vehicle	8 (6)
Other	10 (7)
Type of firearm involved (130 cases) — no. (%)	
Handgun	111 (85)
Rifle	13 (10)
Shotgun	6 (5)
Site of injury (134 cases) — no. (%)†	
Head	97 (72)
Face	1 (1)
Neck	3 (2)
Chest	23 (17)
Abdomen	3 (2)
Other	11 (8)
Outcome (138 cases) — no. (%)	
Died at scene	93 (67)
Died in emergency department or hospital	26 (19)
Treated and released from emergency department	5 (4)
Discharged from hospital alive	14 (10)

*There was a total of 138 cases. Rates for racial or ethnic groups have been adjusted for age and sex; rates for the three cities have been adjusted for age, sex, and race or ethnic group. Percentages in each category are based on the total number of cases with available data (shown in parentheses).

†Individual wounds exceeded the total number of cases.

TABLE 5. CONFIRMED ASSAULTS BY MEANS OF FIREARMS IN THREE CITIES.*

VARIABLE	VALUE
Incidence — no./100,000 person-yr	
Race or ethnic group	
Non-Hispanic white	15.6
Black	308.3
Hispanic	42.8
Asian	49.9
Other	51.7
City	
Memphis	122.5
Seattle	84.1
Galveston	127.2
Circumstances (1346 cases) — no. (%)	
Argument or altercation	412 (31)
"Unprovoked"	334 (25)
Felony-related (e.g., robbery)	274 (20)
Drive-by shooting	208 (15)
Drug-related activity	43 (3)
Legal intervention	13 (1)
Other	62 (5)
Shooter's relationship to victim (1063 cases) — no. (%)	
Stranger	445 (42)
Nonintimate acquaintance	408 (38)
Rival or adversary	86 (8)
Spouse, intimate friend, or family member	78 (7)
Other	46 (4)
Location of shooting (1423 cases) — no. (%)	
Victim's home	266 (19)
Shooter's home	36 (3)
Another person's home	136 (10)
Street or parking lot	663 (47)
Motor vehicle	99 (7)
Bar or nightclub	79 (6)
Store or place of work	68 (5)
Other	76 (5)
Legally justifiable shooting or self-defense (1475 cases) — no. (%)	
Yes	
Police	13 (1)
Citizen	21 (1)
No	1441 (98)
Type of firearm (1089 cases) — no. (%)	
Handgun	972 (89)
Rifle	19 (2)
Shotgun	96 (9)
Other	2 (<1)
Site of injury (1443 cases) — no. (%)†	
Head	159 (11)
Face	81 (6)
Neck	66 (5)
Chest	223 (15)
Abdomen	160 (11)
Back	111 (8)
Pelvis or perineum	25 (2)
Arm	261 (18)
Leg	477 (33)
Hand or fingers	90 (6)
Foot or toes	67 (5)
Back or buttocks	84 (6)
Outcome (1496 cases) — no. (%)	
Died at scene	114 (8)
Died in emergency department or hospital	124 (8)
Treated and released from emergency department	582 (39)
Discharged from hospital alive	632 (42)
Unknown or refused care	44 (3)

*There was a total of 1496 cases. Rates for racial or ethnic groups have been adjusted for age and sex; rates for the three cities have been adjusted for age, sex, and race or ethnic group. Percentages in each category are based on the total number of cases with available data.

†Individual wounds exceed the total number of cases.

The relationship between the shooter and the victim was documented in 71 percent of cases of assault. Forty-two percent were strangers, and 38 percent were nonintimate acquaintances. Eight percent of the victims were shot by a rival gang member, a criminal adversary, or a romantic rival. Seven percent were shot by a spouse, an intimate friend, or a family member (Table 5).

Among those injured in assaults, 13 people (1 percent of the total) were shot by police in the line of duty. Another 21 (1.4 percent) were shot by private citizens in self-defense. Twelve victims were bystanders who were caught in the line of fire.

Nearly half of all assaults took place on a street or in a parking lot. Thirty-one percent occurred in the home of the victim, the shooter, or a third party. Seven percent of the victims were shot in a motor vehicle; 6 percent were shot in a bar or nightclub.

More than half of all firearm assaults took place at a range of less than 10 feet. Fifteen percent of the victims sustained multiple gunshot wounds. Sixteen

percent died; nonfatal injuries outnumbered deaths 5.3 to 1. The type of weapon was documented in 73 percent of the cases. In 89 percent of these cases, it was a handgun (Table 5).

Acute Care after Injury

An ambulance was dispatched to the scene of 1206 shootings (63 percent). Two hundred nine victims were pronounced dead at the scene, and 29 refused transportation to a hospital. The rest (n=968) were taken to a hospital.

A total of 1677 victims received care in an emergency department. Five percent (n=83) could not be resuscitated and were pronounced dead in the emergency department. Fifty-two percent (n=867) were hospitalized, and 42 percent (n=708) were treated and released. Nineteen victims (1 percent) left without permission or signed out against medical advice.

Twenty percent of hospitalized patients underwent surgery within 12 hours. Thirty percent were admitted to an intensive care unit for a median stay of 2 days (range, <1 to 78 days). The median length of stay for all hospitalized patients was 3 days (range, <1 to 78 days). Eight percent of hospitalized patients (n=72) died in the hospital. All but 11 of these died within 24 hours of the injury.

Charges for Hospital Care

The median charge for patients who were released or who died in the emergency department was $538, exclusive of professional fees (range, $36 to $26,193). Hospitalized patients were charged a median of $10,050 (range, $304 to $510,420). Total charges exceeded $16.5 million, exclusive of professional fees. Twenty-eight patients generated individual bills in excess of $100,000.

DISCUSSION

Epidemiologic analyses of firearm-related deaths are important, but conclusions based on deaths may not apply to nonfatal cases. Inpatient studies have been hampered by lack of information about the manner in which injuries occurred. Neither approach is adequate to characterize the full spectrum of injuries due to firearms.

Four groups have previously studied firearm injuries in defined populations. Lee and colleagues[29] linked archived records of the police, emergency department, emergency medical services, and medical examiners to identify all fatal and nonfatal shootings that occurred in Galveston between 1979 and 1981. A total of 239 cases were identified during this three-year period. The age-adjusted rate of injury due to firearms was 128 per 100,000 person-years. The overall case fatality rate was 30 percent. Recently, Sadowski and Muñoz[37] adopted a similar approach in their study of fatal and nonfatal firearm injuries in rural Johnston County, North Carolina. The overall, age-adjusted incidence of injuries due to firearms was roughly half that noted by Lee and colleagues,[29] but the percentage of injuries that were fatal was somewhat higher.

In 1993, Ozonoff and colleagues at the Massachusetts Department of Public Health established a statewide Weapon-Related Injury Surveillance System (WRISS).[24,25] All 85 emergency departments in the state were asked to participate. The following year, 825 reports of injuries due to firearms were submitted to the system.[26] The crude rate of such injuries in Boston was calculated to be 49 per 100,000.

The only truly national estimate of nonfatal firearm injuries has been generated by Annest and colleagues at the Centers for Disease Control and Prevention (CDC), using counts supplied by the National Electronic Injury Surveillance System (NEISS).[27] NEISS uses a stratified sample of 91 hospital emergency departments to monitor rates of product-related injury. During a one-year reporting period, emergency departments participating in NEISS treated 4468 cases of gunshot injury. Fifty-seven percent of the victims were injured seriously enough to require hospitalization. Extrapolating this total to the United States as a whole suggests that 99,025 nonfatal gunshot injuries (95 percent confidence interval, 56,325 to 141,725) occurred nationwide during the one-year study period. Combining this estimate with vital records generated a ratio of 2.6 nonfatal injuries per death (case fatality rate, 28 percent).

Both WRISS and NEISS rely on reporting by emergency departments; neither system identifies victims who are pronounced dead at the scene. Both lack data on patients who seek treatment outside an emergency department. Most important, neither incorporates data from police records. As a result, important details about the incidents are missing from many reports.[24-27]

To identify as many eligible cases as possible, we adopted the approach of Lee and colleagues.[29] Police and medical records were linked to generate a complete picture of each event. To increase the generalizability of our observations, we conducted our study in three cities with widely differing characteristics.

This strategy has many advantages, but it is still limited in important respects. To maximize the detection of cases, we included shootings of city residents that occurred immediately outside city limits. To avoid overcounting, we excluded cases of gunshot injury to nonresidents. Although every effort was made to identify victims, we probably missed a few. Some declined treatment, and others may have sought care from practitioners who are willing to treat patients for gunshot wounds without notifying the police. Our figures should therefore be considered conservative.

Most police and medical reports were complete, but others offered only a sketchy account of the events. Some victims were too severely injured to

communicate, and others may have withheld information for various reasons. Sometimes it is impossible to reconstruct events after the fact.

Despite the fact that health care providers in all three cities are required to report cases of gunshot injury to the authorities,[34-36] we could not find a matching police report for 9 percent of the cases we identified. This lack of matching was not due to misfiled or misplaced records. In busy emergency departments and trauma centers, it is not always clear who has the responsibility to contact the police. Some health care providers do not bother to call if the victim reports that an officer was present at the scene.[28] Unfortunately, there is no way to verify such a statement.

We were able to document emergency department and inpatient charges directly in the 82 percent of cases that were treated in a level 1 trauma center or university-affiliated hospital, but we were unable to obtain comparable data from private community hospitals. Charges from these institutions were estimated on the basis of charges per day or per visit. We did not include physicians' fees, charges for follow-up care, or charges associated with rehospitalization for complications.[20] In any event, charges are a poor approximation of actual costs.[23]

Although we conducted our study in three cities with widely differing characteristics, our results cannot be generalized to the nation at large. The pattern we observed is probably typical of large cities, but circumstances may vary in rural areas and small towns.[37,38] All three of the cities we studied have sophisticated emergency-medical-services systems and level 1 trauma centers. Communities that lack these resources may be less successful at saving the lives of critically injured patients.

Our results support five major conclusions. First, firearm-related injuries are a major cause of morbidity and mortality in urban areas. Young black men are being shot and killed at a particularly alarming rate. The reasons for this observation are complex,[39-41] and there is no evidence that one population group is inherently more prone to violence than any other.[42]

Second, assaults are the predominant cause of nonfatal gunshot wounds. Annest and colleagues estimated that assaults account for almost three fourths of all nonfatal gunshot injuries nationwide.[27] Almost 90 percent of the injuries we identified were due to a confirmed or probable assault.

Third, fatality rates vary markedly according to the intent of the shooter. The ratio of nonfatal injuries to deaths ranged from roughly 16 to 1 for unintentional injury to 0.16 to 1 for suicide attempts. Most of this difference appears to be due to different anatomical patterns of injury. The overall ratio of nonfatal cases to deaths was 4.2 to 1.

Fourth, handguns are disproportionately involved. Although handguns account for roughly half the new guns sold in the United States,[43] they were involved in almost 90 percent of the shootings in the three study communities. The ability of handguns to be concealed readily and their ease of use are the most likely explanations for this observation.[44]

Fifth, greater emphasis must be placed on prevention. In cities like Memphis, Seattle, and Galveston, the benefits of timely access to emergency medical services have already been realized. Further refinements in trauma care are unlikely to produce substantial increases in survival. Ninety-seven percent of deaths occurred within 24 hours of the injury. Future efforts should focus on the primary prevention of gunshot wounds.[45]

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