Safety of One-Way Urban Streets

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The relative safety of one-way streets as compared to two-way streets was studied by comparing accident rates for the two types of streets in one city during the same time period (a cross-sectional design). The study population consisted of all single-carriageway streets in Jerusalem and all injury accidents that occurred on these streets during a 3-year period, 1983 through 1985. Streets were grouped according to class—arterial, collector, or local—and location—in the central business district (CBD) and elsewhere. Accident rates by type of accident—pedestrian and other (vehicle)—were compared within each group of streets. Rates were calculated separately for midblock sections and for intersections. The study concentrated on collector and local streets. In general, one-way streets do not contribute to an improvement in safety relative to two-way streets.

One-way streets are widely used as an inexpensive solution to capacity and parking problems, mainly on arterial or collector streets. In residential areas, one-way streets are used to prevent through-traffic, to reduce conflicts at intersections, and to provide more parking space.

The effects of converting to one-way streets were summarized by Parsonson et al. (*1*). Generally, two-way to one-way conversion results in an increase in speed and a decrease in the number of stops and total travel time. On the other hand, volumes and trip lengths are increased (*2–5*). One-way streets and intersections also have fewer potential vehicle conflicts than do two-way systems.

These effects associated with one-way streets have safety implications that may be reflected in the number, type, and severity of road accidents. The decrease in conflicts and stops implies an increase in safety, whereas the increases in speed, volume, and trip length may lead to an increase in accidents.

Studies on the safety of one-way streets are generally of the before-and-after type and deal mostly with arterial or central business district (CBD) streets. Most of the studies report an accident decrease of 20 to 30 percent (*2,4–6*). The number of midblock accidents is generally reduced more than the number of intersection accidents (*7*). The least reduction in accidents is reported for nonsignalized intersections (*5*).

As mentioned, most studies deal with the conversion of CBD or arterial streets from two-way to one-way operation. The current study examines the safety of one-way streets by comparing accident rates on all one-way streets in one city to those on all two-way streets in the same city, for the same time period.

METHODS

Information on all injury accidents in Jerusalem for 1983 through 1985 was extracted from the injury accident file of the Israel Central Bureau of Statistics (ICBS). In addition, a street and junction file was compiled containing the following data items for each street:

- Code of street according to ICBS;
- Type of street—two-way, one-way, or dual carriageway);
- Class or function—arterial, collector, or residential;
- Location—CBD or other; and
- Length and width of street.

Similar information was compiled for intersections. A junction was defined as one-way if at least one of its legs was a one-way street. The class of a junction was determined by the highest class of its legs. The two files were matched so that each accident record was appended by data pertaining to the street or junction on which it occurred. Dual-carriageway streets and junctions were excluded from the file and from subsequent analysis.

No data were available on traffic and pedestrian volumes. Thus, in the first phase of the analysis, only length of streets and number of junctions were used as exposure measures. Accident rates per kilometer and per intersection were compared for one- and two-way locations. In order to control some of the possible differences in exposure between one- and two-way locations, streets were grouped according to class—residential, collector, or arterial—and location—CBD or other—and the analysis was performed within each group. Within each group, accident rates were analyzed by type of accident—pedestrian or vehicle (mostly collisions)—and by severity. Accident rates were analyzed separately for junctions and for road sections.

The ratio of accident rates between one- and two-way locations served as a measure of the relative risk of one-way locations. A ratio smaller than 1 means that one-way streets have fewer accidents than two-way streets. A ratio greater than 1 means that one-way streets have more accidents.

Only 1.5 km of one-way street sections in Jerusalem are classified as arterial (none within the CBD); thus, any results pertaining to arterial one-way streets could not be generalized, and no results on this type of street are presented. As the CBD area consists of only 12 km of streets, results for local and collector streets in the CBD were analyzed together.

In the second phase of the analysis, exposure data of traffic and pedestrian volumes, speeds, and street widths were collected on a sample of streets. These data were used to examine possible differences between one- and two-way streets of the same type and to obtain accident rates per vehicle-kilometer of travel. A stratified random sample was taken of the population of all streets in Jerusalem; streets were grouped according to location (CBD and non-CBD), class (arterial, collector, or local), and type (one-way or two-way). For each

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type, the sampling quota for the different groups was roughly proportional to the total street length, with at least two streets sampled from each group. Data on 43 streets were collected: 22 one-way streets and 21 two-way streets.

A road section adjacent to a junction was chosen at random for each street. All data were collected at this section. These included width of the street, traffic and pedestrian volumes, and free speeds. Crossing pedestrians were counted for 1 hr at three locations—at the crossing (if one was present), on a 50-m strip adjacent to the crossing, and on the next 100-m strip. Vehicles were also counted manually for 1 hr, by type. Speeds were measured for free-flowing traffic only, 100 m from the junction. At least 50 speed measurements were taken on each street.

The hourly counts were transformed into daily volumes using expansion factors derived from appropriate daily distributions. Pedestrian distributions for CBD and non-CBD streets were taken from a previous study (*8*). Daily distributions of traffic volumes were calculated from existing junction or cordon counts for the major activity hours (7:00 a.m. to 7:00 p.m.) and from 24-hr mechanical counts performed as part of the current study on 15 streets in the sample. Separate distributions were used for CBD and non-CBD streets and for two-way and one-way streets. For one-way streets, separate distributions were used according to whether the traffic flow was to or from the CBD.

The characteristics of one- and two-way streets within each group of class and location, as measured on the sample of streets, were compared to determine whether any differences exist that could explain disparity in accident rates. Accident rates per million vehicle-kilometers were calculated for each group of streets, on the basis of traffic volume sample counts. The relative risk, as measured by the ratio of rates, was used to compare the safety of one- and two-way streets. No similar rates could be calculated for intersections, because no volume data were available for them.

RESULTS

Table 1 presents data on street length and number of intersections in Jerusalem by type and class. From 525 km of the streets in Jerusalem, 13 percent are one-way and the rest are two-way. An additional 83 km are dual-carriageway roads. Of 2,473 intersections, 30 percent have at least one leg that is a one-way street.

Only 12 km, or 2.2 percent of the total street length, lies within the CBD boundaries; of this, 45 percent are one-way streets. No one-way arterials are in the CBD. There are 74 intersections in the CBD, about 3 percent of the number of intersections in the city. Of these, 77 percent have at least one one-way leg. The average width of one-way streets was

TABLE 1 LENGTHS OF STREETS (km) AND NUMBER OF INTERSECTIONS IN JERUSALEM

Type of Location	Arterial	Collector	Local	Total
Length of street				
One-way	1.50	9.14	58.16	68.80
Two-way	19.09	57.36	379.90	456.35
No.of Intersections				
One-way	80	239	405	724
Two-way	58	186	1508	1752

TABLE 2 MIDBLOCK ACCIDENTS PER KILOMETER IN NON-CBD AREAS, 1983–1985

Type of Street	Arterial	Collector	Local	Total
Pedestrian Acc.				
One-way	- (19)	3.72(29)	1.00(54)	1.61(102)
Two-way	2.62 (46)	3.12(172)	0.69(259)	1.06(477)
Relative Risk		1.19	1.45	1.51
Vehicle accidents				
One-way	- (10)	2.31(18)	0.65(35)	0.99(63)
Two-way	2.16 (38)	1.81(100)	0.59(221)	0.80(359)
Relative Risk		1.27	1.10	1.24

Numbers in brackets denote number of accidents

TABLE 3 ACCIDENTS PER INTERSECTION IN NON-CBD AREAS, 1983–1985

Type of Junction	Arterial	Collector	Local	Total
Pedestrian Acc.				
One-way	0.53(37)	0.35(73)	0.06(24)	0.20(134)
Two-way	0.35(19)	0.17(31)	0.02(25)	0.04(75)
Relative Risk	1.53	2.04	3.71	4.65
Vehicle accidents				
One-way	1.20(84)	0.50(105)	0.14(53)	0.36(242)
Two-way	0.58(32)	0.38(69)	0.04(58)	0.09(159)
Relative Risk	2.06	1.32	3.53	3.96

Numbers in brackets denote number of accidents

TABLE 4 MIDBLOCK ACCIDENTS PER KILOMETER IN THE CBD (NONARTERIALS, 1983–1985)

	Pedestrian Acc.	Vehicle Acc.	Total
One-way	4.74(25)	1.71(9)	6.45(34)
Two-way	4.79(24)	1.20(6)	5.99(30)
Relative Risk	0.99	1.43	1.08

Numbers in brackets denote number of accidents

TABLE 5 MIDBLOCK ACCIDENTS PER MILLION VEHICLE-KILOMETERS IN NON-CBD AREAS, 1983–1985

Type of Street	Arterial	Collector	Local	Total
Pedestrian Acc.				
One-way	- (19)	0.61(29)	0.73(54)	0.73(102)
Two-way	0.14(46)	0.39(172)	0.49(259)	0.37(477)
Relative Risk	-	1.57	1.49	1.90
Vehicle accidents				
One-way	- (10)	0.38(18)	0.47(35)	0.45(63)
Two-way	0.12(38)	0.23(100)	0.41(221)	0.28(359)
Relative Risk	-	1.68	1.14	1.63

Numbers in brackets denote number of accidents

almost equal to that of the two-way streets. The number of junctions per kilometer of road was also very similar for the two types of street.

During 1983 through 1985, 1,142 injury accidents occurred in midblock sections, 17 percent on one-way streets. During the same period, 712 injury accidents occurred at intersections, 66 percent at one-way junctions. Tables 2 and 3 present accident rates per kilometer and per intersection by type of accident and street class, for one- and two-way locations. Jerusalem has only two sections of one-way arterial streets, with a total length of 1.5 km; therefore, the rates for one-way arterial sections were not displayed. Accident rates were clearly higher on one-way streets for all street classes and accident types, both for midblock sections and for intersections. The relative risks of one- and two-way sections were similar for pedestrian and vehicle accidents, and their magnitude was between 1.1 and 1.5. The relative risks for intersections were generally higher. The ratios for local intersections were much higher, 3.5 and 3.7 for pedestrian and vehicle accidents, respectively.

For the CBD, the analysis pertains to local and collector streets only, because there are no one-way arterials within the CBD. Accident rates per kilometer were similar for both types of streets. The relative risk, which was 1.1 for all accidents, was 0.99 for pedestrian accidents and 1.43 for vehicle accidents. However, the latter figure was based on a small number of accidents in each group (Table 4).

Tables 5 and 6 present accident rates per million vehicle-kilometers and relative risk by location, class of street, and type of accident for one- and two-way streets. The rates were

TABLE 6 MIDBLOCK ACCIDENTS PER MILLION VEHICLE-KILOMETERS IN THE CBD (NONARTERIALS, 1983–1985)

	Pedestrian Acc.	Vehicle Acc.	Total
One-way	0.49(25)	0.18(9)	0.68(34)
Two-way	0.62(24)	0.15(6)	0.77(30)
Relative Risk	0.80	1.15	0.88

Numbers in brackets denote number of accidents

based on traffic counts on a sample of streets. The results are similar to those obtained for rates per kilometer. One-way streets outside the CBD area had higher pedestrian and vehicle accident rates. The relative risk ranged between 1.1 and 1.7. In the CBD, the relative risk was 1.15 for vehicle accidents and 0.8 for pedestrian accidents.

Table 7 presents the percentage of severe and fatal accidents by street type and function. There was no difference in severity for collector streets; for local streets and junctions, however, one-way accidents were less severe than accidents at two-way locations.

Table 8 presents the average characteristics of one- and two-way streets in the sample by type and location of street, daily traffic volumes, daily flow of crossing pedestrians in a 100-m midblock section, average free-flow speeds, and pavement width. The following paragraphs describe the findings for each attribute.

Traffic Volumes

In the non-CBD area, traffic volumes on one- and two-way streets were similar, and the differences were not statistically significant. In the CBD, the results were not as clear. Although the volumes on two-way streets differed considerably according to class, one-way volumes on collector and local streets were similar and displayed a large variation.

Pedestrian Volumes

Crossing-pedestrian volumes were generally higher on one-way streets in all categories, except for local streets outside the CBD. In this group, the average pedestrian volume on two-way streets was 3.5 times higher than on one-way streets, but the variation was very large, indicating that some streets had an exceptionally high pedestrian count. The original counts revealed one such street. After taking out the outlier count, the average pedestrian volume was 564, slightly higher than the volume on one-way local streets.

Speed

Contrary to expectations, higher speeds were measured on two-way streets than on similar one-way streets in non-CBD areas. In the CBD, higher speeds were measured on one-way streets. However, none of the differences was significant.

Width

One- and two-way streets in each group were of similar width and had no significant differences.

DISCUSSION OF RESULTS

Accident rates per kilometer were compared for one- and two-way streets at midblock and per intersection. The study population consisted of all single-carriageway streets in Jerusalem and all injury accidents that occurred on these streets during a 3-year period (1983–1985). Rates were compared within groups of streets with similar class—arterial, collector, or local. Streets were also divided according to location—in the CBD or elsewhere. The validity of this phase of the analysis was based on the assumption that within each group of function and location, pedestrian and traffic volumes are distributed similarly for one- and two-way streets. Detailed measurements were taken of street widths and lengths, speeds, traffic, and pedestrian crossing volumes, for a random sample of streets. Accident rates per vehicle-kilometer for midblock accidents were calculated on the basis of these measurements.

TABLE 7 PERCENTAGE OF SEVERE AND FATAL ACCIDENTS BY STREET TYPE AND CLASS

Type of Location	Arterial	Collector	Local	Total
Midblock				
One-way	-	19	16	18
Two-way	17	18	27	22
Junction				
One-way	13	14	14	14
Two-way	17	14	20	17

TABLE 8 AVERAGE CHARACTERISTICS OF STREETS BY LOCATION CLASS, AND TYPE

Street Category	Width	Speed (Km/hr)	Traffic Volumes	Pedestrian Volumes
Non CBD				
Local One-w	5.4(1.2)	30.7(6.5)	1252(1371)	407(446)
Local Two-w	5.8(1.1)	33.2(6.9)	1291(1167)	1472(2466)
Collector One-w	8.9(3.8)	34.7(5.6)	5581(4978)	531(267)
Collector Two-w	9.0(2.5)	39.8(6.4)	7346(4478)	286(175)
Arterial One-w	8.1(2.0)	40.7(7.5)	10487(4869)	1447(1251)
Arterial Two-w	12.0(4.7)	40.8(7.8)	16479(5767)	946(944)
Total One-w	6.9(2.7)	33.4(7.5)	3839(4246)	626(685)
Total Two-w	8.0(3.5)	38.8(7.6)	5179(5776)	1018(1796)
CBD				
Local One-w	5.6(1.3)	34.6(6.3)	8760(7160)	2295(695)
Local Two-w	5.9(0.5)	23.8(4.9)	1939(319)	1116(609)
Collector One-w	8.9(0.1)	33.0(6.1)	9062(6048)	3075(1961)
Collector Two-w	8.5(2.1)	32.3(5.8)	13445(966)	1099(1179)
Total One-w	7.3(2.0)	32.8(8.0)	8911(5930)	2685(1383)
Total Two-w	6.8(1.6)	26.6(5.8)	5774(5962)	1110(707)

Numbers in brackets denote standard deviations

When non-CBD locations were compared, accident rates on one-way streets were higher than those on two-way streets for all street types. The relative risk between one- and two-way streets was similar for pedestrian and vehicle accidents. At midblock locations, rates for one-way collector and residential streets were only slightly higher—ratios ranged from 1.1 to 1.7. The rates were similar, whether kilometers or vehicle-kilometers were used for exposure, because traffic volumes on the two types of streets were similar within the same category.

At intersections, ratios were higher. Especially high were the ratios for residential intersections—3.6 and 3.8 for vehicle and pedestrian accidents, respectively. Thus, one-way junctions in residential areas, which are generally not signalized, had almost four times as many accidents as two-way junctions. These findings are in accord with the trend reported in the literature (*5,7*), whereby the change from two-way to one-way street reduces midblock accidents more than intersection accidents. The least reduction in the number of accidents was found at nonsignalized intersections. Possible explanations for the higher accident rates at one-way nonsignalized junctions are the higher speeds and possibly the lower levels of attention on one-way approaches. Moreover, although some conflicts are avoided, the volume increase of other movements may result in an increase in the frequency of other, possibly more severe, conflicts. Unlike midblock rates, the findings for intersections could not be substantiated by incorporating traffic volumes in exposure, because volume data were not available for all intersection approaches. However, the results from the midblock counts indicated that traffic volumes were similar within categories. Also, the definition of one-way intersections was quite crude, as it grouped together intersections with one, two, or more one-way legs; however, this grouping should produce conservative findings.

The analysis for the CBD was based on a small number of accidents, particularly vehicle accidents, of which only 15 occurred on collector and local streets during the study period. Thus, the results pertaining to vehicle accidents in the CBD are of little validity. The class of pedestrian accidents in the CBD is the only one for which there is an indication that one-way streets may be safer—the relative risk per vehicle-kilometer was 0.8, indicating a lower rate of pedestrian accidents on one-way streets.

Analysis of accidents by severity indicates that for local streets and junctions, accidents are less severe at one-way locations than at two-way sites. This finding may reflect the difference in accident type between the two types of location; the majority of vehicle accidents on two-way streets are head-on collisions, while one-way streets are characterized by rear-end collisions. No difference in accident severity was found on collector streets.

The characteristics of one- and two-way streets in each category of class and location, as measured on a sample of streets, were compared to examine possible differences between the two types of streets that may account for the differences in accident rates. The attributes that were examined were width, free-flow speeds, traffic volumes, and crossing pedestrian volumes. It is often stated that narrow streets are made one-way to allow for parking and adequate flow; thus, one-way streets should be narrower as a rule. In fact, within each category of class and location, the two types of street had very similar pavement widths.

Average speeds on one-way streets were slightly lower than on two-way streets for all categories except local streets in the CBD. Differences of 3 to 5 kph were found on local and collector non-CBD streets. Thus, the findings indicate that higher accident rates occur on one-way streets of these two categories even though speeds are lower. As expected, free speeds on CBD streets were significantly lower than on streets outside the CBD (29.7 kph versus 35.6 kph), and speeds increased with class from 30.2 kph on local streets to 40.7 kph on arterial streets. The results do not indicate that higher average speeds are the cause of the differences found in accident rates. Only free-flow speeds were recorded; the possible effect of queues was not considered. Differences may exist in the speed distributions, which were not analyzed at this stage.

Traffic volumes outside the CBD were similar for one- and two-way streets of the same class. Thus, class and location were reasonable proxies for exposure and the results based on vehicle-kilometers traveled were similar to those based on street lengths alone. In the CBD, volumes of one-way local and collector streets were similar on the average and had a large variation. It seems that the classification for one-way streets is not well defined. In other words, some streets that, from a geometrical point of view, are classified as local, function as collector streets, probably because of their enlarged capacity. Since street class is not well defined in the CBD, all CBD streets should probably be grouped together for the purpose of analysis, as was done anyway for considerations of population size. At least for Jerusalem, location and class categories were as good proxies for exposure as average daily traffic volumes.

Crossing-pedestrian volumes were generally higher on one-way streets. Outside the CBD, differences in pedestrian volumes were inconsistent and significant; thus they cannot account for the differences in accident rates. In the CBD, the difference in pedestrian volumes was opposite in direction to that of accident rates. In summary, it seems that different pedestrian volumes could not, in general, explain the different accident rates. On the basis of this study, which compared accident rates on all one-way streets in Jerusalem to the rates on all two-way streets for the same period, it is possible to conclude that one-way streets do not, in general, contribute to an improvement in safety. Accident rates per vehicle-kilometer were higher on one-way streets for all street classes, both for pedestrian and vehicle accidents, with the exception of pedestrian accidents in the CBD. The relative risk of one-way locations was higher for intersections than for midblock sections. The higher accident rates on one-way streets could not be accounted for by differences in pavement width, free speed, or pedestrian volumes.

It seems that although one-way streets may boost traffic and parking capacity, and may increase safety in crowded, high-volume areas such as CBDs, they may not, in general, solve safety problems, especially in residential areas. Flow considerations are usually not relevant for residential areas, where one-way streets are used to increase parking space, reduce through traffic, and lessen conflicts at intersections. Rather, one-way streets may encourage higher travel speeds, which are not desirable in residential areas. They create unexpected patterns of vehicle movement, which may be hazardous to pedestrians, and they cause increases in trip length, thus increasing exposure. In addition, the paucity of enforcement in residential areas may encourage unlawful and dangerous driving in the wrong direction on one-way streets. As pointed out by Landstrom (*9*), restrictions on turns may be a better solution to safety problems at junctions and for reducing through traffic.

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