Accident Data Requirements for Improving Cycling Safety

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Canadian cities have experienced a 50 to 60 percent increase in police-reported collisions between bicycles and motor vehicles over the past decade; along with this increase are growing problems in coping with bicycle traffic. In some locales, as many as 10 percent of police-reported injury-producing road accidents involve a cyclist. Even though cycling accidents are increasing, efforts to make urban areas more accommodating to cyclists are seldom based on accident experience. A thorough understanding of the nature and extent of cycling accidents is essential to develop meaningful countermeasures. The poor representation of cycling accidents in existing data sources inhibits the understanding of such accidents. Police data have traditionally been the primary information source on bicycle accidents and are generally limited to collisions involving motor vehicles. Emergency room surveys show that between 50 and 87 percent of these accidents do not involve motor vehicles. Thus police-reported data represent only a small fraction of cycling accidents. An analysis of police-reported data in Winnipeg, Canada, for 1990 reveals several problems: collision descriptions are inaccurate in 60 percent of the cases, inconsistencies in coding are common, and information on cyclist safety equipment and contributing factors is completely overlooked. Opportunities exist to improve data collection efforts and to extend data sources so that they cover all bicycling accidents. Hospital emergency room surveys can determine the nature and magnitude of cycling accidents and associated injuries. Travel surveys can be used to estimate distances cycled and to develop accident rates. Cyclist surveys can provide information on the nature of accidents, distances cycled, and accident rates.

To assist urban planning efforts in making cities safer and more accommodating to cyclists, a thorough understanding of the nature and extent of cycling accidents is essential. Police accident data have traditionally been the primary source of information on bicycle-related accidents. This information is generally limited to the study of collisions between bicycles and motor vehicles and represents only a small fraction of the bicycle accident problem. Furthermore, the subject of cycling accidents is poorly understood and is poorly represented in existing accident data sources.

This paper (a) discusses the need for bicycle accident data for developing countermeasures and assesses the adequacy of existing bicycle accident data sources in serving this need; (b) examines the quality of data in police accident reports, using Winnipeg's police-reported data for 1990 as an example; and (c) explores possible methods to extend bicycle accident data sources to satisfy requirements.

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ACCIDENT DATA REQUIREMENTS AND THEIR USEFULNESS IN DEVELOPING COUNTERMEASURES

The purpose and application of bicycle accident data are described in this section. Key questions are posed to define the application of data collection efforts and to determine the limitation of existing bicycle accident data sources. This section also assesses the adequacy of current data sources in addressing the key questions.

Key Question 1: Trends in Number of Bicycle Accidents, Amount of Bicycle Travel, and Bicycle Accident Involvement Rates

What are the trends in number of bicycle accidents, amount of bicycle travel, and bicycle accident involvement rates per mile traveled?

Information about bicycle accident frequencies, travel, and accident rates is useful for determining and justifying the need for countermeasures. Trends in bicycle accident rates are needed to determine whether cycling safety is improving or getting worse. For example, an increase in the number of accidents in a particular region may be attributable to an increase in bicycle travel instead of an increase in the danger of cycling.

Currently, police-reported data in most jurisdictions are available to determine only trends in bicycle–motor vehicle collisions. Exposure data relating to bicycle travel are largely unavailable. Even with the police-reported data, there is an important potential problem with underreporting. Cross and Fisher estimated that only a third of all bicycle–motor vehicle collisions are reported to police (1).

Good data on bicycle accidents that do not involve a motor vehicle are also largely nonexistent. Cross demonstrated that 95 percent of all bicycle injuries do not result from collisions with motor vehicles (2). Hospital emergency room surveys examining bicycle accidents have been carried out in a number of locales. These studies show that between 50 and 87 percent of bicycle accidents reported by emergency rooms do not involve cars (3,4). Many of these accidents were the result of cyclist falls or collisions with fixed objects, other cyclists, pedestrians, or animals.

Key Question 2: Types of Accidents and Their Severity Levels

What are the types of accidents (e.g., car/bike, bike/bike, bike/pedestrian, bike/animal, falls, and collisions with fixed objects)

in which cyclists are likely to be involved, and what are the corresponding severity levels?

Information on accident type is useful to determine the potential accident reduction benefits of countermeasures and to determine the type of countermeasures that may be required. Examples of countermeasures include roadway improvements, provision of separate bicycle facilities, increased roadway maintenance, increased enforcement of traffic laws, awareness campaigns, and cyclist training programs. Information on accident severity is useful to determine the relative safety of different types of facilities and operations. Information on accident types can be used to assess the content of cyclist training programs.

Police reports provide a readily available source of information on bicycle collisions involving motor vehicles. Generally, such data provide only limited information on the nature and severity of injuries sustained by cyclists. However, in many places, the number of accidents is statistically large enough that the nature of car-bike collisions and their contributing factors can be understood.

Key Question 3: Bicycle Accident Involvement Rate and Cyclist Age and Experience

What is the relationship between bicycle accident involvement rate and cyclist age, training, and experience?

This information is useful to identify the types of cyclists that are at greatest risk of having an accident and to identify target groups for cyclist training programs. It is also useful to determine how cycling experience and amount of training influences accident rates and whether training programs can be a partial substitute for experience.

Police-reported data usually record the cyclist's age but do not keep any record of an individual's previous accident experience or amount of bicycle travel or training.

Key Question 4: Bicycle Accident Involvement Rate and Roadway Type

What is the relationship between bicycle accident involvement rate and roadway type (e.g., arterial, collector, residential, bike path), rural or urban areas, and daytime or nighttime?

Information on cycling accident rates by roadway type is useful to determine whether certain types of roadways are more dangerous than others. For example, do efforts to encourage cyclists to use side streets in lieu of arterial roads actually increase safety or merely shift the accident problem from one part of the roadway system on to another? This information may be used to determine whether facilities such as separate paths or bike lanes improve safety or are counterproductive. Knowledge of accident locations and roadway types are necessary to determine high risk areas and to determine where countermeasure programs should be applied. Information on daytime versus nighttime and rural versus urban accident rates can be used to identify special nighttime or rural needs.

Police-reported data are useful for determining the time and location of bicycle–motor vehicle collisions. The roadway type, light conditions, and setting can be easily deduced. How-

ever, without data on bicycle travel volumes, accident rates cannot be determined. Police reports also exclude accidents occurring on separate paths, except for those involving motor vehicles where the path crosses a roadway.

POLICE-REPORTED BICYCLE ACCIDENT DATA: WINNIPEG EXPERIENCE

To identify problems and inconsistencies in police-reported data, a 100 percent sample of Winnipeg's traffic accident reports involving cyclists was examined for 1990. The purpose of the analysis was to determine how well data coded on the face sheets of traffic accident reports describe collisions and to identify inconsistencies in coding.

The analysis was carried out by comparing the data coded on the face sheet with the description of the collision as "reconstructed" from the police narratives in the reports. Of particular interest was the police description of the collision configuration, contributing factors on the part of the motorist and the cyclist, and the availability of safety equipment on the cyclist.

A total of 302 bicycle-related accidents were reported to Winnipeg police in 1990; of these, only 9 (or 3 percent) did not involve a motor vehicle. Four collisions involved persons walking bicycles, so only 289 of the accidents could be classed as car-bike collisions.

Collision Configuration

The distribution of accidents by police configuration code for the 289 collisions involving motor vehicles is shown in Figure 1. These collisions were also classified according to a system devised by the authors by reconstructing each collision from the narratives (5). This classification is shown in Figure 2. The following findings were made:

● Only 40 percent of the police configuration codes agreed with the configurations as determined from the narratives.
● More than 30 percent of the collisions were coded by police as "99-other." This indicates that to understand the nature of the collision, it is often necessary to refer to the collision narratives in the pages after the face sheet.
● Nearly 5 percent (or 14) of the collisions were coded as "16-pedestrian." In fact, only one of these collisions involved a person walking a bicycle and thus should not have been classified as a car-bike collision. The other 13 "pedestrian" collisions involved persons riding a bicycle. Three other accidents that were coded as car-bike collisions involved persons walking bicycles.
● Nearly 30 percent of the collisions were coded by police as "11–right angle." This is lower than the 48 percent as determined from the narratives. The police configuration codes do not accurately reflect all likely car-bike collision configurations. In particular, the "straight through cyclist struck by motorist turning right" (Configuration 7a) and "opening car door" (Configurations 2a and 2b) are not clearly represented by the police codes. The closest police codes would be "5-overtaking" and "15-parking," respectively.

Configuration Code	Rear End	Head On	Side Swipe	Side Swipe	Over-taking	Right Turn	Right Turn	Left Turn	Left Turn	Left Turn	Inter-section 90°	Off Road Right	Off Road Left	Fixed Object	Parking	Pedestrian	Other Explain in Police Comment Section
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	99
Total 289 (100.0)	13 (4.5)	2 (0.7)	6 (2.1)	22 (7.6)	14 (4.8)	3 (1.0)	6 (2.1)	4 (1.4)	1 (0.3)	26 (9.0)	84 (29.1)	2 (0.7)	0 (0.0)	0 (0.0)	4 (1.4)	13 (4.5)	89 (30.8)

FIGURE 1 Distribution of accidents by police configuration code, Winnipeg, 1990.

Contributing Factors

On the police face sheet there is provision for identifying as many as three contributing factors for both the motorist and the cyclist.

From the police-reported data, the most frequent contributing factor for the motorist was "failure to yield right of way," in 8 percent of the collisions. For the cyclist, the most frequently coded factor was "disobeyed traffic control device," in 6 percent of the collisions. In nearly half of the collisions, no codes were assigned whatsoever.

From the collision reconstruction based on the narratives, the most frequent contributing factors for the motorist were as follows:

	Percentage
Failure to yield right of way	14
Improper right turns	3
Improper overtaking	5

For cyclists, the following contributing factors were most frequent:

	Percentage
Failure to yield right of way	14
Sidewalk/wrong-way riding	23
Disobey traffic control device	11
Lack of nighttime equipment	10

In the police reports, there are no applicable codes for driving or riding on a sidewalk or any other area intended for use by pedestrians. Similarly, there are no codes for lack of headlights, taillights, or reflectors.

Safety Equipment

The face sheet data were examined to determine if the cyclist was using pertinent safety equipment, particularly helmets, lights, reflectors, or retroreflective clothing. Of the 289 collisions involving motor vehicles, only five cyclists were noted to be wearing helmets. Twenty-five cyclists were coded by police as not wearing helmets. In the remaining 259 collisions (90 percent), cyclists' use of safety equipment was coded as either "no safety equipment available" or "not applicable."

In all 29 of the nighttime collisions, the use of appropriate lights, reflectors, or retroreflective clothing by the cyclist was not noted. It is highly probable that these cyclists lacked a headlight and adequate rear reflectors at the time of the collision. The use of a headlight is crucial in preventing many of the intersection collisions, and a taillight and rear reflectors are necessary to reduce overtaking collisions.

METHODS TO EXTEND BICYCLE ACCIDENT DATA SOURCES

The findings of bicycle accident studies on the basis of a review of the literature are reported. These findings are related to the key questions posed earlier. This section also presents possible methods to extend bicycle accident data sources to address the key questions.

Trends in Number of Bicycle Accidents, Amount of Bicycle Travel, and Bicycle Accident Involvement Rates

Police-reported data can be used to identify trends in the number of bicycle–motor vehicle collisions. In most locales, it is possible to obtain these data over several years. To determine the trend in numbers of accidents that do not involve motor vehicles, hospital emergency room surveys would be the primary data source. However, with hospital data, it is often not possible to determine historic trends from previous data. Therefore, efforts to collect hospital data would have to be carried out for several years with a consistent sampling plan.

Determining trends in the amount of bicycle travel is much more difficult, since such data are not collected in most locales. Questions on the type and amount of personal trip-making by all travel modes could be included in travel surveys. In Great Britain, the Department of Transport monitors the amount of travel and number of casualty accidents for different modes of road travel, including bicycling (6). The Department of Transport data have been used to determine historic trends in the bicycling accident rate, as shown in Figure 3. From this figure, the accident rate rose steadily between 1954 and the early 1970s. From the early 1970s to 1987, the rate declined slightly. The accident rate for the general cycling population was approximately 10 times greater than the rate for motoring (6).
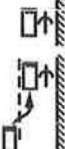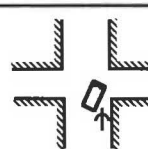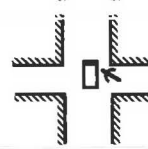
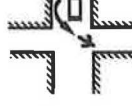| Configuration	Description	Principal Contributing Factors

A. Mid - block Collisions

Configuration	Description	Principal Contributing Factors
1. Rear End 7 (2.4%)	Cyclist strikes rear of stopped or parked motor vehicle.	• Cyclist inattentiveness • Cyclist loss of control
	Rear of cyclist struck by front of overtaking motor vehicle.	• Motorist improper overtaking • Cyclist swerves unexpectedly • Cyclist lack of reflector / taillight
2. Opening Car Door 15 (6.3%)	Cyclist strikes driver side door.	• Motorist opening door into traffic • Cyclist too close to parked car
	Cyclist strikes passenger door	• Cyclist improper overtaking
3. Sideswipe same Direction 29 (10.1%)	Cyclist sideswiped by overtaking motor vehicle	• Cyclist swerves unexpectedly • Motorist improper overtaking • Cyclist lack of reflector / taillight
	Motorist changes lane to right	• Motorist improper lane change
	Motorist entering/exiting parking spot	• Cyclist improper over taking • Motorist fails to yield right of way
4. Sideswipe - Opposite Direction 3 (1.0%)	Cyclist sideswiped by motor vehicle travelling in opposite direction	• Cyclist or Motorist travelling wrong way • Cyclist or Motorist loss of control
5. Head on 1 (0.4%)	Front of cyclist struck by front of motor vechicle travelling in opposite direction	• Cyclist or motorist travelling wrong way • Cyclist or motorist loss of controll

B. Intersection Collision

Configuration	Description	Principal Contributing Factors
6. Right Angle 138 (47.8%)	Cyclist proceeding straight intersection struck by straight through motor vehicle on perpendicular road way	• Cyclist or motorist disobeys traffic control device • Cyclist or motorist fails to yield right of way • Cyclist on sidewalk and / or wrong way • Cyclist lack of head light
7. Right turn 46 (15.9%)	Cyclist going straight struck by motorist turning right	• Motorist improper turning • Cyclist improper over taking • Cyclist riding on sidewalk and / or wrong way • Cyclist lack of reflectors / taillight
	Straight through cyclist struck by motorist turning right from perpendicular road way	• Motorist fails to yield right of way • Cyclist riding on sidewalk and / or wrong way • Cyclist lack of head light
	Right turning cyclist struck by motorist travelling straight on perpendicular roadway	• Cyclist fails to yield right of way
8. Left Turn 47 (16.3%)	Straight through cyclist struck by motorist turning left across his path	• Motorist fails to yield right of way • Cyclist riding on sidewalk and / or wrong way • Cyclist lack of head light
	Left turning cyclist struck by overtaking motorist	• Cyclist turning left from curb • Cyclist failure to shoulder check • Cyclist lack of reflector / taillight
	Cyclist turns left across motorist's path	• Cyclist fails to yield right of way

FIGURE 2   Distribution of accidents by configuration, from narrative reconstruction, Winnipeg, 1990.
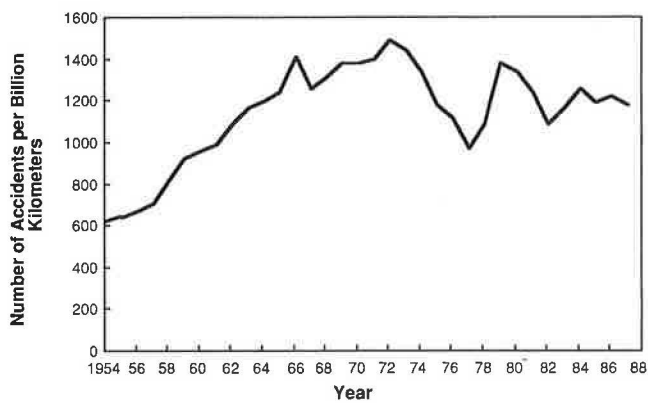
FIGURE 3 Cyclists killed or seriously injured per billion veh-km.

Types of Accidents and Their Severity Levels

In a survey of League of American Wheelman (LAW) members, Kaplan was able to determine the frequency of accidents by type and by injury severity (7). In this survey, "serious" was considered to be accidents that required hospital admission. The reported frequencies are given in Table 1.

It is important to note that these frequencies are for a group of highly experienced, club-level cyclists. A survey carried out by Schupack and Driessen of college-age cyclists shows a greater proportion of falls and smaller proportions of collisions with cars and other cyclists (8). A survey of elementary school children by Chlapecka et al. indicates a much higher proportion of falls than the LAW members, but only 10 percent with cars (9).

Hospital emergency room surveys can serve as the principal source of information on the frequency of bicycle accidents by type and injury severity for the general cycling population.

BICYCLE ACCIDENT INVOLVEMENT RATE AND CYCLIST AGE AND EXPERIENCE

A number of surveys of cyclist accidents have been used to provide general accident rate data. Surveys have been carried out on elementary school children, college adults, and adult club cyclists. The adult club cyclists had a significantly lower accident rate than the first two groups, but they were involved in a somewhat higher proportion of car-bike collisions. The

TABLE 1 Accident Types and Frequencies, LAW Members

Type	Percentage of all Accidents	Percentage of Serious Accidents
Fall	44	38
Collision with moving motor vehicle	18	26
Collision with moving bicycle	17	13
Collision with moving dog	8	10
Collision with parked car	4	2
Bicycle defect	3	3
Collision with pedestrian	1	1
Other	5	7

TABLE 2 Accident Rates by Cyclist Type per Million bicycle-mi

	Elementary School Cyclists (9)	College Cyclists (8)	Adult Club Cyclists (7)
Basic accident rate	720	510	113
Fall rate	575	300	50
Car-bike collision rate	72	80	20
Car-bike collision proportion	0.10	0.16	0.18

corresponding accident rates by accident type for these groups are presented in Table 2. In these three surveys there was little difference between the accident definitions.

Cross's Santa Barbara study of accidents not related to motor vehicles has been used to determine the influence of cycling experience on the accident rate (2). The annual probability of an accident for cyclists of different annual mileages has been calculated from Cross's data. The relationship between annual mileage and accident rate derived from these calculations is shown in Figure 4. This figure indicates that the accident rate decreases with increasing annual mileage.

In a study of cyclists' behavior in The Netherlands, Maring and von Schagen determined the relationship between a cyclist's age and accident rate per billion bicycle-km for 1983 and 1984 (10). The accident rates were developed by using collision data collected by the national traffic accident registration system and relating them to the distances covered by various age groups through annual surveys of the Central Bureau of Statistics. The relationship is shown in Figure 5. From this figure, the accident rates for cyclists younger than 12 and older than 70 are higher than for other age groups.

To determine the relationship between the amount of bicycle travel and accident rates for a particular area, surveys should include questions on the estimated amount of bicycle travel over a specified period and on the number and types of accidents in which an individual cyclist has been involved. To obtain meaningful data, the definition of accident must be consistent. Surveys could be carried out on hospital emergency room cases of bicycle-related accidents or on specific groups of cyclists (e.g., school children and cycling club members).

To distinguish rural from urban and daytime from nighttime accidents, surveys should include questions on light conditions
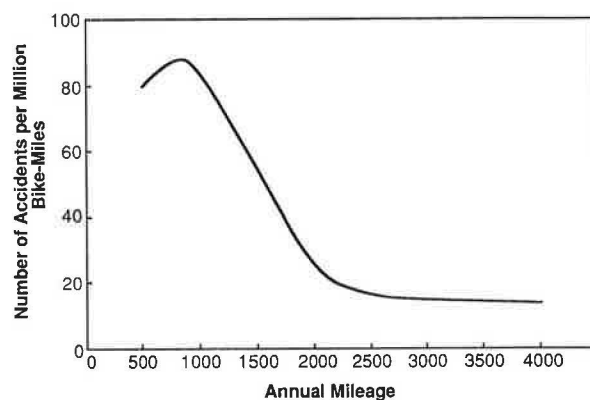

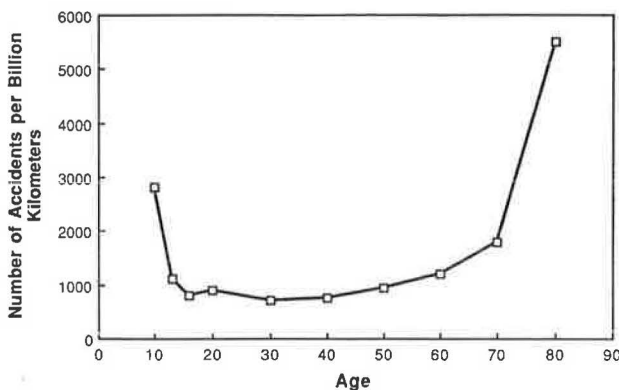**FIGURE 4 Annual mileage and accident rate.**

FIGURE 5 Cyclist age and accident rate.

and on urban versus rural settings. However, it may be very difficult, if not impossible, to develop individual accident rates for these variables, since most cyclists do not know the proportion of nighttime or rural travel to total bicycle travel.

To date, no study has been able to demonstrate whether urban cycling is more dangerous than cycling in rural areas.

Bicycle Accident Involvement Rate and Roadway Type

Kaplan's survey of LAW members showed that the accident rate increases with traffic levels (7). The distribution of accident rate by roadway type from this survey is given in the following table:

Roadway type	Accidents per Million bicycle-mi
Arterial	111
Collector	104
Residential	58
Bike path	292

Off-street bike paths experienced the highest accident rate: 292 accidents per million bicycle-mi, or approximately 2.5 times the rate of arterial roads. This indicates a major safety problem with the design and operation of special bicycle facilities that were intended to improve safety.

CONCLUSIONS AND COMMENTARY

On the basis of this work, the following comments can be made:

● Effective countermeasures require sound knowledge of cycling accidents.
● Bicycle accident information is generally inadequate and covers only a small portion of the accident situation.
● Meaningful information systems require the expansion of the data base to cover accidents that do not involve a motor vehicle and the improvement of the quality of existing data sources.
● The quality of police-reported data is often poor. In particular,

  –Coded data provide an inaccurate description of collisions.

–Bicycle collisions are often miscoded as pedestrian collisions. Cyclists and pedestrians are two completely different groups of road users with different operating characteristics. Cyclists should be regarded as vehicle operators and collisions should be classified according to the most appropriate configuration code. To assist in this effort, a sketch of all collisions should be made on the diagram provided.

–A cyclist's use of safety equipment such as helmets, reflectors, and headlights is not noted.

–Contributing factors on the part of motorists and cyclists are frequently not coded. In describing contributing factors, special codes should be created to describe riding/driving in pedestrian areas and lack of nighttime equipment. Closer attention must be paid to the behavior of the motorist and the cyclist before the collision.

● Opportunities exist to improve the quality of existing bicycle accident data sources and to extend the data base to cover the full range of cycling accidents. Hospital emergency room surveys may be used to develop data on accidents that do not involve a motor vehicle and on the nature and severity of cyclists' injuries. Data on cycling accident experience and bicycle travel can be collected through surveys of specific groups of cyclists. Travel surveys can be used to estimate the amount of bicycle travel in order to develop meaningful exposure data.

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