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Bicycle crash casualties in a highly motorized city

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ABSTRACT

The characteristics of bicycle crashes in cities where bicycles are a minor transport mode have received little attention in road safety research. However, the characteristics of these injury-inflicting bicycle crashes are expected to be very different from those happening in cities where cycling is generally considered as one of the major transport modes. Specifically, this study has the following three objectives: (1) to conduct the first scientific spatial analysis of bicycle crashes in Hong Kong; (2) to analyze the circumstances leading to bicycle crashes; and (3) to conduct an epidemiological study on injury patterns of cyclist casualties. Various spatial and statistical tools, including buffer analysis, chi-square tests, analysis-of-variance and binary logistic regression, are used to analyze the bicycle crashes in Hong Kong from 2005-2007. An important finding of this paper is that the bicycle safety problem has a clear spatial dimension. The crash circumstances in different parts of the city differed systematically. Furthermore, the findings suggest that initiatives to develop new cycle tracks and to encourage bicycles as a transport mode must be planned carefully with new infrastructure and policies to ensure the safety of cyclists.

1. Background

Cycling is being increasingly encouraged as a sustainable, inexpensive, environmentally friendly, transport mode, that is also good for health. However, cyclists are exposed to higher risk of injury and fatality in road crashes. In view of worldwide initiatives to encourage cycling, there should be higher awareness about the risk of cycling, especially in highly motorized societies where cycling is currently a minor transport mode and there are no special provisions (such as lane separation) for cyclists on the public road network. In these cities, cycling is often considered as a recreational activity, especially for teenagers, on designated cycle tracks or parks. The characteristics of bicycle crashes in these cities have received little attention in road safety research because of the lack of historical data which are sufficiently large and detailed for meaningful statistical analysis. However, the characteristics of these bicycle crashes are expected to be very different from those happening in cities where cycling is generally regarded as one of the major transport modes, such as many British, Dutch and German cities (McCarthy and Gilbert, 1996; Pucher and Dijkstra, 2003). Moreover, such analysis would provide useful reference for cities where cycling is mainly a recreational activity but there are plans to promote more cycling on the highly motorized urban roads.

Overall, this study aims to conduct a comprehensive and systematic analysis of injury-inflicting bicycle crashes in Hong Kong, where bicycle is a minor transport mode. A bicycle crash is defined as a road crash which involves at least one bicycle. In other words, bicycle-vehicle, bicycle-pedestrian and bicycle-object crashes are within the scope of this study. The major aim is to enrich the literature on bicycle safety, which is increasingly important in the development of sustainable urban transport. Hong Kong is a metropolitan city with busy motorized traffic; and bicycle is a minor transport mode. To the Government, cycling is generally perceived as a sports or recreational activity common in the new towns and rural areas (Transport Department, 2004). Bicycle safety has not been considered as a territory-wide road safety problem.

Specifically, this study has the following three objectives: (1) to conduct the first scientific spatial analysis of bicycle crashes in Hong Kong; (2) to analyze the circumstances leading to bicycle crashes; and (3) to conduct an epidemiological study on injury patterns of cyclist casualties. For the first objective, the major research questions are: did bicycle crashes mainly happen in the new towns and the rural areas? To what extent were the urban areas protected from bicycle crashes? In relation, did most bicycle crashes happen on the cycle tracks or roads near them, as cyclists tried to access to and/or egress from the cycle tracks? If so, measures to improve bicycle safety should focus on cyclists using cycle tracks. Moreover, efforts to establish a more accessible and well-connected cycle tracks within the new towns and the rural areas should receive high priority. In relation to the second objective of analyzing the circumstances leading to bicycle crashes in a highly motorized society,

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the key research questions are: were most injury-inflicting bicycle crashes involving vehicles, other bicycles, pedestrians or objects? Were they mainly head-on, rear-end, other types of crashes? In terms of the major contributory factors, were the cyclists or other road users mainly at fault in causing the bicycle crashes? These data can inform policy-makers about the most effective way of improving bicycle safety. Last but not least, the third objective is to conduct an epidemiological study on the injury patterns of cyclist casualties. The research questions are: were most cyclist casualties teenagers? How was age related to the injury patterns of bicycle casualties and the patients' outcomes, for example, disabilities and deaths? By meeting the above three objectives, one would be in a better position to understand the bicycle crash problem in highly motorized societies where bicycle is a relatively minor transport mode, and to suggest ways to improve bicycle safety and promote bicycle usage.

2. Data and Methods

2.1. Database

Since any road crash involving injury to any person, whether the driver, passenger or pedestrian, or any animal, must be reported to the police in Hong Kong, the Traffic Accident Database System (TRADS) is an appropriate database for bicycle crash analysis. Nonetheless, research worldwide has increasingly suggested that under-reporting of injury-inflicting crashes to the police is not uncommon (Amoros, Martin and Laumon, 2006; Austin, 1992; Bulls and Roberts, 1973; Rosman, 2001). Moreover, research using hospital-based traffic casualty databases shows that under-reporting was particularly serious among the cyclists (Langley et al., 2003; Loo and Tsui, 2007). Therefore, this study also makes use of a hospital-based Road Casualty Information Database (RoCIS) to supplement TRADS and to gain valuable medical information about the injury patterns of bicycle crash casualties.

2.2. Statistics and Patients

2.2.1. Scientific Spatial Analysis of Bicycle Crashes in Hong Kong

Since crashes are rare events at any point in space and time, they have a random element which makes detailed statistical crash analyses of a year's crash records insufficient for identifying systematic road safety problems and vulnerable to the regression-to-mean pitfall (Shih and Washington, 2007). Pooling or aggregating time-series data of such rare events is a commonly recognized means to overcome such problems. Generally, the three-year period is preferable in balancing data requirements and keeping other circumstances like traffic volume or other road environment relatively stable. After a brief overview of the trend of bicycle crashes in Hong Kong from 1993 to 2007, the crash data are aggregated by the three-year period of 2005–2007. In order to analyze whether bicycle crashes in Hong Kong are located near the cycle tracks, the centerlines of cycle tracks are first digitized and then buffers of 10 meters (m), 100 m and 500 m are generated using the geographic information systems (GIS). Next, these buffers are intersected with the geovalidated TRADS database (Loo, 2006) to identify bicycle crashes happening on or near the cycle tracks. In this way, this study is the first scientific analysis of the spatial pattern of bicycle crashes in this highly motorized society.

2.2.2. Circumstances Leading to Bicycle Crashes

Next, crash details, including the type of other vehicles involved, if any, the direction of impact and the contributory factors, are extracted from the TRADS database. Together with the analysis at the first stage, this study would be in a position to analyze whether the crash circumstances in different parts of the city differed systematically. In the context of Hong Kong, due to its highly transit-oriented transport system, there are many franchised buses (most of them double deck buses) on urban roads. Hence, the nature of the crashes and their consequences on the traffic casualties can be very different in different areas. Based on the analyses at the first two stages, bicycle crashes are broadly classified into three groups–those happening on or near cycle tracks (within 10 m), those happening on roads near cycle tracks (within 500 m), and those happening far away from the cycle tracks (beyond 500 m). Then, variables related to the crash details are cross-tabulated with the three major groups of bicycle crashes to identify any statistically significant difference at the 0.05 level. Depending on the nature of the dependent variables, chi-square and analysis-of-variance (ANOVA) tests are used.

2.2.3. Epidemiological Study on the Injury Patterns of Cyclist Casualties

In this part, the demographic characteristics and injury patterns of the cyclist casualties are examined in details. While the information in TRADS database can shed valuable light on bicycle casualties, it suffers from three major deficiencies for epidemiological studies. Firstly, as most other police-based traffic casualty database system, TRADS is known to be suffering from under-reporting problems. The overall reporting rate was estimated to be 57.5-59.9% in 2004 (Loo and Tsui, 2007). Among different types of road users, the under-reporting rate was the highest among cyclists. These non-reported cases of cyclist casualties do impose burdens on the medical system and incur enormous mental stress and burden on the cyclist casualties and their families. Secondly, the injury classification system used by the Hong Kong Police (that is, fatal, serious and slight injury) is very crude and is often inconsistent with the levels of injury sustained by the traffic casualties. While a fatal traffic casualty is defined following the international standard of "deaths arising from the traffic crash and within 30 days of injury", the distinction of serious and slight injuries is based on whether the estimated length of hospital stay is over 12 hours or not. Under many circumstances (such as the need to wait for a report or to stay at the hospital for observation), a hospital stay of over 12 hours may not imply serious injury in the medical sense. A recent work of Tsui et al. (2009) estimated that only 5.15% (36 out of 699 cases) of the serious injury casualties in the police database could be classified as serious injury (ISS of 16 or above). Lastly, the TRADS database does not yield any information about the injury patterns (such as the body part injured and the operations undertaken) and the long-term medical implications (such as the length of hospital stay and whether disabilities are sustained). For these reasons, RoCIS is used to supplement TRADS in this part of the study. Nonetheless, analyses based on RoCIS cannot completely replace TRADS in the epidemiological study because of it is only a trial scheme involving one of the five trauma centres, Tuen Mun Hospital. While the data are not perfect, it can shed valuable light on the injury patterns of bicycle crash casualties in Hong Kong. With the availability of RoCIS since 2005, the epidemiological study of bicycle crash injuries is also conducted for the 2005-2007 period.

3. Results

3.1. Scientific Spatial Analysis of Bicycle Crashes in Hong Kong

Did bicycle crashes constitute a significant road safety problem in Hong Kong? From 1993 to 2007, bicycle crashes have become an increasingly acute road safety problem in Hong Kong. Its share in the total traffic crashes has increased significantly and continuously from about 2.9% in 1993 to 12.74% in 2004. The trend was