Moped Rider Violation Behaviors and Moped Safety in China

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ABSTRACT
The purpose of this study is to identify the Moped rider violation behaviors leading to conflicts and crashes and to help guide future countermeasure development. Mopeds (electric bicycles and light motorcycles) are a commonly used personal transportation mode in China, and Moped crashes are increasing rapidly. This increase in crashes may be attributable to certain traffic behaviors of Moped riders. We used video recordings to acquire data on Moped riders’ violation behaviors and the violation behaviors of Bicycle, Tricycle (BTs) and Motorcycle (MCs) riders at signalized intersections. A total of 125 minutes of video was recorded from 10 intersections and rider behaviors were coded from 1455 vehicles. The video data showed that Moped riders commit more violations than riders of bicycles, tricycles, and electric bicycles, and that Moped riders who engage in violation behaviors at intersections are involved in more frequent and more severe conflicts than Moped riders who do not engage in violation behaviors. Typical Moped violation behaviors include running red lights, riding in improper directions, waiting at improper positions, riding in improper lanes, and overloading. Violation behaviors were closely associated with the traffic environment (traffic facilities, traffic flow, traffic signal status and other riders’ behaviors), but not with either the vehicle’s characteristics or the rider’s characteristics. This suggests that countermeasures related to the traffic environment would be more effective than those related to either vehicle or rider characteristics. Countermeasures within the areas of traffic regulation, traffic management, traffic facilities, vehicle management, and rider education are proposed.

Keywords: Traffic safety, Moped, Violation behaviors, Conflicts, Traffic behavior, Countermeasure
1 INTRODUCTION

Mopeds are inexpensive, two-wheeled vehicles powered either by battery or internal combustion engines under 50cc displacement by the OECD definition. Both electric bicycles and light motorcycles are classified as Mopeds (1), the former being similar in size and weight to bicycles, while the latter are closer to motorcycles in size and weight. Mopeds are able to travel at higher speeds than bicycles, and this may lead to more aggressive riding by Moped riders compared to bicycle riders (2). Mopeds fulfill the trip needs for those who want a higher level of personal mobility than is provided by bicycles, but who are not able to afford private cars (3). The categories of vehicles we are considering in this study are shown in Figure 1 below. This report will adopt the following naming abbreviations when referring to these vehicles. Bicycles and tricycles will be treated as a single category and abbreviated as BTs. Electric bicycles, as well as, light motorcycles, whether electric or gas powered, will be referred to as Mopeds. Motorcycles will be abbreviated as MCs.

The Traffic Safety Law of the People’s Republic of China (4), enacted on May 1, 2004, classifies electric bicycles as non-motorized, and light motorcycles (both electric and gas powered) as motorized vehicles. This classification based on motorization is important because the law states that electric bicycles (one legally defined category of Moped) must share the non-motorized vehicle lanes with bicycles, and that electric and gasoline light motorcycles (another legally defined category of Moped), as well as motorcycles (defined as two-wheeled vehicles with engines larger than 50cc), must share motorized vehicle lanes.

Following the prohibition of most motorcycles in the major cities of China in
Mopeds have been gradually replacing both bicycles and motorcycles, recently have become the most common personal motorized travel mode in China. (6). In Shanghai, for example, China’s most populous city at 22 million as of 2011, Mopeds comprise over 50% of all riding vehicles (6). This increasing use of Mopeds in China has been accompanied by a sharp increase in Moped crashes. Considering Shanghai alone, 212 people died in Moped crashes in 2010. This amounts to about 20% of all traffic fatalities in the city (7), which would never be neglected.

Previous research has identified some rider, vehicle, and operational characteristics of Mopeds that are associated with Moped crashes, but has not focused on violation behaviors of riders as a potential contributor to Moped crashes. Moped rider behavior in this study will usually be contrasted with BT rider behavior. MCs for the most part will not be considered as they represent only 5.3% of the vehicles sample collected in Shanghai. However, there are many more MCs studies than Moped studies available, and while the characteristics of these vehicles are similar, some findings from MCs studies may be generalized to Mopeds. Therefore, some MCs studies have been reviewed, even though MCs are a small part of the two-wheel vehicle population in China. An earlier study, based on 1,231 Moped crashes in Mangalore City, India during 2000 to 2004, revealed that the crash rate of men was four times higher than that of women (8). In another study of Moped and motorcycle crashes conducted in France between 1996 and 2005, researchers found that, (besides gender), vehicle type, rider age, helmet use, drunk driving, driving technique, and overloading were important factors associated with Moped crashes (9). It has also been found that motorcyclists or Mopeds drivers who had been drinking were far more likely to be inattentive to the driving task just before they crashed, and to be the primary or sole cause of the crash. Drinking riders were also more likely to be hospitalized and far more likely to be killed than non-drinking riders (10). In another study of crash causes, the hand position of motorcyclists or Mopeds drivers was found to be strongly related to crashes (11). Other human factors, such as driving experience, accident history, education or income have also been found to be significantly associated with motorcycle and Moped safety (12). A survey study of 800 riders in Chongqing, China (13) acquired data on motorcycle and Mopeds riders’ riding behaviors, personality, and traffic safety attitudes, and used a relational model to link these variables to crashes. They found that motorcycle riders’ personality, traffic safety attitude and riding behaviors were all significantly related to crashes. Based on the developing situation of Mopeds in China, it is likely that various Moped violation behaviors, the traffic mix, and unsound and ambiguous Moped traffic regulations are all affecting Moped traffic safety (14).

The current study focused on Moped violation behaviors and the conflicts they lead to. The violation behaviors observed in this study were classified according to their temporal and spatial differences and then each violation was coded into one of five categories. Binary Logit models were used to identify and compare the significant factors associated with the various violation behaviors observed. Typical conflict patterns were also determined from the videos. The relationship between violations and conflicts has been found in other settings...
(15), however, it is an assumption of this study that a positive relationship exists between 
conflicts and crashes in this setting. This research also identified countermeasures that could 
be developed to improve the safety of Moped riders.

2 METHODS

2.1 Video Data Collection
Moped rider behaviors were videotaped at 12 busy signalized intersections with a high 
proportion of Moped riders. The video cameras were installed at the intersections from an 
inclined rear direction, and were capable of recording the operation of all riding vehicles 
entering and leaving the intersection for about 10 continuous minutes. Table 1 below shows 
the details of the video data recording schedule, and the specific characteristics of each 
intersection. Video recording was conducted on weekdays and occurred one or two hours 
before or after the morning and evening rush hours. A total of 125 minutes of video were 
recorded at 12 intersections. SONY HDR-CX180E HD Video Cameras were used. These 
high definition (1440 x1080 resolution) cameras allowed the coder to determine vehicle type, 
 rider characteristics (including gender and approximate age), road facilities and rider 
behavior characteristics.

<table>
<thead>
<tr>
<th>ID</th>
<th>Intersection Shape</th>
<th>Stop Line</th>
<th>Separator of Motor and Non-motor</th>
<th>Separator of Non-motor and Pedestrian</th>
<th>Widened Area of Waiting Zone</th>
<th># of Crossing Lanes</th>
<th>Observation Time</th>
<th>Duration (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Three-leg Y</td>
<td>Line</td>
<td>Curb</td>
<td>Right turn</td>
<td>4</td>
<td>2011/3/4 7:40</td>
<td>720</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Three-leg Y</td>
<td>Curb</td>
<td>Barrier</td>
<td>None</td>
<td>6</td>
<td>2011/3/4 9:40</td>
<td>775</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Three-leg Y</td>
<td>Barrier</td>
<td>Barrier</td>
<td>Right turn</td>
<td>4</td>
<td>2011/3/4 10:20</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Four-leg Y</td>
<td>Curb</td>
<td>Barrier</td>
<td>Separated Waiting Zone</td>
<td>6</td>
<td>2011/3/4 8:15</td>
<td>480</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Four-leg Y</td>
<td>Line</td>
<td>Curb</td>
<td>None</td>
<td>2</td>
<td>2011/3/4 9:00</td>
<td>560</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Four-leg N</td>
<td>Barrier</td>
<td>Line</td>
<td>None</td>
<td>4</td>
<td>2011/3/8 11:15</td>
<td>640</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Four-leg Y</td>
<td>None</td>
<td>Curb</td>
<td>None</td>
<td>2</td>
<td>2011/3/8 11:50</td>
<td>660</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Four-leg Y</td>
<td>Line</td>
<td>Curb</td>
<td>None</td>
<td>2</td>
<td>2011/3/9 15:20</td>
<td>640</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Four-leg Y</td>
<td>Curb</td>
<td>Barrier</td>
<td>Right turn</td>
<td>5</td>
<td>2011/3/9 16:00</td>
<td>630</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Four-leg Y</td>
<td>Line</td>
<td>Barrier</td>
<td>None</td>
<td>1</td>
<td>2011/3/9 16:45</td>
<td>546</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Four-leg Y</td>
<td>Line</td>
<td>Barrier</td>
<td>None</td>
<td>4</td>
<td>2011/3/9 17:55</td>
<td>498</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Four-leg Y</td>
<td>Curb</td>
<td>Barrier</td>
<td>None</td>
<td>3</td>
<td>2011/3/10 10:20</td>
<td>757</td>
<td></td>
</tr>
</tbody>
</table>

Note: ‘Y’ stands for Stop Line present, and ‘N’ stands for no Stop Line present; ‘Barrier’ stands for 3 or 4 feet high separator; ‘Separated Waiting Zone’ stands for exclusive non-motorized waiting zone separated from the non-motorized lane.
The physical layout of the intersection approach, typical of the 12 intersections examined in this study, is shown in Figure 2. Detailed traffic facility and traffic flow features, such as separators for different vehicle types, presence of absence of a stop line, whether the waiting zone was widened, and the number of crossing lanes, were recorded and coded.

**Figure 2** Layout of an Intersection Approach

2.2 Video Data Coding

Traffic environment, rider characteristics, rider behavior, and conflicts are the four major categories of variables coded. Specific coding details of these four categories are listed in Table 2 below. Please note that rider age was coded into three categories (teenage, middle age, older age), based on the following (subjective) criteria: riders appearing young-looking and with agile motions were coded as teenagers, riders who looked mature, with moderately agile-motions were coded as middle aged, and riders who looked aged and exhibited slower
motions were coded as older aged. Violation Behaviors (VBs) were coded into one of five categories. A conflict was coded after a speed or direction change of either or both vehicles was observed when their close approach occurred. Conflict severity (slightly interrupted, moderately interrupted, full stop, or sudden direction change) was also coded according to the nature of the riders’ speed and direction change.

Table 2 Specific Items in Video Data Coding

<table>
<thead>
<tr>
<th>Category</th>
<th>Items</th>
<th>Specific Items</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road facilities</td>
<td>Effective width of non-motorized vehicle lane</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Moped crossing distance</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Traffic characteristics</td>
<td>Approach split green ratio</td>
<td>The ratio of green time and cycle length at the approach</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Signal cycle length</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Approach volume of all riding vehicles</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volume of motorized vehicles</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>non-motorized vehicles and pedestrians on the crosswise direction</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Crosswise traffic saturation time ratio</td>
<td>Total time recorded divided by saturation time of crosswise traffic</td>
<td></td>
</tr>
<tr>
<td>Traffic management</td>
<td>Presence of traffic policemen</td>
<td>Yes or no</td>
<td></td>
</tr>
<tr>
<td>Rider characteristics</td>
<td>Age</td>
<td>Teenage, middle age, older age</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gender</td>
<td>Male or female</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Helmet use</td>
<td>Yes or no</td>
<td></td>
</tr>
<tr>
<td>Rider behaviors</td>
<td>Rider operation</td>
<td>Moving or stopped and travel direction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Violation type</td>
<td>Red Light Running, Improper Travel Direction, Improper Waiting, Improper Lane Use, and Overloading</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Violation location</td>
<td>Lane position and position in the waiting zone</td>
<td></td>
</tr>
<tr>
<td>Conflict</td>
<td>Conflict event</td>
<td>Yes or no</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conflict severity</td>
<td>Lightly interrupted, moderately interrupted, full stop, or sudden direction change</td>
<td></td>
</tr>
</tbody>
</table>

Moped conflicts (defined as a change of speed or direction of either vehicle involved in a close approach) could be a negative consequence of violation behaviors (VBs). Based on the video recorded at the 12 intersections in Shanghai, Moped conflicts at intersections were classified as follows:

1) Moped conflicts with other right turning vehicles;
2) Moped travelling straight or turning left conflicting with vehicles on the crossing lanes;
3) Mopeds turning right or travelling straight conflicting with other through or left turning vehicles;
4) Mopeds conflicting head on with other vehicles
5) Mopeds conflicting with opposite left turning vehicles;
6) Mopeds conflicting with pedestrians or non-motorized vehicles on the crosswalk.

These six types of conflicts are shown in Figure 3 below:

![Figure 3 Types of Moped Conflicts](image)

### 3 RESULTS

#### 3.1 Violation Percentages and Behavior Differences between Moped and BT Riders

We define the Violation percentage (VP) as the number of all riders observed performing violations divided by the total number of observed riders. This yields an overall VP of 0.511
for all vehicles (shown in Figure 1). For Moped riders, the VP was 0.549, and for BTs the VP was 0.459. Apart from overload violations, the VP of Moped riders does not differ significantly from BT riders, even though they differ in certain of the specific violations they commit. However, Violation Behaviors (VBs) by Moped riders are more of a problem than VBs by BT riders because Mopeds currently consist of about 60% of all riding vehicles in Shanghai, and they are increasing faster than BTs. Motorcyclists’ violation behaviors are not compared with Moped riders for two reasons: 1) a small sample of motorcyclists were recorded in this study (only 5.3% of all riding vehicles were motorcycles); 2) motorcycles in Shanghai share roads with cars and trucks rather than with Mopeds or BTs, and this results in little interaction between them.

We observed that both Moped and BTs sometimes commit more than one of the five possible violation types on any given occasion. Moped riders are responsible for 71.7% of riding vehicles making two, and 75.0% of riders making three violations at an intersection. This suggests that the characteristics of Moped violations are complex, and that Moped riders differ from BT riders in their violation behavior patterns. VBs for Moped and BTs will be described in detail below. Improper Travel Direction VBs are not covered here, because they are not so common in Shanghai.

**Red Light Running**

Due to the better power and performance of Mopeds, they are different from BTs in the characteristics of Red Light Running and Overloading. Moped riders tend to violate red lights further into the red cycle when compared to BT riders. Mopeds are 62.8% of riding vehicles that violate late in the red light phase while they are 48.1% of those that violate early in the red light phase. This finding indicates that signals turning from green to red restrict Mopeds more than BTs, while signals turning from red to green restrict Moped riders starting up early compared to BTs. It is because mopeds could start and brake sharper than BTs, which make their driver behave more aggressive.

**Overloading**

Mopeds, by law in China, are limited to carrying one passenger and a maximum cargo size of (< 1.5 meters high, <0.15 meters wide, <0.2 meters beyond the vehicle’s length). Overloading violations are significantly greater for Moped riders than for BT riders, with Mopeds accounting for 84.8% of all riding vehicle overloading violations. Overloading with teenagers and middle-age persons is the main type of Moped overloading (92%). This may be attributable to the better power and performance of Mopeds compared to BTs.

**Improper Waiting**

Figure 4 (a) shows that both Mopeds and BT riders tend to wait on the crosswalk for the green lights (beyond the Stop Line). Although proportionally more Mopeds wait beyond the stop line, the data also show there is little difference in improper waiting position between Mopeds and BTs as they both usually wait for the green light together. Figure 4 (b) shows
improper lane use positions. Both figures are presented below.

Figure 4 Positions of Improper Waiting and Improper Lane Use: (a) Improper Waiting Position; (b) Improper Lane Use Position

The video data suggests that Moped riders regard their vehicles as non-motorized. Figure 4 (b) shows that riding out of the painted edge of the non-motorized lane (on motorized lanes) is the most common Moped improper lane use. As stated above, the Traffic Safety Law of the
People’s Republic of China (4) classifies light motorcycles as motorized vehicles and electric bicycles as non-motorized vehicles. But under this classification, fully 80.5% of light motorcyclists are actually illegally sharing the non-motorized vehicle lane with BTs. It is possible most light motorcycle riders in Shanghai do not view their Mopeds as motorized vehicles subject to the specific legal requirements of motorized vehicles (i.e., requirement for a license tag, rider license, and helmet use). This could explain the extensive use of improper lanes by Mopeds found in this study, along with the reason that it would be safer for mopeds riding in non-motorized lane than in motorized lane.

**Helmet Use**

Apart from these typical VBs acquired from video, helmet use percentage was also recorded because of its importance for rider safety. The Traffic Safety Law of the People’s Republic of China (4) states that riders of light motorcycles (legally one of the two categories of Mopeds) and motorcycles must wear a helmet on the road. However this law is commonly ignored. Figure 5 below shows that only 25.2% (187 in 842) of Moped riders wore helmets and just 2.7% (2 in 77) of motorcycle riders wore helmets. The proportion of Motorcyclists in Shanghai is relatively low (only 5.3% of the total), compared to that of Moped riders (57.9%). Also, motorcycles in Shanghai usually serve as an illegal mode of transit that only travel in short distances. Thus, it may be that motorcyclists tend do not wear helmets for convenience and business reasons. Interestingly, around 15% riders of bicycles and electric bicycles wear helmets even though the law does not require it.

![Proportion of Riders Wearing Helmets by Vehicle Category](image_url)

**Figure 5** Proportion of Riders Wearing Helmets by Vehicle Category
In summary, Moped riders have several unique violation characteristics that separate them from BT riders. The greatest difference is that a much higher proportion of Mopeds are overloaded, and Moped violation patterns are much more complex. The next section will consider some of the key variables with which Moped violation patterns are associated.

### 3.2 Some Variables Associated with Violation Behaviors

The association of the Moped rider, vehicle characteristics, and the traffic environment to violation behaviors (VBs) can be revealed by the use of Binary Logit models. The following variables: rider demographics (gender and age), vehicle characteristics (type and power), vehicle operation (direction), and traffic and road facility features of the intersection (split green ratio of the approach, signal cycle, volume of riding vehicles at the approach, effective width of the non-motorized vehicle lane at the approach, distance for non-motorized vehicles passing through at the intersection, volumes of motorized vehicles, non-motorized vehicles and pedestrians at crosswise lanes, ratio of saturation time of traffic flow on the crosswise lanes and presence of traffic police) are all variables that may be predictive of any of the five typical VBs (Red Light Running, Improper Lane Use, Improper Waiting, Improper Travel Direction, and Vehicle Overloading).

Given that Red light Running VBs lead to the most frequent conflicts of any of the five Moped VBs, we consider the Red Light Running Binary Logit model first. In the 12 intersections where video recordings were made, we found 16.6% of Moped riders violated red lights, and of those, 46.6% were involved in conflicts.

Results of the Red Light Binary Logit model, Improper Waiting Violation Model, and Improper Lane Use Violation Model are shown in Table 3 below.

**Table 3 Variables Associated with Moped Red Light Running**

<table>
<thead>
<tr>
<th>Significant Variables</th>
<th>Coef</th>
<th>S.E</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.473</td>
<td>.550</td>
<td>~.000</td>
</tr>
<tr>
<td>Signal cycle</td>
<td>-.007</td>
<td>.003</td>
<td>~.000</td>
</tr>
<tr>
<td>Volume of RVs at approach</td>
<td>-.001</td>
<td>.001</td>
<td>~.000</td>
</tr>
<tr>
<td>Ratio of crossing traffic saturation time</td>
<td>-2.662</td>
<td>.544</td>
<td>~.000</td>
</tr>
<tr>
<td>Improper waiting before red light running</td>
<td>1.382</td>
<td>.255</td>
<td>~.000</td>
</tr>
</tbody>
</table>

**Moped Red Light Running VB Model**

The Red Light Model results show that all traffic environment factors (such as signal cycle and the saturation time ratio) are significantly associated with red light violations while none of the rider and vehicle characteristics factors were significantly associated with red light violations. Specifically, the short signal cycles and saturation time of crossing traffic are associated with a great number of Moped riders’ red light running. This may occur because when cycles are shorter there are more opportunities for Mopeds to follow one
another through red lights. In contrast, the longer cycles are associated with Moped riders
tending to stop and wait as more other Moped riders are doing so during the longer red light
time. The crossing traffic state is also an important variable associated with Moped red light
running. When the crossing traffic is less saturated, Moped riders are more inclined to violate
the red light. Also, Moped red light running increases as the volume of riding vehicles at
approach decreases, suggesting that riders would seize the chance to violate the red light
when fewer riding vehicles are present that may block their non-motorized lane. Improper
waiting behaviors are also predictive of red light running, as these two violations may share
the feature of riders’ being impatient. Table 4 shows the results of the improper waiting
Binary Logit model.

### Table 4 Variables Associated with Moped Improper Waiting Violation

<table>
<thead>
<tr>
<th>Significant Variables</th>
<th>Coef</th>
<th>S.E</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-.526</td>
<td>.328</td>
<td>.109</td>
</tr>
<tr>
<td>Moped operation direction (through)</td>
<td>.620</td>
<td>.235</td>
<td>~.000</td>
</tr>
<tr>
<td>Non-motorized vehicle lane width at approach</td>
<td>-.703</td>
<td>.133</td>
<td>~.000</td>
</tr>
<tr>
<td>Improper lane use before improper waiting</td>
<td>-1.381</td>
<td>.361</td>
<td>~.000</td>
</tr>
</tbody>
</table>

**Moped Improper Waiting VB Model**

The VB of waiting for the green light at improper locations was committed by 12.1% (102)
riders according to the video records. This VB Binary Logit Model found that the direction of
Moped operation, and the width of the non-motorized vehicle lane are significantly
associated with this improper waiting violation. Through running Mopeds have comparably
higher VPs of improper waiting, and this could be linked to the shorter passing distance when
going straight. Also, when there is not enough room in the waiting zone area for riding
vehicles, Moped riders are also inclined to wait for the green light at an improper position (i.e.
beyond the stop line). Moreover, most Moped riders that wait at improper positions usually
use the non-motorized lane because motorized vehicles usually occupy motorized lanes when
the light is red. Table 5 presents the findings from the model for Improper Lane Use.

### Table 5 Variables Associated with Moped Improper Lane Use Violation

<table>
<thead>
<tr>
<th>Significant Variables</th>
<th>Coef</th>
<th>S.E</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.310</td>
<td>.414</td>
<td>~.000</td>
</tr>
<tr>
<td>Moped operation direction (through)</td>
<td>-.834</td>
<td>.201</td>
<td>~.000</td>
</tr>
<tr>
<td>Non-motorized vehicle lane width at approach</td>
<td>-.839</td>
<td>.130</td>
<td>~.000</td>
</tr>
<tr>
<td>Motorized traffic flow at crosswise lanes</td>
<td>-.009</td>
<td>.001</td>
<td>~.000</td>
</tr>
<tr>
<td>Non-motorized traffic flow at crosswise lanes</td>
<td>-.001</td>
<td>.000</td>
<td>~.000</td>
</tr>
<tr>
<td>Constant</td>
<td>1.310</td>
<td>.414</td>
<td>~.000</td>
</tr>
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</table>
Moped Improper Lane Use VB Model

Turning Mopeds are significant group for improper lane use VBs, as they ride out of the non-motorized vehicle lane early to take a shorter route for left turns or to avoid the Mopeds stopped for right turn. And, it is easier for Moped riders to use an improper lane when the width of the non-motorized vehicle lane is insufficient and the motorized or non-motorized traffic volume is small. Therefore, Moped riders are inclined to use lane improperly when traffic facilities are limited and interrupting traffic volume is small.

Other Moped VB Models

Red light running, Improper Waiting and Improper Lane Use violations of Mopeds are the most severe and common VBs at urban signalized intersections. The improper travel direction VB is not so common at signalized intersection areas in Shanghai, as only 51 riders (6.1%) ran from an illegal direction. The model shows that the Moped improper travel direction VB is only significantly related to non-motorized vehicle lane width at the entering approach of an intersection (Coef=.382, P=.021). This VB occurs more often when the non-motorized lane is wider, possibly due to the fewer potential conflicts when running from illegal direction. Furthermore, 17.9% (151) of Moped riders commit the overloading VB. The Binary Logit model shows that male riders (Coef=.596, P=.035) and gas powered light motorcycle riders (B=.475, P=.013) are both more likely to overload than other riders. Better power performance of Mopeds compared to BTs enable Moped riders to overload without sacrificing too much performance. It should be noted that intersection traffic environment factors have not been included in this model, as they do not affect the overloading decisions.

Therefore, according to the results of the violation behavior analysis of Moped riders in Shanghai, the VP of typical Moped VBs varies significantly under different traffic environment but is not significantly related to rider and vehicle characteristics.

3.3 Violations and Conflict Severity

The various conflict types identified above were classified into three severity levels, (slightly interrupted, moderately interrupted, and full stop or sudden direction change, or, low severity, moderate severity, and high severity). If we assign severity levels as follows: ‘slightly interrupted’, 1; ‘moderately interrupted’, 2; ‘full stop or sudden direction change’ 3; the weighted total percentage of Moped conflicts following each VB can be calculated. For the five typical Moped VBs, the most likely occurring conflicts severity level are ‘Moderate Severity’, while that of non-violation remains ‘Low Severity’. This is shown in Figure 6 below.

We found the severity of conflicts following a Moped violation was significantly greater than the severity when there was no violation. We also found (when considering the weighted total percentage of conflicts) that conflicts after VBs are more probable than conflicts not preceded by VBs. Red Light Running violations result in the highest likelihood of conflict, while the Improper Travel Direction results in the lowest.
DISCUSSION AND CONCLUSIONS

Research to date has recently begun to examine the factors most closely associated with Moped riders’ traffic behaviors in China. Previous studies have shown associations between various Moped riders’ behaviors and variables such as gender, age, education, driving technique, helmet use, vehicle state, traffic police presence (16), lane facilities (17), culture, and education background (18).

This study analyzed violation behaviors (VBs) of Moped riders and VBs of bicycle and tricycle (BT) riders, at 12 signalized intersections in Shanghai. The study found several factors that can help us understand the antecedents and effects of Moped riders’ violation behaviors (VBs). We found the traffic environment (i.e., traffic facilities, background traffic and signal characters) to be more strongly associated with Moped VBs than either rider characteristics (gender and age) or vehicle characteristics (vehicle type and vehicle power). This means that different traffic environments affect the violation behaviors of Moped riders, but riders’ behaviors do not differ much under the same traffic conditions. The implication is that the traffic environment is the primary determinant of VBs.

We found that Mopeds riders commit more different types of VBs than BT riders. Also, the severity of conflicts following a Moped violation was significantly greater than that when there was no violation according to this study. This finding suggests it is likely that the

Figure 6 Conflict Likelihood and Conflict Severity Percentages of the Five Typical Moped Violation Behaviors
poor driving behaviors of Moped riders are placing others at risk. The regression model also showed that red light violations are positively associated with improper waiting. Riders running red lights depends to a large extent on the traffic conditions (red light violations occur most often when apparently safe). The same is the case with other moped VBs in that it is the traffic environment that limits or encourages improper behavior. For example, riders tend to ride a little bit outside the non-motorized lane or wait outside the legal waiting zone when the lane is tight. It should be noted that the data show fully 80.5% of light motorcyclists are actually illegally sharing the non-motorized vehicle lanes with BTs. One likely reason which could be is that these non-motorized lanes are much safer for mopeds than sharing the lanes with cars and trucks. Thus, the law is not effectively restricting riders’ behaviors and, therefore, should be revised. It was also shown that some electric bicycles riders wear helmets even though they are not required to by law. This suggests that some riders have strong safety concerns.

There continues to be a large gap in China in the understanding of Moped riders’ behaviors, including their violation behaviors. Behavioral analysis based on video data can be used effectively to examine the variables that underlie these behaviors and provide a stronger basis for the development of countermeasures. Some possible countermeasures will be considered in the next section.

5 RECOMMENDATIONS

Sound regulation could help to effectively control the use of Mopeds in China. Mopeds in both Taiwan and in the US and are well regulated in their specifications and operations (19). Also, in Taiwan, the policy is to encourage the construction of traffic facilities, such as electrical charging stations, to support Moped use. (20). Regulations should serve as effective guidance for Moped riders and need to be specific in encouraging or discouraging the use of Mopeds.

Legislation should take into account the history, background and the prevailing culture of Moped use to encourage better compliance with traffic law. It is recommended that legislation be considered that covers Moped categorizations, pre-riding qualifications, licensing, rules for Moped operation, and rules that specify precise enforcement protocols. Specifically, it is recommended that the law allow light motorcycles to ride with non-motorized vehicles because this would be safer for them then riding with cars and trucks. However, the Moped vehicle specification should be strictly limited by law to ensure the capabilities are do not exceed by too much the capabilities of bicycles and other vehicles that use the non-motorized lanes. Also, the non-motorized lanes could be designed to have signs and markings color matched to different types of Mopeds to help guide them to the left side of the non-motorized lane. License tags with specific colors for identifying different types of Mopeds and lane markings with corresponding colors could be considered. Traffic facilities could also offer separate, safe and comfortable riding and designated stopping areas for
Mopeds. The improvement of traffic facilities should be combined with the driving education that conveys the idea of facilities to riders.

While this paper has focused on Moped violations, previous crash research (especially motorcycle crash research (24)) has shown that in collisions with cars and trucks, it is usually the riders that are injured or killed, and it is often not the rider who is at fault in these collisions. It also should be noted that even if the Moped violation behaviors we observed in this study are found to frequently precede crashes, the extent to which they cause crashes is still an open question. Future work will examine this and other questions more closely.

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