Critique of "Evaluation of Shared-Use Facilities for Bicycles and Motor Vehicles"

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Evaluation of Shared-Use Facilities For Bicycles and Motor Vehicles is a monograph produced by the University of North Carolina Highway Safety Research Center for the Pedestrian/Bicycle Safety Office of the Florida Department of Transportation. The report can be found online at: http://safety.fhwa.dot.gov/fourthlevel/pdf/UnivNCMar96.PDF. An article of the same title is also available in Transportation Research Record No. 1578, pages 111-118.

Disclosure: I was employed by UNC HSRC at the time this study was conducted.

This critique is organized into two main sections: General Criticisms, which provides broad review, and Specific Criticisms, which offers detailed criticism of the study's main findings.

General Criticisms.

The study overstates its value.
Statement on page 1:
"The objective of this study was to evaluate the safety and utility of shared-use facilities in order to provide engineers and planners comprehensive results that can be used in planning, designing, and constructing roadways to be shared by motorists and bicyclists."

Criticism:
This study is far from "comprehensive." It examined only motorist and bicyclist lateral positions during overtaking operations on wide roads. These included bike lanes, paved shoulders, or wide curb lanes, all so-called "bicycle facilities." (Technically, only bike lanes are bicycle facilities.)

It is well known that the vast majority of bicycle-motor vehicle collisions, the measure of safety, occur via turning or crossing path maneuvers at junctions. Overtaking type collisions are rare, and have predisposing conditions, precipitating actions, and contributing circumstances that typically do not include road width. Wide roads especially, as examined in this study, are not implicated in Overtaking collisions. Further, wide roads are a minor subset of the roads bicyclists use. Every road is a "bicycle facility" unless bicyclists are prohibited by law.

Flawed and misleading research methodology.
Statement on page 5:
"The field data collection consisted of following traffic stream vehicles along each of the selected sites and videotaping and taking slides of the interactions between each motor vehicle followed and any bicyclists passed along the route."

Criticism:
"...any bicyclists passed...", as well as the cover photos imply that subjects were regular, traffic stream bicyclists who were examined happenstance. In fact, the subjects were a small group of recruited volunteers at each site who circled repeatedly over a given road segment. This was done because there were not enough normal traffic stream bicyclists to make data collection logistically feasible. Thus, (1) the data collected are homogenous since the same subjects were used repeatedly, were compromised by "learning," and likely rode in the same lateral positions; (2) the subjects knew they were being filmed, compromising their objectivity, which could have lead to altered lateral positioning; and (3) the failure to disclose the true nature of the sample is a clear breach of research integrity, and calls into question the veracity of the findings and conclusions.

Sloppy wording. Sloppy calculations?
There are several places in text, and in Figures 3 and 4 on page 8, where the authors confused their independent variables (all listed in Table 2 on page 11) of Total Paved Width (useable pavement width) and Total Width (useable pavement width plus the width of the gutter pan). It is possible that the authors similarly interchanged these variables when doing lateral distance calculations (as described on page 8 and in Figures 3 and 4), resulting in fatal errors. This will also be discussed in the Specific Criticisms section.

Faulty and simplistic reasoning.
Statement on the second page of the Executive Summary:
"Bicyclists are more likely to ride further from the edge of the roadway in a bicycle lane or a paved shoulder than they are in a wide curb lane. This increased distance from the roadway edge.....significantly increases the distance to the right of the bicyclist which can be used, if needed, as "escape" space." On page 23 the authors assert that this increased space "...can be used, if needed, to ... move further from passing traffic, e.g., a large truck."

Criticism:
The space to the right of a bicyclist is not "escape" space as the authors maintain. It is virtually impossible for a bicyclist to tell whether a passing motorist will be too close and to then take evasive action to avoid being struck. Moreover, this 1.2 feet of added space is not sufficient to be "escape" space even if it was possible to escape.

Statement on page 23:
"In general, the presence of the stripe separating bicyclists from motorists results in fewer erratic maneuvers on the part of motorists and enhances the comfort level for all roadway users."

Criticism:
The authors use the word "erratic" to describe motorist change in lateral position and encroachment on a left adjacent motor traffic lane to allow more clearance from bicyclists being passed. In fact, these maneuvers on the part of the motorist were calculated, controlled, and were not found to be dangerous. Indeed they are a benefit to bicyclists. Contradictorily, on page 6 the authors say, "Also recorded were any erratic maneuvers or braking applications which took place during the passing maneuver; these events were extremely rare and were not included in the analysis due to the small number."

Statement on Page 23:
"...it appears that bicycle lane widths as narrow as 3 feet can provide sufficient space for motorists and bicyclists to safely interact."

Criticism:
The authors' interpretation of "safely interact" was arrived at using only a small number of observations of overtaking motor traffic, and is not based on other more important interactions including turning movements and cross traffic operations. They did not address that a 3 foot bike lane is a substandard width bike lane, and a substandard width lane in general. When in a 3 foot bike lane or shoulder, the bicyclists were found to operate with their rear tire only 0.9 and 0.6 feet respectively from the line. This would have placed the bicyclists' left side over the line, encroaching into the adjacent lane. They fail to acknowledge that any bike lane reduces bicyclist operating space by de-legitimizing bicyclists' use of the standard lane(s), restricting (implicitly, or sometimes by law) bicyclists to the narrow rightmost portion of the road. Without the micro-management of a bike lane stripe, bicyclists have typically 10-15 feet of lane in front of them from which to choose their optimal lateral position for the conditions then existing.

Specific Criticisms

Following are criticisms of the study's four main findings. Three of the findings are touted by the authors as offering "distinct advantages." The four primary independent variables shown in Table 2 on page 11 of the study are listed below (The table shows five independent variables. However, Encroachment with Vehicle Present, ENCV, was not discussed by the authors.).

1. Lateral Position of Bicyclist (Distance of Bicyclist to Roadway Edge).

Finding:
Bicyclists rode 1.2 feet farther from the edge of pavement in a bike lane than a wide curb lane. This is offered as a distinct advantage of bike lanes as compared to wide curb lanes.

Criticism:
Operation further from the edge is indeed a positive behavior. However, while 1.2 feet may be statistically significant, the practical significance is questionable. Also, the bicyclists were not randomly selected, so their lateral positioning is not indicative of an unbiased population.

Statement on page 13:
"Another covariate showing a large effect on this MOE [measure of effectiveness] was total width: as the total width of the roadway increases, so does the distance of the bicyclist to the roadway edge."

Criticism:
Here the authors say "total width," but Table 3 lists Total *Paved* Width, a different variable. It is unclear whether this error is simply one of semantics, or extends to errors in calculations which would bear heavily on results. In either case, it reflects careless work.

Why bicyclists rode farther from the edge in a bike lane is unclear. The authors assert that bicyclists have greater comfort behind a stripe (from their statement on page 23), and that this manifests in riding further left. On page 1 the authors defined comfort as "...reducing unpredictable or potentially unsafe movements by either motorists or bicyclists and minimizing the risk of a conflict or crash." The authors have varying definitions of "comfort."

An alternative explanation is that bicyclists rode further left closer to the bike lane stripe to avoid rightmost debris. See Figures 1 and 2.

Figure 1. Typical debris in a bike lane causes bicyclists to ride further from the edge of pavement.
Pittsboro St., Chapel Hill, NC.

Figure 5 on page 12 of the report shows that bicyclists in a bike lane or paved shoulder tracked 2.7 feet from the roadway edge on average, with a range of 0.2 feet to 5.0 feet. From Table 11 of the report, the average width of the 10 bike lanes/paved shoulders was 4.4 feet with a range of 3.0 to 6.5 feet. The 2.7 foot tracking distance is 61% of the 4.4 foot bike lane width. Bicyclists riding 5.0 feet from the edge were using 77% of the 6.5 foot bike lane. Figure 6 of the report shows that bicyclists rode 2.1 and 2.4 feet from the edge of road in a 3.0 foot bike lane or shoulder, only 0.9 and 0.6 feet from the line, respectively. Clearly, in this study the bicyclists rode on the left half of their prescribed space, close to the bike lane line. In the 3.0 foot cases, the bicyclists' left sides would have encroached on the adjacent "motor vehicle" lane!

Figure 2. Motor vehicles sweep debris right, just over bike lane stripes to where they don't operate, causing bicyclists to ride further left. Without the stripe, debris is pushed further right, out of bicyclists' typical traveled way. Country Club Rd., Chapel Hill, NC.

Why would the bicyclists purposely ride closer to motor traffic, and why didn't they operate down the center of their marked area, as would be expected? Debris is a plausible explanation.

2. Separation Distance Between the Motorist and the Bicyclist.

Finding:
Motorists pass bicyclists with approximately 0.5 feet more clearance in a wide curb lane than when in a bicycle lane.

Criticism:
This is expected positive behavior, and a benefit to bicyclists. But this finding was not noted by the authors as a plus for bicyclists.

Statement on Page 22:
"In general, the motorist positioned their vehicle (sic), on average, between 5.9 ft (bicycle lane) and 6.4 ft (wide curb lane) from the bicyclist as the passing maneuver was initiated. Since this distance is obviously controlled by the motorist, it appears that a distance of approximately 6 ft to 6.5 ft is the spacing with which the motorist is most comfortable."

Criticism:
It is well known that bicyclist lateral position in normal lanes plays a key role in motorist overtaking behavior. Indeed, it is a cornerstone of bicyclist education, and promulgated by experienced bicyclists, that bicyclists can and should sometimes "control" overtaking motorists by their lateral positioning. More assertive lateral positioning compels or forces motorists to be more cautious, improving their behavior. Conversely, by riding too far to the right, bicyclists enable poor passing behavior, which is sometimes realized.

In the study, the mainly volunteer bicyclist subjects rode a very close 1.4 feet from the edge of the roadway when in a wide curb lane. Had they operated at a more assertive, say 4 foot position, many passing motorists would have fully moved into the adjacent lane to pass. With a more aggressive lateral position near the center of the lane, all motorists would have changed lanes. See Figure 3.

Figure 3. Bicyclist lateral position exerts a large measure of control on motorist overtaking behavior. Here, the bicyclist is preparing for a high speed descent requiring considerable operating space.

Statement on page 14:
"The results of the ANCOVA, shown in table 5, indicate that the significant covariates were facility type, vehicle presence, gutter pan presence, number of lanes, and total width."

Criticism:
In Table 5 on page 14, the variable Total Paved Width is again shown, rather than Total Width as is stated in the text. Again, it is unclear whether this error is simply in the wording, or is symptomatic of errors in procedures which altered calculated results.

3. Change in Motorist Lateral Position.

Finding:
Motorists have less variation in their lane placement (about 1.5 feet or less) when passing a bicyclist on a bicycle lane or paved shoulder facility. This is offered as a distinct advantage of bike lanes as compared to wide curb lanes.

Criticism:
This variable was defined as "the difference between the position of the motorist at the time the bicyclist was passed and the position of the motorist downstream of the bicyclist." While the variation distance was found to be statistically significant, it is questionable whether it is practically significant. Moreover, what is the useful significance of the motorist's position downstream having already passed the bicyclist? Rather than an advantage, it can be argued that consistent motorist lateral position is irrelevant, at best. At worst, the pursuit of consistent motorist lateral position by confining bicyclists to a substandard width lane (by definition, any bike lane) at the side of the road can be thought of as absolving motorists of their need to react to bicyclists' presence. This is not a benefit to bicyclists.

Statement on page 15:
"Results from the ANCOVA are shown in table 7 and indicate that the significant covariates affecting this measure were facility type, gutter pan presence, area type, number of lanes, speed limit, total width and vehicle presence."

Criticism:
In Table 7, Total Paved Width is shown again rather than Total Width as is stated in the text.

4. Motorist Encroachments (into left-adjacent lane).

Finding:
There were more encroachments on wide curb lane roads (22.3%; 15.4% unadjusted) as compared with bicycle lane (8.9%; 10.9% unadjusted) or paved shoulder roads (3.4%; 5.3% unadjusted). This is offered as a distinct advantage of bike lanes as compared to wide curb lanes.

Criticism:
Significant covariates here were found to be Area Type, Gutter Pan presence, Vehicle Presence, and Facility Type. Notably absent were Total Paved Width (or Total Width; it is unclear which) and Number of Through Travel Lanes. They *were* significant factors in the other three dependent variables. What is the plausible explanation for why they were not found to be significant here?

It makes intuitive sense that Total Pavement Width should be important in whether a motorist encroaches or not. The actual widths are given in Table 11 in the report's Appendix. The widths of the three wide curb lanes used were 15, 14, and 14 feet, an average of 14.3 feet. There were 10 bike lane or paved shoulder roads. Two were 14 feet total, two were 15 feet, one was 15.5 feet, three were 16 feet, one was 17 feet, and one was 19.5 feet, an average of 15.8 feet. This is 1.5 feet greater than the wide curb lane average. Since bicyclists rode 1.2 feet further from the edge in a bike lane, and motorists passed bicyclists by only 0.5 feet more in a wide curb lane, the increased encroachments in a wide curb lane should in part be explained by less total pavement width of wide curb lanes.

Furthermore, it is highly unlikely there were any encroachments at the very wide 17 feet and 19.5 feet bike lane sites. It is similarly unlikely that any encroachments would have occurred in wide curb lanes of the same width, had they existed.

Regarding number of lanes, two of the 10 bike lane/paved shoulder roads had only 2 lanes. At those locations, encroachment would likely have been more difficult as compared to 4 lane roads, which allow more freedom to maneuver. All of the wide curb lanes were 4 or 6 lane roads.

Given the differences between wide curb lane roads and bike lane/paved shoulder roads in terms of total pavement width and number of lanes and the expected effects on motorist encroachment, the lack of statistical significance for these variables requires explanation.

Finally, the authors assert that overtaking encroachment is unsafe. Yet there were no negative safety findings. An alternative explanation must be that such encroachment was not dangerous and was done simply as a courtesy and benefit to bicyclists. See Figure 4.

Figure 4. The motorist encroached only because it was safe to do so, and as a courtesy.

Critique Conclusions

Evaluation of Shared-Use Facilities For Bicycles and Motor Vehicles overstates its value by claiming to be "comprehensive;" has flawed and misleading research methodology because predominantly volunteer subjects were used rather than traffic stream bicyclists as implied; uses sloppy wording that transposed two key independent variables, raising the issue of the possibility of erroneous calculations; and employs faulty and simplistic reasoning.

Given these failings, it is reasonable to question the quality of the lateral spacing findings, and study conclusions. Moreover, alternative explanations for the findings are well known.

Lateral position of the bicyclist was likely largely influenced by the homogeneity of the assistant bicyclist subjects, and debris in bike lanes and paved shoulders which compels bicyclists to have a more left tracking position. Separation distance between the motorist and bicyclist in shared lanes is known to be strongly related to lateral position of the bicyclist, but this was not addressed, and the increased separation distance in a wide curb lane was not recognized as a benefit to bicyclists. The importance of change in motorist lateral position, defined as the difference between the position of the motorist at the time the bicyclist was passed and the position of the motorist downstream, is questionable. The motorist encroachments analysis is suspect because key variables were inexplicably found to be not significant, and the conclusion that encroachments are erratic and a detriment is unsupported.

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John Forester provides his own critique at:
www.johnforester.com/Articles/Facilities/BLvsWCL.htm