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ORIGINAL RESEARCH

Ramp-Related Incidents Involving Wheeled Mobility Device Users During Transit Bus Boarding/Alighting

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Abstract

Objectives: To estimate the prevalence of wheeled mobility device (WhMD) ramp-related incidents while boarding/alighting a public transit bus and to determine whether the frequency of incidents is less when the ramp slope meets the proposed Americans with Disabilities Act (ADA) maximum allowable limit of $\leq 9.5^{\circ}$.

Design: Observational study.

Setting: Community public transportation.

Participants: WhMD users (N=414) accessing a public transit bus equipped with an instrumented ramp.

Interventions: Not applicable.

Main Outcome Measures: Prevalence of boarding/alighting incidents involving WhMD users and associated ramp slopes; factors affecting incidents.

Results: A total of 4.6% (n=35) of WhMD users experienced an incident while boarding/alighting a transit bus. Significantly more incidents occurred during boarding (6.3%, n=26) than during alighting (2.2%, n=9) ($P<.01$), and when the ramp was deployed to street level (mean slope=11.4°) compared with sidewalk level (mean slope=4.2°) ($P=.01$). The odds ratio for experiencing an incident when the ramp slope exceeded the proposed ADA maximum allowable ramp slope was 5.4 (95% confidence interval, 2.4−12.2; $P<.01$). The odds ratio for assistance being rendered to board/alight when the ramp slope exceeded the proposed ADA maximum allowable ramp slope was 5.1 (95% confidence interval, 2.9−9.0; $P<.01$).

Conclusions: The findings of this study support the proposed ADA maximum allowable ramp slope of 9.5°. Ramp slopes >9.5° and ramps deployed to street level are associated with a higher frequency of incidents and provision of assistance. Transit agencies should increase awareness among bus operators of the effect kneeling and deployment location (street/sidewalk) have on the ramp slope. In addition, ramp components and the built environment may contribute to incidents. When prescribing WhMDs, skills training must include ascending/descending ramps at slopes encountered during boarding/alighting to ensure safe and independent access to public transit buses.

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Many of the 2.7 million wheelchair users[1] in the United States rely on public transportation to access work, medical care, school, and social activities. Studies indicate that approximately 40% of wheelchair users encounter problems when attempting to access public transit[1,2] and that most incidents involve traversing the wheelchair ramp to board/alight the bus.[3,4]

The Americans with Disabilities Act (ADA) Accessibility Specifications for Transportation Vehicles[5] states that "ramps shall have the least slope practicable" (Subpart B, §1192.23(c)(5). However, as currently written it is difficult, if not impossible, for bus operators to ensure compliance with ramp slope requirements, given variations in the built environment (eg, curb vs street deployment) and extent of vehicle kneeling implemented by bus operators. In 2010, the U.S. Access Board announced a Notice of Proposed Rulemaking to revise the Accessibility Guidelines for Transportation Vehicles that provide minimum accessibility requirements for public transit buses. The U.S. Access Board proposed reducing the maximum allowable ramp slope from 14.0° (1:4) to 9.5° (1:6) when deployed to boarding/alighting areas.[6]

Ascending/descending an inclined ramp with little clearance on either side of a wheelchair or scooter (collectively, wheeled

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mobility device [WhMD]) can be challenging. Chen et al[7] reported that 20% of accidents experienced by wheelchair users involved traversing over sloped terrain. Our previous retrospective review of wheelchair-related adverse incident reports maintained by a metropolitan transit agency revealed that WhMD users experienced more incidents when using bus ramps (42.6%) than during transit (33.9%) and 43.6% of ramp-related incidents resulted in injury.[3] Our subsequent pilot study using video surveillance footage indicated that steep ramp slopes were associated with 27.5% of ramp-related difficulties and incidents.[4] However, the ramp slope was not measured. We subsequently installed an inclinometer in a transit bus ramp to assess in situ deployed ramp slopes encountered by WhMD-using passengers.[8] The findings revealed that ramp slopes measured in situ were skewed toward steeper slopes (range, −4° to 15.5°), exceeding the proposed ADA maximum allowable ramp slope of 9.5° (1:6).

In this study, we sought to determine the prevalence of ramp-related incidents among WhMD users when boarding/alighting public transit buses. We hypothesized that ramp slopes less than or equal to the proposed ADA maximum allowable ramp slope (9.5°) would be associated with fewer incidents. Secondarily, we sought to identify WhMD characteristics, ramp-related factors, and features of the built environment associated with incidents. The findings from this study could inform transit bus ramp designs and affect policies related to public transit accessibility.

Methods

Participants

This study was conducted in accordance with the University of Louisville institutional review board (IRB protocol #12.0098). The study population consisted of WhMD-using passengers observed boarding/alighting a public transit bus equipped with a video surveillance system and instrumented ramp. Transit buses are randomly assigned daily to operators and routes throughout the urban/suburban service region. Signs posted on all camera-equipped buses notify passengers that activities are monitored/recorded for public safety.

Vehicle and instrumentation

A single, low-floor transit bus[a] equipped with a foldout ramp[b] was used for this study. Boarding and alighting activities were recorded using a 2-camera system previously described.[8] One camera provided an overhead view of the front interior portion of the bus, ramp, and external terrain (~3m beyond the deployed ramp). A second camera was mounted beneath the operator's seat platform and provided a view of the lower portion of the WhMD during contact with the ramp and in the bus. Together, these cameras provided views of the external terrain, WhMD user's ramp approach, and WhMD user's ramp ascent/descent and turn into/from the bus aisle. The ramp slope was measured using an inclinometer mounted within the ramp structure that interfaced with a data logger as previously described.[8] Video files and inclinometer data were time stamped for synchronization.

List of abbreviations:

ADA	**Americans with Disabilities Act**
CI	**confidence interval**
MWC	**manual wheelchair**
PWC	**power wheelchair**
WhMD	**wheeled mobility device**

Data collection and analysis

Ramp slope and video data were retrieved every 7 to 10 days over a 15-month period. Videos were reviewed (C.S., K.L.F.); if uncertainty or disagreement occurred, the video was concurrently reviewed and discussed, and additional input (G.B.) was obtained as needed.

Data for each WhMD-using passenger's boarding/alighting event were abstracted and compiled into a database.[c] Data collection included WhMD type and drive wheel position, approximate WhMD ramp approach angle, wheelchair orientation on ramp, ramp deployment level (street/sidewalk), ramp slope, whether or not a difficulty or incident occurred while accessing/traversing the ramp, ramp component(s) involved in difficulty/incident, and whether or not assistance was provided. The WhMD approach angle was used as a proxy for constraints encountered in the built environment that prohibited approaching the ramp coincident with its path of travel (approach angle aligned with the ramp, approach angle misaligned up to 30°, approach angle between 30° and 60°, or approach angle between 60° and 90°).

A "difficulty" was defined as an event involving ≥2 maneuvering attempts to reorient the WhMD or a minor impact with a bus or ramp component while the WhMD was in contact with the ramp. Difficulties would not cause the WhMD to stop or require third-party assistance, but might require the WhMD user to make ≥2 attempts to traverse the ramp, increasing the boarding/alighting time. An incident was defined as (1) WhMD tipping with ≥1 wheels leaving the surface (WhMD may or may not tip over, and passenger may or may not fall from the WhMD); (2) WhMD-seated passenger falling from the WhMD; or (3) major impact with a bus or ramp component interrupting WhMD forward movement and possibly requiring third-party assistance. The prevalence of WhMD-related incidents and difficulties and factors contributing to ramp-related incidents were determined.

Descriptive statistics[d] were used to describe WhMD types, frequencies and proportions of incidents and difficulties, and factors associated with incidents. Analysis of variance and independent chi-square tests[d] were used to determine whether significant relations existed among dependent and independent variables. Chi-square analysis was performed to test the hypothesis that ramp slopes below the proposed ADA maximum allowable ramp slope (9.5°) would be associated with a decreased rate of incidents. Significance was established at $P \leq .05$, and statistical analysis was conducted using SPSS version 21.[d]

Results

The transit bus used in this study is 1 of 240 operated by a metropolitan transit agency serving a population of approximately 1.3 million. The transit agency reports an average of 10,400 to 13,000 annual WhMD trips. The geographic region sits on a flat floodplain with gently rolling hills.

Four hundred fourteen WhMD-using passengers were observed boarding and/or alighting the bus (3 attendant-propelled strollers were excluded from the analysis because of the small sample size). In 2 cases, only boarding was captured, and in 1 case, only alighting was captured, resulting in small differences in sample size. Most of the WhMDs boarding/alighting were power wheelchairs (PWCs) (table 1). Among PWCs, 126 were front-wheel