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Institutionen för Folkhälsovetenskap

PRIORITIES AND POTENTIAL OF PEDESTRIAN PROTECTION

**- ACCIDENT DATA, EXPERIMENTAL TESTS AND
NUMERICAL SIMULATIONS OF CAR-TO-PEDESTRIAN
IMPACTS**

AKADEMISK AVHANDLING

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ABSTRACT

Pedestrian disability and fatality as a consequence of car crashes is a large global health problem. To introduce maximally effective car-based countermeasures it is important to understand which injuries are most common and from which car parts they originate. It is also important to focus on the most severe injuries resulting in disability or death. The aim of this thesis was therefore to determine priorities for and evaluate the potential of car-mounted safety systems designed to mitigate severe upper-body injuries (including disability and fatality) of pedestrians in car crashes.

Accident data was collected from two areas; severe (AIS3+) accidents in Dresden/Hannover in Germany and fatal accidents in Sweden. For the surviving pedestrians an estimate of long-term injury was performed using accident data-derived risk matrices of permanent injury. Results showed that 31% would sustain a permanent impairment of some kind and 5% would sustain a more severe impairment, where the head was most susceptible to severe impairment. The car front frequently caused leg injuries, which is addressed in current regulations. However, current legal tests do not address the most common upper-body injury source, the windshield, which was found to be the dominating cause of head injuries. Chest injuries, frequently caused by both the hood and windshield areas in the severe and fatal crashes in this thesis, are also unaddressed in legal tests. Children are most commonly head-injured from the hood area, which is addressed in current regulations. Further, regulations do not fully consider brain injury with the current head test methods. Therefore, in this thesis focus was on upper-body injury/source combinations not addressed in the regulations, that is, the head-to-windshield area and chest-to-hood/windshield areas, and the evaluation of brain injury in hood and windshield impacts.

Experimental head-to-hood component tests with succeeding brain simulations were performed to evaluate the influence of the under-hood distance and head impact speed. A hood designed to minimize linear head loading to acceptable injury levels was also found effective in reducing combined linear/rotational brain loading. Further, in full-scale car-to-pedestrian finite element simulations both a braking and deployable system alone proved efficient in reducing head and chest loading, and an integrated countermeasure of combining the two systems proved to increase the protection potential.

While current pedestrian countermeasures focus on the head-to-hood impact, this thesis recommends extending countermeasures to the lower part of the windshield and the A-pillars, and adding brain and chest injury assessment for both hood and windshield areas to effectively minimize disabling and fatal injuries. Since head impact location and head impact speed is dependent on the car design, the introduction of full-scale simulations in the test methods to determine impact conditions for experimental component tests is recommended. If the deployable countermeasures are combined with autonomous braking in an integrated system the most effective system is achieved. Auto-brake systems should, in high speed impacts, aim to reduce speeds to where the secondary countermeasures can effectively mitigate injury. Future pedestrian test methods should therefore evaluate how primary and secondary countermeasures interact.