were developed. The majority of these studies had a follow-up period of one week or less which is clearly not enough time to assess effectiveness. The individual or worker-focused intervention studies lack detail about the intervention making replication difficult. The presence of few and dissimilar studies limits the conclusions about the effectiveness of worker-focused interventions.

At this time, intervention effectiveness research on upper extremity injuries is mostly preliminary and descriptive, but this body of work does suggest several possible directions for larger-scale and more definitive research. One promising area involves interventions that combine participatory and engineering/redesign efforts. A second area involves interventions that are more theory-based and more closely linked to identified injury mechanisms. And third, research might benefit from a more ecological or systems focus that would acknowledge interactive links between worker, task, organizational, and extra-organizational influences.

THE PROGRESS OF OCCUPATIONAL SAFETY RESEARCH: KNOWLEDGE AND GAPS

Hongwei Hsiao, Ph.D.

Occupational injuries pose a continuing major threat to the health and well being of American workers. On a typical day, an estimated 16 workers are killed and more than 36,000 workers are injured (Jenkins et al., 1993). The associated economic costs are high, costing the nation more than AIDS and as much as cancer and heart disease (Leigh et al., 1997). Yet the investment in occupational injury preventions is slim compared to resources dedicated to disease prevention research (NIOSH, 1998). Approaches for reducing occupational injuries and their cost in the workforce may include redesign of work practices, work environments, equipment, and tools to eliminate hazards. For hazards that cannot be eliminated, such as exposure of fire fighters to fires, the personal protective equipment (PPE) is served as the last line of defense for the worker (Hsiao and Halperin, 1998).

The influence of some factors on the safety performance of occupational tasks has been studied for more than 50 years (NIOSH, 1988). The results have been developed into standard industry practice and guidelines to reduce the risk of occupational injury. However, the etiologies of many occupational injuries are still not clear, particularly when human-environment/ system/ task interactions are involved. The author will discuss the knowledge we now possess and certain critical gaps concerning occupational injury control. The safety research activities in NIOSH will also be presented. These thoughts are derived from literature as well as from several NIOSH-organized workshops (NIOSH, 1998; Pizetella and Hsiao, 1998; Hsiao et. al., 1997).

TRANSPORTATION HUMAN FACTORS

Rudolf G. Mortimer

Traffic fatalities in the US have been reduced from about 56,000 in 1967 to 42,000 in 1997 in spite of steadily rising miles of travel. Human Factors research has played a role, though it would be difficult to quantify. Initial thinking by safety researchers in the 1930s was that there were accident prone drivers who caused a substantial proportion of crashes, and, hence, personality factors should be studied. Later statistical studies did not confirm accident proneness which led to an emphasis on human factors and the traffic system.

Research on the size, width, color and contrast of letters used to ensure adequate legibility of signs for route guidance was among the first by human factors researchers to have a direct impact, and forms the basis for recommended standards of such installations.

By studying the overtaking behavior of drivers, HF researchers in the 1940's and 50's began to learn about the basis of those judgements and their accuracy, which helped to provide guidelines for passing zones as well as identifying the need for means to aid drivers in making passing decisions. Such aids are still sorely needed.

Traffic signs have received considerable attention by HF researchers whose work has defined the current symbolic, diagrammatic and verbal signs in studies that have evolved over many decades.

Motor vehicle design, including brake systems, headlighting and other vehicle lighting as well as the driving compartment, controls and displays have benefited from HF research and application. One example, that has been often cited as a human factors success is the high-mounted stop lamp. However, this is also an example where human factors research was used to require an apparently beneficial change in the design of the motor vehicle rear lighting system that did not live up to its original expectations, although it has contributed to a modest reduction in rear-end collisions.

Human factors research has also been applied to reduce alcohol as a factor in crashes. This includes the recommendations for improved roadway delineation for better lateral control of vehicles on the road especially at night, alcohol ignition interlocks that can prevent inebriated drivers from starting their vehicles, and basic research that has shown how drivers' visual search is affected by alcohol.

The advent of new technologies poses new challenges. Human factors research under the general rubric of Intelligent Traffic Systems (ITS) has been concerned with, among others, the development of guidelines for the design of on-board mapping and guidance devices. Clearly, such devices take away some of the driver's attention from the basic driving task while, at the same time, providing useful information that can reduce the driver's uncertainty and thereby allow more attention to be paid to the basic task and reduce stress and anxiety. It can allow drivers to plan ahead so that they can position their vehicle for a future maneuver. Studies of telephone use by drivers have shown that they distract from the driving task. Turning the vehicle into a mobile office can have similar negative effects and will require human factors design to minimize those effects.

Computer technology and improved sensors also allow the development of systems that can relieve drivers of aspects of the driving task. Cruise controls that automatically adjust the spacing between vehicles by acceleration and deceleration and that apply the brakes, if needed, have been studied and are

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