Fig. 2. System representation at different spatial scales

The economic capacity is based on the benefits generates through the provision of services, i.e., mobility for people and goods through taxes or toll roads. In some cases, infrastructure assets such as bridges or viaducts may also provide a cultural and historical value that is transformed into economical service related to tourism.

REFERENCES

1.P. Gardoni, C. Murphy, Society-based design: promoting societal well-being by designing sustainable and resilient infrastructure, Sustain. Resil. Infrastruct. 5 (1–2) (2020) 4–19.

2.W. Sun, P. Bocchini, B.D. Davison, Resilience metrics and measurement methods for transportation infrastructure: The state of the art, Sustain. Resil. Infrastruct. 5 (3) (2020) 168–199.

P. Khriap (PhD Student, PSACEA, Dnipro)
Scientific supervisor: V. Shalomov, Cand.Sc. (Tech), Assoc. Prof.
Language consultant: K. Sokolova, Cand. Sc. (Phil), Assoc. Prof.

ANALYSIS OF THE IMPACT OF INDUSTRIAL GLOVES ON THE PERCEPTION OF HAND DEXTERITY, FUNCTION AND STRENGTH OF HANDS BY THE EXAMPLE OF THE US CONSTRUCTION INDUSTRY

Work-related hand injuries can have significant functional implications. If a worker sustains amputations to all five digits of one hand, this injury represents an overall impairment of 90% of the upper extremity and, thus, 54% of the whole person. In 2020, over 102,000 workers sustained hand injuries resulting in days away from work, according to the U.S. Bureau of Labor Statistics (U.S. Bureau of Labor Statistics, 2021). A systematic review calculated the total costs of acute hand and wrist injuries consisting of direct costs (healthcare costs, worker's compensation payments) and indirect expenses (lost productivity, accident investigation) could range from $3257 to $169,408. As such, glove wear is a critical component of personal protective equipment (PPE), and the type of glove utilized must be based on the nature of the exposure.

Among those in the building industries, exposure to awkward postures and confined spaces lead to musculoskeletal disorders, which decrease efficiency and increase the risk of injury. The most severe hand injuries in the building industry have been associated with maintenance tasks, roof bolters, and equipment operations. These hand injuries are attributed to exposure to metal parts (e.g., pipe, wire, and nails), metal covers and guards, inserting roof bolts, drilling steel, and maintaining belt conveyors. Injuries to the hands occur almost evenly to both the right hand (48%) and left hand (52%).

To mitigate the direct and indirect injury costs, workers in industrial settings such building and extraction are often required to wear industrial metacarpal gloves as PPE. In some situations, employers provide or mandate PPE gloves to be worn without assessing the glove's impact on the worker's effectiveness in completing various tasks required for the job. Workers wear those gloves to complete various occupation specific tasks, including manipulating tools and equipment. However, if the gloves do not fit well or limit their dexterity, workers may be non-compliant with glove-wearing requirements, thus increasing the risk of severe injuries. Researchers recently identified 16 factors that contribute to PPE non-compliance in the construction industry, including poor risk perception and safety supervision.

Previous studies focused on evaluating the level of mechanical protection offered by metacarpal gloves , but there is limited research examining the impact of metacarpal gloves on manual hand dexterity, strength, and perception of exertion, within heavy-duty industries. Prior pilot research on metacarpal gloves was conducted with a small-sized subject pool (Fig. 1). In this previous pilot study, the participants were predominately student younger females who were asked to complete dexterity tests (placing and turning tests) and hand strength tests (grip, pinch, and pronation) with bare hands and wearing a selection of metacarpal gloves. While females represent 5–10% of the global building and extraction industry workforce and are known to have differences in hand strength compared to males of the same age, the sample size and age selected for the pilot was not representative of the predominantly male population who typically would wear metacarpal gloves in building industries. The pilot study indicated that a bigger and more diverse set of participants, including males of working age (~23–65 years old), would be needed to generalize the results.

Based on the previous pilot study and shortcomings seen in the literature, this study aims to determine the effect of metacarpal gloves on hand dexterity, hand strength, and perceived exertion by conducting a series of standardized tests and involving a more robust representative sample. The specific objectives of this study are:

1) Quantify hand dexterity achieved while wearing metacarpal gloves, as compared to bare hands, with respect to gender;

2) Quantify gender-specific hand grip strength while wearing a metacarpal glove, as compared to bare hands;

3) Quantify the perceived exertion completing simulated work tasks while wearing gloves, as compared to bare hands, with respect to gender.

We hypothesize an inverse relationship with metacarpal gloves that offer higher levels of mechanical protection (i.e., impacts, punctures, abrasions) will negatively influence hand dexterity and exertion.

Therefore, the safety professional must view glove selection with a holistic consideration of fit, protection, dexterity, type of exposure, cost, and quality.

Fig. 1. Industrial metacarpal gloves selected for testing. All branded labels have been intentionally removed from the figure to prevent bias. The gloves are presented from thinnest (Glove 1) to thickest (Glove 3).

The more protective features the glove has, the less flexible it becomes and the higher its impact on dexterity. Sturdier gloves offer the most mechanical protection but at the expense of reduced flexibility and, thus, decreased dexterity. Conversely, relatively thinner and more flexible metacarpal gloves offer lower mechanical protection but allow much more dexterous function.

Protection against injury is an important mitigation strategy against lost productivity, healthcare spending, and worker's compensation payments. However, these results suggest that employers and safety professionals should consider all aspects of a glove, its potential impact on hand function, and the task requirements when selecting gloves for worker utilization.

REFERENCES

1. Baltimore Therapeutic Equipment (BTE) Technologies, 2023. Rehabilitation equipment. Primus RS. Retrieved February 10, 2023, from: https://www.btetechnologies.co m/rehabilitation/primus/.

2. U.S. Bureau of Labor Statistics, 2021. Number of nonfatal occupational injuries and illnesses involving days away from work by nature of injury or illness and selected parts of body affected by injury or illness private industry, 2020. Retrieved February 10, 2023. https://www.bls.gov/iif/nonfatal-injuries-and-illnesses-tables/case-and-demographic-characteristics-table-r13-2020.htm.

3.Viradia, R., Annie, F., Kali, M., Pollock, F., Hayes, J., 2021. Hand injuries of coal miners in Southern West Virginia: a pilot study on health-care resources in Southern West Virginia. J. Emergencies, Trauma, Shock 14 (1), 18. https://doi.org/10.4103/JETS. JETS_39_19.

S. Kodola (PSACEA, Dnipro)
Scientific supervisor: V. Shalomov, Cand.Sc. (Tech), Assoc. Prof.
Language consultant: L. Druzhinina, Assoc. Prof.

EVACUATION ROUTE DESIGN BASED ON VISIBILITY FOR REDUCING EVACUATION DELAYS

Fire-related incidents continue to pose a significant threat to human life in spite of advancements in fire prevention technology and legislation. It is reported that almost half of the fatalities resulting from fires are caused by delayed evacuation in Ukraine. Recent incidents in which victims were unable to evacuate, in which people lost their lives. When the electrical system stopped, the doors of the train cars closed. Many victims did not know how to open the doors manually, which led to the inability to evacuate. Opening doors and locating evacuation exits is a challenge in many emergency situations. Unfortunately, this has led to tragic outcomes in some cases. [1-3]

Fig. 1 shows the evaluation structure of visual environment, which is closely connected with three factors: environmental conditions, object conditions, and human visual ability. Visual stimulus is defined by the former two factors, while visual sensitivity is defined by the latter. The evaluation of visual response, or visibility, depends on both visual stimulus and visual sensitivity. Visual stimulus is represented by four elements: size (m) or visual angle (arc minutes) of the visual target, adaptation (background) luminance (cd/m2), luminance contrast between the visual target luminance and background luminance (no units), and observation time (milliseconds).