

Assessment of greenhouse pesticide applicators' needs for personal protective gear (PPG)

Sanjay Guria, and Huiju Park, Cornell University, USA

Keywords: pesticide, protection, comfort, mobility

Introduction: Pesticides are widely used in agricultural production to control infestation by pests, reduce potential yield losses and ensure high produce quality (Damalas and Eleftherohorinos, 2011). However, the poisonous nature of pesticides can entail a high risk to human health, depending on exposure levels. Under the jurisdiction of the Environmental Protection Agency (EPA), risk assessments are conducted to determine the mitigation required to protect the health of pesticide applicators handling pesticides. Appropriate personal protective gear (PPG) consisting of coverall, face mask, respirator, gloves and boots, is a basic tool for risk mitigation that can provide an effective barrier between the pesticide and the human body. Generally, PPG is made of thick, stiff and highly impermeable material causing heat stress, bulkiness and impaired mobility. This impacts the efficiency of the applicators along with acceptability of the protective gear, and improper use resulting in risks of contamination. This study aimed to identify possible channels of contamination and concerns related to heat stress, fit and mobility of the existing PPG and provide suggestions for improved PPG design.

Methods: A multi-method approach was used to record user issues and functional limits to the performance of the PPG in field. A questionnaire followed by a semi-structured focus group interview was conducted with Institutional Review Board approval. Four males (age: 38.8 ± 5.4 years; work experience 14.5 ± 1.1 years, 23.9 BMI) and 4 females (age: 44 ± 5.6 years; work experience 24.3 ± 4.0 years, 33 BMI) greenhouse pesticide applicators from upstate New York participated in the study. Information was collected regarding (1) participants' demography (e.g. gender, age, height, weight, ethnicity, work experience etc.) (2) work dynamics and work environment, and (3) issues and concerns related to the use of the PPG. Participants wore their respective PPG to demonstrate common working positions and highlight size, fit, mobility, donning, doffing issues and stress areas. Photo and video documentation further supplemented the questionnaire and interview data.

Results & Discussions: Findings of this study highlighted four major issues related to the existing PPG. *Heat Stress:* From the questionnaire and focus group interview, heat stress emerged as the key physiological strain affecting the performance of the pesticide applicators. Several factors, like the kind of task (activity), design, fit, material of the PPG and environmental conditions (greenhouse) affected thermal comfort. Of the primary tasks of mixing, loading and application, spraying of pesticides while wearing PPG inside the greenhouse, emerged as most thermally uncomfortable. Radiant heat and absence of airflow led to heat built-up inside the coverall while working. There was considerable sweating at the chin inside the respirator, which led to fogging, thereby affecting visibility and performance.

Mobility: The design of current PPG limited mobility in several ways. Incorrect size of PPG, improper fit, uncomplimentary design, weight and bulkiness, type of task and equipment being handled affected work efficiency considerably. As the PPG design is unisex, it isolated several fit issues of individual gender. Female pesticide applicators preferred to go one size up for the coverall, as they felt ease at the bust and hip region to be insufficient during extended body movement. The sleeve and pant inseam was reported to be longer leading to bunching up of excess material at the wrist and ankle, negatively impacting work efficiency. The excess material can lead to rips and tears increasing chances of contamination and raising safety concerns. Analysis of common work postures revealed improper fit leading to restrictive movement during elbow, knee and hip flexion. Some applicators tucked their coverall sleeves inside the rubber gauntlets, which restricted arm extension. Instability of the face mask during movements affected performance. The integrated booties of the coverall bunched up inside the boots. *Integrity of the interface and contamination:* Risk of contamination was observed with loss of integrity of the interface between hood and face mask, gloves and coverall sleeves and bottom hem of pants and boots. This was an outcome of poor garment design further accentuated by extended body movements. Prominent gap was noticed during hyperextension of the neck, resulting in unzipping of front zipper thereby exposing base of the neck. Oversize rubber gloves did not conform to hand anthropometry, affecting dexterity of the fingers and was reported to turn slippery when wet. A few issues of fogging were reported which was a result of incorrect sealing of the face mask. *Behavioral responses:* Video analysis revealed improper doffing to be a common channel of contamination. Inconsistencies in applicants' knowledge and compliance to safety in practice was observed. Work procedure and attitude to risk mitigation varied from participant to participant, which could be a barrier for further improvement of the design of PPG.

Incorporation of conductive, convective or phase change cooling mechanism that alleviate heat stress in confined spaces (e.g. greenhouse) could greatly improve the thermal comfort in the current PPG. Furthermore, a new sizing system and fit suggestions need to conform to gender specific requirements. Future studies will be conducted with a larger sample size of pesticide applicators from different geographical locations that will provide a richer and more diverse set of data. Application of technologies like 3D motion tracking for dynamic body movements and 3D scanning of the applicators work procedures will provide a more comprehensive understanding of demand on PPG design.

References

Damalas, C. A., & Eleftherohorinos, I. G. (2011). Pesticide exposure, safety issues, and risk assessment indicators. *International Journal of Environmental Research and Public Health*, 8(5), 1402-1419.