Can the Skellefteå model reduce firefighters' exposure to chemical agents in operative work?

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ABSTRACT

The project “Can the Skellefteå model reduce firefighters’ exposure to chemical agents in operative work?” analysed firefighters’ exposure to chemical agents through different exposure routes. In addition to this, factors that increased firefighters’ total exposure were evaluated, as well as how chemical exposure affected firefighters’ inflammation and stress markers after firefighting tasks. Because firefighters might also be exposed to carcinogenic agents during their work tasks, the project assessed whether the criteria were fulfilled to register firefighters to the ASA registry for workers whose health must be monitored more precisely due to increased risk of cancer. Smoke divers’ potential inhalation exposure was measured during smoke diving, during their return to the fire station from the fire truck and in the room where they store their firefighting garments. The spreading risk of chemical agents from the dirty area to the clean area at the fire station was evaluated during normal fire station service.

Smoke divers from the rescue departments of North-Savo, Middle-Finland, West-Uusimaa and Helsinki served as volunteer test subjects. In this project, all fires studied were limited to residential fires, where structures were already damaged. One of the aims of the study was to evaluate whether the Skellefteå model could reduce firefighters’ exposure compared to the conventional model. The sub-project “case Tellervonkatu” also analysed the symptoms of other firefighters than smoke divers after the extinguishing task in a residential fire. At the same time, the project produced information about the cleaning performance of washing machines when washing firefighting garments using the normal washing program.

The measured air concentrations of acrolein, benzene, formaldehyde and furfural during smoke diving were high in operative work and corresponded to the measured level from conventional smoke diving simulators during trainings. With regard to formaldehyde, air concentrations in operative work were higher than in training conditions. In fire trucks and fire stations after tasks, a significant amount of chemical agents from the fire was found. The target value for good industrial air, established by the Finnish Institute of Occupational Health, was exceeded inside cleaned fire truck as well as in the maintenance room for compressed air equipment during normal fire station service. The amounts of chemicals from fire decreased while entering the clean area from the dirty area at the fire station. The reference value for indoor air was achieved in all clean areas at all measured fire stations. Firefighters’ total exposure to polycyclic aromatic hydrocarbon was high. Firefighters who smoke dived for 21–60 minutes showed higher average urinary metabolite concentrations of naphthalene than the highest result from all industries according to the statistic of Finnish Institute of Occupational Health from 2012. Those who smoke dived for longer than 60 minutes showed a 3,9-fold higher urinary excretion on average than the highest result from all industries in Finland. The highest metabolite concentrations of pyrenes and benzene exceeded the action limit value, which means that employers must immediately make improvements to decrease workers’ exposure to carcinogenic agents. In addition, firefighters’ inflammation markers were measured and the increased levels of protective and long-term effects causing markers seemed to correlate with smoke diving times. Firefighters’ benzene exposure correlated with the increase of physical stress as indicated by stress hormones.

Factors increasing firefighters’ total exposure were smoke diving time, clearing time, duration of the whole situation, time spent wearing the firefighting garment and maintenance of firefighting equipment. Hence, firefighters must pay attention to their exposure during the firefighting task and maintenance of firefighting equipment if they want to decrease their total exposure in future.

The tested firefighters who followed the Skellefteå model in their work tasks had lower total exposure and hand exposure to the polycyclic aromatic hydrocarbons than firefighters who followed the conventional model. Hence, the Skellefteå model seems suitable as a basis for the new directives to reduce firefighters’ exposure, but the model must be updated according to the needs of Finnish rescue departments. For

example, for the residential fires, a “protection zone” way of thinking is required, as is the case in chemical fires. The firefighter in charge of the fire situation defines three areas around the fire: immediately dangerous, dangerous and protection zones. For each areas, the protection levels for workers are defined, as well as the activities allowed in the area. Fire equipment maintenance was one important factor affecting firefighters’ total exposure. For this reason, more attention must be paid to firefighters’ exposure during maintenance tasks. Recommendations for the protection level and cleaning technology used for the fire equipment must be linked to the fire class in which the equipment has been contaminated before maintenance activities. The more contaminant-heavy class, the better protection and more efficient cleaning technology must be followed in equipment maintenance.

Firefighters are exposed to carcinogenic substances at work and for this reason, their exposure and health condition are monitored intensively. The first step of exposure monitoring is to register firefighters who work actively in the operative field operations in the ASA registry. Their individual exposure must also be registered in the database covering all stages of exposure. This way, it will be possible to monitor firefighters’ real exposure times during residential fires, traffic accidents, forest fires, accidents involving hazardous materials and maintenance of firefighting equipment. Enhanced monitoring of firefighters’ health status includes an active discussion about firefighters’ health risks in operative work with occupational health doctors and nurses, as well as the importance of firefighters’ lifestyle in managing the total body burden of carcinogenic agents. Enhanced follow-up also means faster detection of potential cancer cases and the consequent better prognosis for recovery.

If a firefighter is exposed heavily during a firefighting task and shows symptoms, our recommendation is to measure his/her urinary 2-naphthol and 1-pyrenol concentrations immediately after exposure. The symptoms should be monitored using a symptom questionnaire and lung function measurements. If the symptoms do not improve in a week, the firefighter must undergo further investigations.

The Tellervonkatu case proved the necessity of the “protection zone” way of thinking also in residential fires. During the firefighting task, the worst protected firefighters showed the worst symptoms and their inflammatory responses were higher than those of the better protected smoke divers after their mission. Some of the firefighters went into hospital as a result of exposure at the fire site and some of them suffered severe symptoms during maintenance of fire equipment. Thus, connecting the protection level and cleaning technology to the fire class in which equipment are contaminated would improve the management of exposure in various maintenance situations. Transportation of contaminated firefighting garments in self-melting bags would have prevented firefighters’ exposure during maintenance, because they would have been able to transfer the closed bags directly to the machine without opening them. In this case, a washing machine reserved only for firefighting garments was particularly important, because the chemicals causing an adverse effect should not be spread further. The washing program intended for firefighting garments showed good cleaning results for water-soluble agents and moderate results for solvent-soluble chemical agents from fire.