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Genetics

The contributions of genetics and genomics to occupational safety and health

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How far away are we from genetics impacting worker health?

In an era when the biomedical community is extolling the benefits of genetic technologies and advances, the question arises whether these benefits may also have a positive impact on occupational safety and health (OSH). Historically, genetic factors have not been widely considered in OSH. Has any change occurred in recent years, or can we expect change in the near future?

Genetic factors contribute to the variable responses of workers to occupational hazards—particularly chemical hazards and some biological and physical agents.[1] Although increasingly workplace exposures are being controlled to lower concentrations, workers with susceptible genetic profiles may still be at unacceptably high risk. There is a broad range of published evidence showing that genetic polymorphisms can lead to differential occupational disease risks in exposed workers.[2–7]

Clearly, genetic technology has been useful in these studies of occupational disease and chemical exposures. The greatest contributions thus far have involved understanding mechanisms and modes of action. Detecting genetic polymorphisms can also lead to identifying susceptible subgroups in exposed populations. Nevertheless, it remains unclear to what extent identifying those susceptible can be applied in OSH. No good examples exist in which occupational exposure limits (OELs) have been based on genetic characteristics or risks in a population subgroup. Nor are there examples of one OEL for the general working population and a different one for a genetic subpopulation. Nonetheless, studies have illustrated risks below a given OEL for significant numbers of workers. Examples include exposure to substances such as benzene, ethylene oxide, polycyclic aromatic hydrocarbons (PAHs), beryllium, and silica.[3–9] Consequently, an important area of continued research is identifying genetically high-risk groups with exposure to widely prevalent workplace chemicals. Including such information in quantitative risk assessments is also warranted. In one simulation that included genetic information in a quantitative risk assessment, estimates were 23% to 30% lower when a genetic polymorphism was included.[10] However, to date, the practice of OSH generally has not changed in the wake of new genetic technologies, and genetic research to date has had few practical applications in this field—such as identifying new hazards or new solutions.

Powerful new technologies for identifying gene mutations and patterns of expression may be useful for identifying hazards[11 12] If patterns that are found using genomic or expression technologies can be validated as pathologic, new ways of screening chemicals or testing populations for the effects of exposure might be found. As a start, the toxicogenomic approach to screening chemicals appears to be useful for dividing them into functional or toxic action classes.[12] Ultimately, linking those changes to known pathologic endpoints will be necessary if this approach is to be widely applied in screening chemicals. In addition, these technologies are being used in studies that start with pathologic endpoints to assess molecular changes indicating a particular exposure or early disease.

The monitoring and screening of worker populations is another area in which the potential contribution of genetics and genomics has been considered. Somatic genetic markers have a long history of use in research and supplemental monitoring of radiation workers.[13] This approach is akin to biological monitoring. Not until recent years have chromosomal aberrations been quantitatively linked to cancer, thus supporting the potential value of genetic monitoring.[14] However, the practice of cytogenetic risk assessment is still on a group basis only, as the meaning of such assessment has not been demonstrated for individuals.

The screening of workers or job applicants for genetic susceptibility is a more controversial issue. No evidence indicates that such screening is widespread. An American Management Association survey, that predates current technologies, showed that this type of screening may be occurring in less than 10% of businesses.[15] However, the extent to which survey respondents distinguished genetic testing from other medical monitoring is not clear. Employers may have incentive for genetic screening of workers, but not so much for work-related diseases. Employers who pay healthcare insurance premiums (as they do in the USA) are more likely to be interested in screening job applicants for susceptibility to any disease they might develop, not to occupational diseases alone.

Regardless, the European Group on Ethics in Science and New Technologies and others have concluded that in the context of the pre-employment medical examination, genetic screening and the disclosure of previous results are not ethically acceptable.[16] Currently when employers defend themselves against claims about the work-relatedness of disease, they may try to determine whether genetic factors have contributed to occupational disease and thus mitigate their liability. This approach was taken in the much criticised US case of railway track workers' claims of carpal tunnel syndrome.[17] Nonetheless, conducting genetic tests in some types of workers' compensation cases in the USA is an allowable component of independent medical examinations.

Clearly, as medical practitioners routinely use more genetic information in the differential diagnosis and treatment of disease, so will occupational physicians. Although genetics has not had a major impact on occupational safety and health so far, it may be too early to conclude that genetics is not likely to have a significant impact on the discovery, control or prevention of major occupational hazards or diseases in the future. In the meantime, it is important to determine where limited occupational research funds will be applied. Clearly, when we suspect a significant genetic component for some occupational illness, the study of its impact on risk is warranted. Additionally, genetic research in occupationally exposed populations may have implications for environmental health practice because workers generally have higher and better documented exposures than the general population.

Science is now broadly engaged in the study of the whole human genome, but it is not clear how much a broader understanding of genetics and environmental factors will lead to better protection for workers. Thus, the need is for continued

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but selective research on working populations to assess the interactions of occupational exposures and genetic factors in the occurrence of disease, disability and death.

Ultimately, as genetic susceptibility information is collected, various issues as to how that information should be used will arise. How will society treat genetically susceptible workers? Will employers have responsibility to protect the subset of workers with specific genetic characteristics? Should workers have the opportunity to learn of their susceptibility? These are the questions that merit further consideration and study.

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