Invited Editorial

Dermal Exposure: a Decade of Real Progress

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Dermal exposure assessment explores the dynamic interaction between environmental contaminants and the skin. Phenol poisonings due to percutaneous absorption were recognized as an occupational health hazard as early as 1880, and the introduction of tetraethyl lead as a gasoline additive in the 1920's resulted in multiple fatalities due to occupational skin exposure (Diechmann, 1949; Hamilton et al., 1925). The recent fatal poisoning of a university researcher in the United States from absorption of dimethyl mercury drew public attention not only to the ability of chemicals to move through healthy skin, but also to the inadequacy of gloves often used for protection in laboratory settings (Smith, 1997). Despite these dramatic events, dermal exposure assessment has remained a nascent field of scientific inquiry for most of the 20th century, caught as it is between the serious problem of occupational dermatitis and occupational hygiene's primary focus on respiratory health hazards.

Yet substantial advances in the science of dermal exposure assessment have occurred during the past ten years. If the 1980s were a time of widespread recognition of the importance of skin exposure in modern industrial and residential environments, the 1990s have seen the beginnings of a systematic characterization of the field.

This issue of the Annals presents the findings of a group of dedicated occupational health scientists from across the European Community, and provides a timely update of conceptual and methodological advances in workplace dermal exposure assessment. The genesis of this effort can be found in a workshop on dermal exposure at the 1992 meeting of International Occupational Hygiene Association in Brussels, Belgium (Marquart et al., 1994). A subsequent meeting of European investigators (Dost, 1995) led to the formation of the European Community project known as the Dermal Exposure Network, a coordinated effort of 34 organisations with almost 80 researchers. Initiated in 1996, this project has supported conceptual, methodological, and field investigations. This work will continue with a new initiative of the European 5th Framework Quality of Life Programme that links dermal exposure to risk assessment. The creation and sustenance of a collaborative network of this kind is very far-sighted, and will almost certainly lead to further progress in the identification, evaluation, and control of dermal exposure hazards.

In the United States the drivers for advances in dermal exposure assessment have come less from occupational health and safety concerns, and more from concerns for the public’s exposure to environmental pollutants. In the study of childhood lead intoxication, for example, it became evident that hand-to-mouth contact was a primary exposure pathway for young children. Thus, an understanding of dermal exposure mechanisms became essential to model exposure and dose. A public outcry over hazardous waste site management led the U.S. Congress to pass the 1980 Comprehensive Environmental Research, Compensation, and Liability Act (CERCLA), known commonly as Superfund. The Superfund law stimulated systematic evaluation of community exposures, and came at time when risk assessment emerged as a formal method for such evaluations. As quantitative risk assessment methods were applied to hazardous waste site scenarios, dermal exposure was quickly identified as a critical pathway. In 1992 the U.S. Environmental Protection Agency’s Office of Research and Development published a comprehensive document on dermal exposure assessment that remains a useful guide to the field today (USEPA, 1992). Finally, the Food Quality Protection Act of 1996 mandates that the U.S. Environmental Protection Agency quantify exposure from all routes to produce an ‘aggregate’ exposure...
assessment for pesticide health risks. This requirement has provided substantial impetus for new dermal exposure research.

Dermal exposure has received less attention in the U.S. occupational health community, but even here the news is good. The 1996 National Occupational Research Agenda developed by the National Institute for Occupational Safety and Health (NIOSH) identified dermal exposure as an essential element of its Allergic and Irritant Dermatitis priority area. A new laboratory at NIOSH’s Morgantown, West Virginia, facility has taken dermal exposure assessment as its primary focus, and NIOSH has formed a Dermal Interest Group that consists of federal, academic, and private sector scientists.

What are the key findings of these new efforts in Europe and North America? First, we see the emergence of more formalized definitions of dermal exposure, its pathways, and its mechanisms. In the U.S. (Zartarian et al., 1997) and Europe (Schneider et al., 1999) new models have been proposed that attempt to integrate dermal exposure assessment into a broader framework of occupational and environmental exposure analysis. Study design and sampling strategies have begun to incorporate statistical principles and methods such that exposure determinants and variability can be characterized more rigorously (Kromhout and Vermeulen, to be published). Second, innovative approaches continue to emerge in personal and surface monitoring methods, coupled with an emphasis on validation, and evaluation of precision and bias (Brouwer et al., 2000; Soutar et al., 2000; Byrne, 2000). Visualization of dermal exposure patterns with fluorescent tracers has proven to be a powerful technique for engaging scientists and non-scientists alike in exploring dermal exposure mechanisms and mitigation strategies (Cherrie et al., 2000). Finally, we see the incorporation of dermal exposure assessment into both epidemiology and risk assessment. An example from epidemiology is the Agricultural Health Study in the United States, a prospective study of pesticide applicators and their families that has enrolled approximately 70,000 individuals (Alavanja et al., 1996). In this study a dermal exposure model has been derived from the North American Pesticide Handlers Exposure Database. An additional component of the study aims to validate the questionnaire data through field monitoring. In the case of risk assessment, occupational risk analyses are incorporating dermal exposure data in Europe (Jackson, 1999), and studies of children’s exposure to pesticides are now incorporating surface and skin sampling as formal components of risk models in the U.S. (Zartarian et al., 2000).

The future of dermal exposure assessment is likely to hold even more opportunities for collaborative and multidisciplinary research and practice. We urgently need a better understanding of the behavioral and psychological components of exposure (e.g., constraints on and motivation of hygienic behavior, perception of dermal hazards and risks), and would do well to expand occupational hygiene curricula to include these topics. We should also focus efforts on the development of rapid, inexpensive, and direct-reading methods for dermal exposure measurement. In this regard, attenuated total reflectance fourier transform infrared spectroscopy (ATR-FTIR) appears to be a promising method for direct identification and quantitation of organic chemicals on the skin (Doran et al., 2000).

Finally, it is clear that dermal exposure assessment has broadened to include a more detailed knowledge of skin anatomy and physiology. Dermal uptake, skin sensitization, and the potential for skin contact to initiate a more generalized sensitization, as is apparently the case with isocyanates (Kimber, 1996), are exciting areas of inquiry where exposure scientists and toxicologists can find common cause. Knowledge of genetic variability and susceptibility related to the skin is also likely to grow rapidly in the next few years. Advances in these areas will in turn lead to more complete and accurate models of risk, and ultimately to improved protection for both workers and the general public.

REFERENCES


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