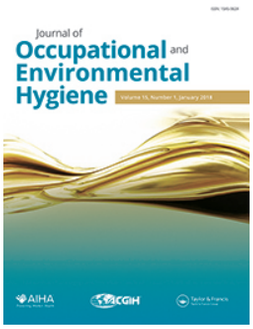

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COMMENTARY

A conceptual model for take-home workplace exposures

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ABSTRACT

The boundary between occupational and environmental exposures is often artificial, as occupational hazards can readily escape the workplace. One way that this occurs is when workers "take-home" occupational hazards, exposing family members. While take-home exposures have long been recognized, there is no comprehensive framework describing the pathways by which workers bring home workplace hazards. In this article, we provide such a conceptual model that includes three pathways for take-home exposures: external contamination, internal dose, and behavior change of workers. This conceptual model should help to describe the problems of take-home exposures more comprehensively in future research.

KEYWORDS

Behavior change; conceptual model; para-occupational; take-home exposures

Introduction

The postulated boundary between occupational and environmental exposures is often artificial. A hazard emanating in a workplace is occupational when it impacts employees of the workplace, and becomes environmental when it escapes confines of the workplace and impacts persons in the wider community. In some cases, workers may be "vehicles" by which occupational hazards are introduced into the home environment. The importance of these "take-home" exposures, also termed "para-occupational" exposures, has long been recognized. For example, in 1995, at the behest of Congress, the National Institute for Occupational Safety and Health (NIOSH) summarized reports of exposures and adverse health effects associated with contamination of workers' homes with hazardous chemicals and substances transported from the workplace.[1] These exposures, however, persist, resulting in occupational diseases and poisonings among family members, including children.[2,3]

Herein, we present a conceptual model of take-home exposures to workplace hazards. While there is a general understanding that take-home exposures involve an occupational exposure that is transported to a worker's domicile and other locations outside the workplace, all pathways in this process have not been comprehensively described. Building on the impact of conceptual models of occupational dermal[4] and inhalation[5] exposures, with this model we seek to encourage and enhance research that comprehensively characterizes take-home exposure pathways.

A limitation of most take-home exposure research is a focus on single stages of a pathway, rather than the length of one or more take-home pathways. As a result, opportunities for intervention and the occupational implications for other public health investigations (e.g., the occupational contribution to indoor air pollution) may be missed. For example, studies describe the distribution of a contaminant in the homes or automobiles exposed workers,[6] or urinary biomarkers of family members,[7] without looking at relationships along steps of the pathway, such as between contaminants in the home and biomarkers of exposure. One example that begins to look at multiple stages of the take-home exposure pathway, employed structural equation modeling to discern exposure determinants within families: the exposure of the father, who applied pesticides, was found to impact the exposure of the mother, which, in turn, impacted the exposure of the children,[8] which suggests the value of interventions in the workplace and in the home.

The model

The conceptual model of take-home exposures that we propose includes three broad pathways by which workplace hazards are brought home (Figure 1): external contamination, internal dose, and behavior change.

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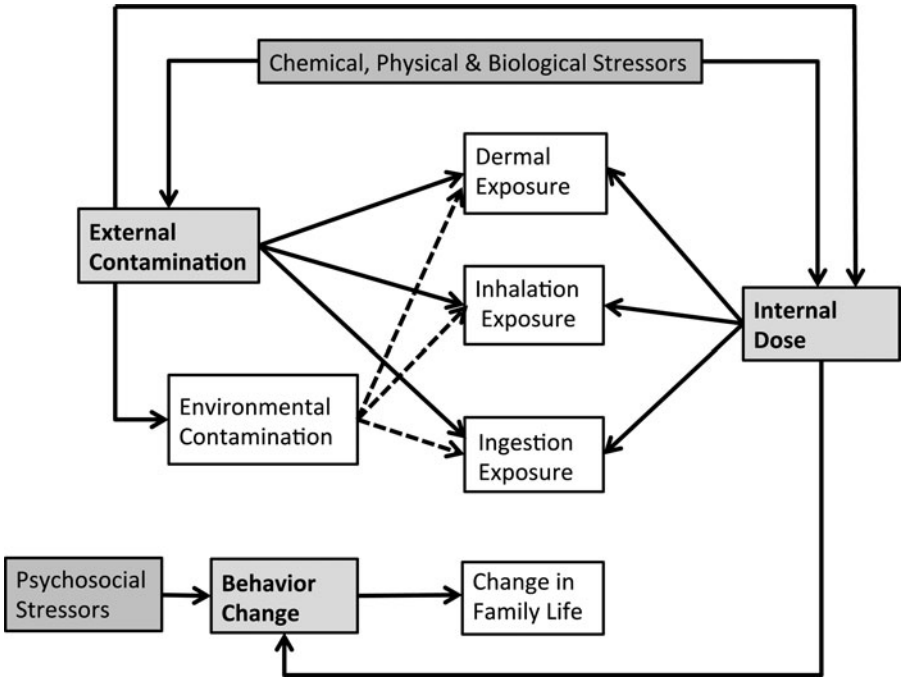

Figure 1. Workplace stressors (dark gray boxes) are brought home by workers through three pathways (gray boxes); unshaded boxes represent exposures of family members. Dashed arrows represent exposure mediated by environmental contamination caused by occupationally exposed person.

While behavior change is fundamentally a result of an internal dose of a stressor, it is defined as a separate pathway because the effect in the home is distinct from the presence of workplace hazards in the body of the worker. Behavior change has not been widely recognized as a take-home exposure, but, in our view, occupational exposures to behavior norms, psychosocial stressors, violence, and trauma at work alter the behavior of workers beyond the end of the work day, affecting workers' families and communities. We describe each pathway in turn, and leverage representative examples from the literature to illustrate the model.

External contamination

Workers may leave the workplace with workplace hazards on their skin, clothes (especially shoes), tools, cars, and other objects; while home-based work may release contaminants directly into the home environment. Exposure in the home may be direct or indirect. Direct exposure involves contact between contaminated objects and family members, such as when a worker embraces his child, transferring contaminants from his body or clothing to the child's body or clothing. Clothing and skin are easily contaminated with dust during work activities,[9,10] and can be a vehicle for direct exposure. Indirect exposure, in contrast, is mediated by the environment. For example, hazards may transfer to the home environment (e.g., carpets), resulting in dermal contact, ingestion, and inhalation of volatilized or re-suspended agents by family members. This can occur when contaminated clothing is handled for laundering, resulting in re-suspension of dusts[11] or through cross-contamination of clothing. Workers' vehicles are commonly identified as a source of home-based exposures either due to contamination at the worksite or from workers' contaminated clothing.[6,10,12] Zirschy[13] provides a comprehensive description of the external contamination pathway that includes mathematical descriptions of many relevant processes.

Internal dose

Hazardous agents enter workers' bodies at the workplace, and these agents may affect workers' families in several ways. Hazardous agents may be present in body fluids (blood, urine, respiratory secretions, and breast milk) that family members contact or ingest. Consider the case of the flame retardants polybromindated diphenyl ethers (PBDEs). Workers with occupational exposures to PBDE-containing products have higher PBDE serum levels than the general public.[14] Serum levels are proportional to breast milk levels, and breastfed babies of women without occupational exposures may be exposed to BDE-47 above the reference dose;[15] suggesting higher exposures for breastfed babies of occupationally exposed mothers. Less well-recognized in the discourse on take-home exposures is the risk that occupationally acquired infectious diseases are transmitted to family members. This

is a growing concern among animal workers exposed to influenza viruses[16] and this concern recurs with outbreaks of emerging infectious diseases, when workers report decreased willingness to provide care to infected patients due to concerns about family members.[17] Workplace hazards in female workers' bodies may transfer across the placenta, resulting in *in utero* exposures to a developing fetus that may manifest across the life course; and in female and male workers' bodies may affect germ cells to exert genotoxicity or reduce fertility.

Behavior Change

Occupational exposures to stressors can cause behavior change, which alters how a worker behaves towards and with family members. The role of occupational psychosocial stressors and behavioral norms on family, the work-to-family spillover, are an important area of inquiry in occupational psychology.[18] For example, emotional labor, such as is required to suppress emotions at work, has been found to adversely impact marital relationships,[19] and exposure to violence can result post-traumatic stress disorder.[20] Work organization and conditions also impact behavior. For example, such as job insecurity among the working poor and high psychological demands among working non-poor have been associated with depressive symptoms.[21] Behavior change, however, may also arise from occupational exposure to other stressors, such as chemical agents. Chronic solvent-induced encephalopathy, for example, affects attention, memory and motor performance,[22] which influence social interactions, but occupational solvent exposure has also been reported to affect the degree of violence at home.[23] Regardless of the cause, behavior change can adversely impact family health and wellbeing. To the extent the behavior change can be traced to occupational exposures, then preventative measures can be implemented in a manner that benefits families of all occupationally exposed persons.

Discussion

Take-home workplace exposures are one example of why the absence of healthy work is a problem for public health at large, not just occupational health. Most people work during their lifetimes and derive numerous benefits from being in the workforce, and yet experience exposures to chemical, physical, biological, and infectious agents, as well as to psychosocial stressors. These hazards affect the health of both workers and their families: take-home exposures can cause illness and injury among family members, and a worker's occupational illness and injury can be devastating to families.

A primary prevention strategy—the prevention of occupational exposures—is the best mechanism for preventing take-home workplace exposures. After work hygiene activities, such as showering after work and keeping work clothes at work or cleaning commuter cars, can reduce external contamination pathway, but worker use of these practices may be difficult in some settings where the practices are not required by the Occupational Safety and Health Administration regulations (e.g., 29 CFR 1910.1025 (Lead Standard)).[24,25] Only the reduction in the magnitude of occupational exposures will reduce take-home exposures through the internal dose and behavior change pathways.

Herein we have presented a conceptual model, but have not attempted to prescribe how best to empirically characterize various exposure pathways or how to best analyze data that results from such an effort because the optimal tools for assessment of the take-home exposure pathways will vary between agents and scenarios. The value of the conceptual model presented is to help investigators take a comprehensive view of the problem of take-home workplace exposures, so that important prevention opportunities are not missed. While the conceptual model we have proposed for take-home workplace exposures is relatively simple, it is the first time these pathways have been comprehensively described and can serve as a point of departure for the systematic study of the issue of take-home exposures. In particular, we hope that the conceptual model highlights the potential role of occupation in home-based pollution and social problems.

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