TEXTBOOK OF CHILDREN'S ENVIRONMENTAL HEALTH

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The Farm Environment

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THE FARM environment presents unique challenges to the health and welfare of farm family children, children employed in agriculture, and children visiting farms. The farm is a combination of home, recreational area, and workplace. It thus contains health benefits and risks associated with each of these settings.

Farm children are at risk of exposure to all of the occupational and environmental hazards inherent in farm operations. Typically beginning at age 7–10 years, farm children start assisting in farm operations by performing a wide variety of tasks—long considered a rite of passage (1,2). The occupational and environmental hazards to which children are exposed in these tasks include major injury, primarily from farm machinery and livestock, organic and inorganic dusts, pesticides, other toxic chemicals such as anhydrous ammonia, and noise from farm machinery and livestock. In addition, farm children are exposed to all of the risks of rural living—increased risk of injury from on- and off-road vehicles, drowning, fires, the direct and indirect effects of interpersonal family violence, and often remote or inadequate access to acute and primary health care.

US farm children are not protected against occupational hazards under the Fair Labor Standards Act, which provides protections to non-farm youth, including legally mandated limits on the number of hours worked and protection against hazardous working conditions. In 2011, the US Department of Labor proposed new regulations to extend these protections to youth hired for farm work, while still exempting from regulation children from farm families. However, the Department of Labor subsequently withdrew the proposed new regulation in the face of stiff opposition from organized agriculture and farm state politicians. As a result, the farm environment remains virtually unregulated, under the law and in practice, for children in the United States.

Lastly, farm children are at risk of exposure to their parents' occupational stress. Traditionally, farm wives had only assisted in farm operations and were therefore in the home to care for children. But today, a majority of US farm wives are directly engaged

in farm operations. In addition, farm wives—like their husbands—are now very frequently employed part- or full-time off the farm for cash income and also to receive health insurance benefits, whose costs have risen sharply in the United States. Added to these economic and organizational stresses are the long hours farm parents must work at the peak, time-sensitive times of planting and harvesting. In those seasons, all family members, even children not usually engaged in farm tasks, often accompany their parents into the fields.

FARM DEATHS AND INJURIES

Injuries are a major public health problem among farm children. Farm children comprise only approximately 8% of US working children but suffer 40% of all work-related fatalities among US working children (3). Based on US National Center for Health Statistics data for 1990–1993, Rivara (4) reported an average of 104 deaths per year due to injuries on the farm among children and adolescents age 19 years and under, a rate of 8/100,000. This rate represents a reduction of 39% since 1978–1983. NIOSH death certificate data from 1995–2000 reported a similar average annual fatality rate of 9.3/100,000. The principal causes of death among farm children are farm machinery (25%), motor vehicles (17%), drowning (16%), suicides (6%), and homicides (6%) (5).

Improved data on injuries among farm youth 19 years and under are now available from the National Institute for Occupational Safety and Health/United States Department of Agriculture Childhood Agricultural Injury Survey (CAIS). This data source reports that nearly 23,000 injuries occur each year in the United States among the 30.7 million youth who live on, work on, or visit farms (6).Two-thirds of these injuries occur among males, 51% are suffered by youth living on farms, 25% are related to farm work, 6% occurred among youth hired to perform farm work, and 40% occurred among youth visiting farms. These data indicate that rates of childhood farm injuries had declined an additional 30% since 1998 but also found that rates for some injuries had increased, including injuries from all-terrain vehicles (ATVs) and horse injuries (7). Of the estimated 1.1 million youth living on farms, 36% had operated an ATV in 2001, and ATV use resulted in 2,200 nonfatal injuries of which 70% were among youth ages 10–15 years, and 58% were associated with recreational use (8).

Many farm-related injuries among children are severe and require hospitalization for treatment of amputations, dislocations, fractures, lacerations, avulsions, concussions, and burns, as well as from encounters with animals, falls, motor vehicles, ATVs, and firearms (9). Limb amputations are among the most severe injuries sustained by farm children and typically are associated with massive contamination and severe infection. Because of infection, replanting of severed limbs is successful in only about 20% of these cases (10).

The annual economic costs of farm injuries to US children are estimated to exceed $1.4 billion—fatalities account for an estimated $420 million each year and work-related injuries for an estimated $347 million. These estimates almost certainly underrepresent the true economic costs of deaths and injuries among farm youth (11). And the additional economic and noneconomic costs of rehabilitation, delayed medical and surgical complications, emotional distress, and long-term disability are unknown.

Given the enormous magnitude, severity, and costs of farm-related youth injuries, numerous efforts have been directed to prevention of these injuries. Almost all of these prevention efforts have focused on educational approaches. Many of these programs have been based on the North American Guidelines for Children's Agricultural Tasks (NAGCAT), which were designed to provide task-specific guidance to farm families about age-appropriate tasks for children and youth (12). Controlled studies indicate that parental knowledge of these guidelines decreases age-inappropriate tasks, particularly when knowledge is reinforced by a presentation by a safety specialist and with information about child development (13–15). Studies show, however, that these guidelines are not in general use. Population-based data from the Keokuk County Rural Health Study found that a large majority of farm parents allow a son (87%) or daughter (70%) to undertake age-inappropriate tasks, most notably operation of ATVs (2).

Additional important risks to children living and working on farms include inadequate supervision of small children, permitting children in areas where moving or unguarded machinery is in use, and errors in communication (16,17). It is also apparent from analyses showing similar patterns of injury

among farm family members across generations that injury-prone behavior among farm parents is passed on to their children (18).

There is now general agreement among public health professionals that educational interventions alone are not sufficient to protect children against farm injuries and that comprehensive injury prevention strategies are long overdue (2,19).

RESPIRATORY EXPOSURES AND HEALTH OUTCOMES

Occupational respiratory exposures to organic dusts and to a wide array of chemicals are well documented among farmers and farm children. Sources of chemical exposure on farms include pesticides, fertilizers, and toxic gases from livestock production. These exposures result in increased rates of asthma, chronic bronchitis, and chronic obstructive lung disease. Hypersensitivity pneumonitis (called "farmer's lung" in the agricultural setting) can occur among farmers of all ages exposed to high levels of fungi and thermophilic bacteria.

Epidemiologic studies among farm children have focused on allergy and asthma. In European studies, farm children have been found to have significantly lower rates of asthma and wheezing in comparison to other rural children (20). In addition, many of these studies have found that prenatal exposure to the farm environment, and also exposures in early postnatal life, are associated with lower rates of allergic rhinitis, eczema, and atopy as measured by positive skin tests to common allergens. These findings are consistent with the "hygiene hypothesis," that posits that maternal and early childhood exposures to microbial compounds protect against atopic sensitization and related health outcomes because of up-regulation of receptors of the innate immune system (21).

By contrast, studies of farm children in North America, where farm operations are often much larger than in Europe and where children may experience significant occupational or bystander exposures to organic dusts and other hazardous respiratory exposures, have found rates of asthma (18%) and asthma symptoms (39%) to be similar to those of other rural children. Asthma rates are especially elevated among children working with grain and among children living or working on farms that raise swine (22,23). Studies of farm children in Saskatchewan, Canada who engaged in agricultural tasks, including filling grain bins, cleaning livestock pens, and playing on or near hay baling, reported significantly higher rates of respiratory symptoms.

It appears from the contrasting results of these European and North American studies that the protective effect of farm exposures in early life cannot be maintained in the face of the intense exposures to organic dusts, endotoxins, and irritant gases that are experienced by children exposed to the typically larger farm operations found in North America. Possibly consistent with these findings are results from Phase Three of the International Study of Asthma and Allergies in Childhood (ISAAC), that studied 6- to 7-year-old children in urban populations in several developing countries and found a significant increase in "current wheeze" among children exposed to farm animals prenatally or early in life (24).

US farm children exposed to livestock operations are at risk of exposure to hydrogen sulfide and other toxic gases emitted into the atmosphere from pits and lagoons at concentrated animal feeding operations (CAFOs). Adverse health effects of CAFO effluent have also been observed beyond the immediate farm environment among children attending school within three miles of such operations in North Carolina. These health effects include significantly higher rates of wheeze, especially at schools where livestock odor was reported, and higher rates of emergency room visits and treatment for asthma (25). Similarly, Sigurdson and Klein (26) reported primary school children attending school within one-half mile of an Iowa CAFO had significantly higher rates of physician-diagnosed asthma than did unexposed school children (OR = 5.71). Dose-related exposures to CAFOs among farm children in Iowa have recently been linked to increased prevalence of medication use for wheeze and/or childhood asthma (27). In summary, it appears that CAFO exposures are linked to asthma, extend well beyond farm boundaries, and should receive the attention of both public health officials and primary health care providers.

NOISE AND HEARING LOSS

The available literature on noise exposures and hearing loss among farm youth shows clear evidence of harmful noise exposures arising from farm operations and from other common sources of noise in the rural environment. Humann et al. (28) found

that daily noise exposures among a sample of 25 rural farm and non-farm adolescents varied widely, ranging from 55 dBA to 104 dBA. Forty-four percent of these daily measurements found noise exposures above the NIOSH Recommended Exposure Level of 85 dBA for time-weighted occupational exposures. These findings are consistent with observations made by Lander et al. (29), who studied noise exposures among farm youth 10–18 years working in summer jobs that averaged greater than 40 hours per week. Sources of noise exposure for these children included tractors, skid steers, ATVs, silo elevators, chain saws, and wood splitters—all occupational exposures that frequently exceed adult OSHA hearing conservation action levels. It is therefore not surprising that studies of rural children in the Keokuk County Rural Health Study found over 70% to have hearing impairment and early evidence of noise-induced hearing loss. Audiograms in these children were characterized by a high prevalence of notch configurations (10%–15%) among both girls and boys under the age of 20 years (30). These findings are consistent with findings of Renick et al. (31), who found nearly 50% of farm youth to have high-frequency hearing loss, twice the rate of a comparable national sample.

Like their parents, farm youth rarely use personal protective equipment, including hearing protection, when engaging in farm tasks. However, a multicomponent 4-year educational hearing conservation intervention study in 34 Wisconsin schools found that the intervention group did use hearing protection devices (88%), significantly more often than the control group (45%) (32). Given the extent of farm noise exposures and well-documented increased prevalence of hearing loss among farm youth, more such intervention research is clearly needed. Hearing conservation needs to be a part of any multicomponent health and safety prevention strategy for farm youth.

NEUROBEHAVIORAL AND MENTAL HEALTH OUTCOMES

The Agricultural Health Study documented that farm children are exposed to commercial and private pesticide applications that arise directly from farm work, and that they are exposed additionally to pesticides tracked into the living environment from work areas on the farm (2,33,34). Elevated levels of urinary pesticide metabolites have been documented among Latino farm worker children in North Carolina and California (35,36). Pesticide exposure can occur among children who are applying pesticides, and additionally there is risk of bystander exposure among children playing around chemical application equipment.

Neurobehavioral studies of farm children exposed to organophosphate pesticides (OP) are difficult to complete because of problems with access, participation, and confounding. Nonetheless, these studies have generally found that farm children's exposures to low concentrations of organophosphate pesticides, arising most commonly from contamination of living quarters by parental take-home exposures, are associated with neurological impairments on standardized tests (37–39).

Recent reports have linked prenatal OP exposure with increased risk of pervasive developmental disorders, as well as with delays in mental development, including deficits in full-scale IQ, perceptual reasoning, and working memory (40–43). Additionally, postnatal OP exposures have been linked to behavioral problems, poorer short-term memory and motor skills, and longer reaction times (37,44,45). An analysis of data from the National Health and Nutrition Examination Survey demonstrated an association between OP urinary metabolite levelsand attention-deficit/hyperactivity disorder (ADHD) (46) (see Chapter 32).

The Keokuk County Rural Health Study has provided population-based data on rates of depression, suicide ideation, and the impact of stress arising from interpersonal violence in rural homes (47,48). While these mental health outcomes are common among rural residents, the KCRHS found no excess of adverse behavioral health outcomes in farm families compared to non-farm rural families. This study found additionally that farm families reported significantly less interpersonal violence than other rural households (49).

By contrast, children of migrant and seasonal farm workers have been reported to often have one or more psychiatric disorders, of which anxiety is the most common. Migrant farm worker children with mental health problems seek professional health care five times as often as migrant children without such problems (50). More than half of the migrant children with mental health problems examined in these studies had been exposed to violence; nearly one-fifth had themselves been victims of violence; and those exposed to violence were subsequently reported to more often carry knives and guns (51). Clearly, migrant farm worker children suffer multiple social and economic disadvantages and must

be regarded as a group at high risk for mental health problems. And for all farm children, mental health outcomes are poorly documented and deserving of more research.

CANCER

Associations between pesticide exposure and risk of childhood cancer are the subject of active investigation and have clear relevance to farm children. A meta-analysis of 38 case-control studies and 2 cohort studies reported that risks of lymphoma and leukemia were increased significantly among children whose mothers had been exposed to pesticides during pregnancy through either household or commercial pesticide application (52). Significantly increased risk of brain cancer was observed among children of fathers who were exposed, either before or after birth, to pesticides (52). A second meta-analysis of 25 studies reported no statistically significant association between childhood leukemia and parental occupation as a farmer or agricultural worker, but it did find a significant association between a history of maternal pesticide exposure and acute nonlymphocytic leukemia in children (53).

Early data on childhood cancer risk from the Agricultural Health Study, which followed 17,357 children of Iowa pesticide applicators, found that overall risk of all childhood cancers was significantly increased, as were risks for all lymphomas combined and for non-Hodgkin's lymphoma (54). Interestingly, this study also observed an excess in lymphoma risk among children whose fathers reported not using chemically resistant gloves in their work. A study from New Zealand of persons who had grown up on farms reported that growing up on a farm with livestock was associated with increased risk of hematological cancer. This risk was not observed among persons who were exposed only to crop farming (55).

Research on brain cancer risk among children whose parents were exposed to pesticides in agriculture provides mixed results. Some associations were found between astrocytoma and primitive neuroectodermal tumors and maternal and paternal exposures to insecticides, herbicides, and agricultural and nonagricultural fungicides, but no associations were found with cumulative or average parental exposures. The study concluded that parental exposure was unlikely to have played an important role in the etiology of childhood brain cancer (56). Similarly, a meta-analysis of paternal pesticide exposure and neuroblastoma found no association (57). However, Efird et al. (58) reported an increase in childhood brain cancer among children whose mothers had been employed as farmers or farm workers during the 5 years before their children's births.

In summary, evidence for increased risk of cancer among children who were exposed prenatally and in early postnatal life to chemical pesticides is accumulating. Although these findings are not yet definitive, there is sufficient information to suggest that preventive measures should be taken to reduce pesticide exposure in early life. Public health officials and health care providers should be aware of these linkages between pesticide exposure and childhood cancer and recommend reduction in exposure whenever possible.

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