Exposure to Contaminants From Agricultural Sources

The entire U.S. population is exposed on a daily basis to numerous agricultural chemicals. Many of these chemicals are known or suspected of having either carcinogenic or endocrine-disrupting properties. The following sections describe the agricultural workforce, the population group most heavily exposed to these chemicals, and hazards associated with specific agricultural chemicals and veterinary pharmaceuticals.

The Agricultural Workforce

In 2007, approximately 1.75 million full-time workers were employed in agricultural production. Unlike nearly all other industries in the U.S., families typically share in agricultural work; half of all farm-based children under age 20 perform farm work and an additional 307,000 children and adolescents are hired to work on farms.

In addition, between three and five million individuals and their families work as migrant or seasonal workers. Due to working and housing conditions, including lack of child care that forces parents to take their children with them into the fields, these workers and their families often have disproportionate exposures to pesticides and other agricultural chemicals. Many migrant workers are not provided with protective clothing or equipment. Further, migrants often have limited access to health care and may experience poor communication with health care providers due to language differences. Undocumented workers are likely to avoid seeking health care even if they become ill. These factors, combined with the mobility of the migrant population, have made it difficult to assess the magnitude of health problems migrants suffer as a result of their exposure to agricultural chemicals.

As with industrial chemicals and other environmental exposures, children are at higher risk for cancer and other adverse health effects from pesticide exposures. Risks for childhood cancers are linked with parental pesticide exposure prior to conception, in utero exposures, and direct exposures throughout childhood. Chemical exposure levels of agricultural
families (and in some cases, other rural residents) tend to be higher than the general population. As is the case with workplace chemicals and other agents, these substances often are introduced into the home on shoes and clothing, and when work clothes are washed with other family laundry. Pesticide levels in carpet dust in the homes of agricultural workers and non-farming families can be 10- to 200-fold higher than levels in the air inside the same home,\textsuperscript{207,208} increasing exposure risk to children who are likely to crawl and play directly on the carpet. Leukemia rates are consistently elevated among children who grow up on farms, among children whose parents used pesticides in the home or garden, and among children of pesticide applicators.\textsuperscript{209–211} Because these chemicals often are applied as mixtures, it has been difficult to clearly distinguish cancer risks associated with individual agents.

The ongoing NIH-sponsored Agricultural Health Study\textsuperscript{212} (AHS) involves more than 89,000 participants, including private and commercial pesticide applicators and their spouses. The goals of the study are to investigate the effects of environmental, occupational, dietary, and genetic factors on the health of the agricultural population.\textsuperscript{212} Among other findings, the AHS has found that although overall cancer rates among farmers and pesticide applicators are not higher than other men and women in the study states (IA and NC), there are increased risks for specific cancers. Farmers and pesticide applicators have significantly higher prostate cancer risk, and female spouses have a significantly higher incidence of melanoma. Female pesticide applicators have significantly higher incidence of ovarian cancer.\textsuperscript{213}

**Exposure to Chemicals Used in Agriculture**

The chemicals most commonly used in agricultural settings are pesticides (including insecticides, herbicides, and fungicides), and fertilizers. Agricultural chemicals can be carried far from their application sites by wind and through soil and groundwater contamination. Some of these chemicals
break down very slowly and are persistent in the environment, even in non-agricultural areas. In addition, residues of agricultural chemicals are found in fruits, vegetables, grains, and beverages that are made from contaminated plants and water. Meats and dairy products also can be contaminated by the water and feed provided to livestock.

Pesticides (Insecticides, Herbicides, and Fungicides)

Nearly 1,400 pesticides have been registered (i.e., approved) by the Environmental Protection Agency (EPA) for agricultural and non-agricultural use. Exposure to these chemicals has been linked to brain/central nervous system (CNS), breast, colon, lung, ovarian (female spouses), pancreatic, kidney, testicular, and stomach cancers, as well as Hodgkin and non-Hodgkin lymphoma, multiple myeloma, and soft tissue sarcoma. Pesticide-exposed farmers, pesticide applicators, crop duster pilots, and manufacturers also have been found to have elevated rates of prostate cancer, melanoma, other skin cancers, and cancer of the lip.

Approximately 40 chemicals classified by the International Agency for Research on Cancer (IARC) as known, probable, or possible human carcinogens, are used in EPA-registered pesticides now on the market. Some of these chemicals are used in several different pesticides; for example, chromium trioxide, an IARC Class 1 carcinogen (carcinogenic to humans), is used in 14 different pesticide products from five different companies. Thus, the total number of registered pesticide products containing known or suspected carcinogens is far greater than 40, but few have been severely restricted in the United States. Among those that have been banned, or had their use restricted, are DDT, ethylene oxide, dimethyldazene, hexachlorobenzene, and some chlorophenoxy herbicides.

An average of 18 new pesticides are introduced every year. EPA standards for registration are primarily risk-benefit based. A pesticide will be registered for use if EPA determines that it does not pose “unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide.”

I believe it is time for a new human experiment. The old experiment...is that we have sprayed pesticides which are inherent poisons...throughout our shared environment. They are now in amniotic fluid. They’re in our blood. They’re in our urine. They’re in our exhaled breath. They are in mothers’ milk....What is the burden of cancer that we can attribute to this use of poisons in our agricultural system?...We won’t really know the answer until we do the other experiment, which is to take the poisons out of our food chain, embrace a different kind of agriculture, and see what happens.

SANDRA STEINGRABER
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In the aggregate, registered pesticides contain nearly 900 active ingredients, many of which are toxic. Many of the inert ingredients in pesticides also are toxic, but are not required to be tested for causing chronic diseases such as cancer. For example, xylene is used as the inert ingredient in almost 900 pesticides and has been associated with increased risk of brain tumors, rectal cancer, and leukemia.

Pesticides, when applied to fields, don’t always stay where they’re intended to stay.

PEGGY REYNOLDS
NORTHERN CALIFORNIA CANCER CENTER

A key concern regarding pesticide use is whether, and to what extent, food products are contaminated with these chemicals. To estimate pesticide contamination of foods purchased by consumers, the Department of Agriculture’s Pesticide Data Program (PDP) samples more than 80 types of fruits, vegetables, nuts, meat, grains, dairy products, and other foods to identify and quantify residues from insecticides, herbicides, fungicides, and growth
The foods, including processed and imported products, are collected from 10 states representing all regions of the country; the samples are collected as close to the point of consumption as possible. In its most recent report, PDP analyzed 11,683 samples, conducting an average of 105 tests on each sample (more than 1.22 million analyses in total). Only 23.1 percent of samples had zero pesticide residues detected, 29.5 percent had one residue, and the remainder had two or more. The majority of residues detected were at levels far below EPA tolerances (limits on pesticide residues on foods; referred to as maximum residue limits, or MRLs, in many other countries) but the data on which the tolerances are based are heavily criticized by environmental health professionals and advocates as being inadequate and unduly influenced by industry.

**Atrazine**

Atrazine is a broad leaf herbicide that has become ubiquitous in the population. Used primarily in corn production, approximately 80 million pounds of atrazine are applied annually in the U.S.—more than any other agricultural pesticide.225 Atrazine is used to increase crop yields by preventing weeds from growing and stealing nutrients from the crop, but some evidence suggests that eliminating its use would have little impact on usable crop levels.226 Atrazine has been shown to affect mammary gland development in animal studies,227 with some findings suggesting multigenerational effects.228,229 The relatively few human studies of atrazine carcinogenicity have been inconclusive.230 IARC has classified atrazine as a group 3 human carcinogen (not classifiable as to its carcinogenicity).231 EPA has faced considerable criticism from the media and environmental groups on its oversight of atrazine and 2003 renewal of atrazine’s classification as “not likely to cause cancer in humans.” In October 2009, EPA announced a comprehensive reevaluation of atrazine’s cancer and non-cancer effects based on the latest scientific data.232 The evaluation is expected to be completed in September 2010; EPA will determine at that time whether the agency’s regulatory position on atrazine should be revised and if new restrictions are needed to better protect health and the public.

**DDT and Metabolites (e.g., DDE, DDD)**

DDT was banned in the United States in 1973, but it remains important because it persists in the environment. It is found worldwide in the breast fat of humans and animals,233 in human breast milk, and in placenta.234 DDT is believed to be an endocrine disruptor. Girls exposed to elevated levels of DDT before puberty, when mammary cells are more susceptible to carcinogenic effects of
chemicals, hormones, and radiation, are five times more likely to develop breast cancer in middle age. Because many American women exposed to high DDT doses in childhood have yet to reach middle age, the public health significance of DDT exposure may be larger than currently is apparent. A recent study indicated that males exposed to DDT were 1.7 times more likely to develop testicular germ cell tumors (TGCT) than men not exposed. Since TGCTs likely are initiated very early in life, these findings raise the possibility that exposure during fetal development or through breastfeeding may increase TGCT risk.

In the most recent PDP sampling, DDE p,p' was the most frequently detected of the DDT metabolites. The chemical was found in 60 percent of heavy cream samples, 42 percent of kale greens, 28 percent of carrots, and at lesser percentages in many other foods sampled. In all cases, the residue levels detected were much lower than the FDA action levels, but the findings demonstrate the persistence of this carcinogen in the food supply and the environment.

I’m a two-time breast cancer survivor [and] a scientist....I did everything healthy....this atrazine—it’s everywhere...I wasn’t being protected by the government and I resent that terribly....my children, my in-laws, my grandchildren are being exposed to this...and, you know, I want something done about it. I want something done about it now.

PEGGY FOLLY
BREAST CANCER SURVIVOR, INDIANA

Fertilizers

Nitrogen Fertilizers

By applying nitrogen fertilizers, burning fossil fuels, and replacing natural vegetation with nitrogen-fixing crops, humans have doubled the rate of nitrogen deposition onto land over the past 50 years. Nitrogen fertilizers may increase cancer risk due to the breakdown of nitrogen by digestive enzymes. Most of the nitrogen in fertilizers is converted to nitrate that seeps into groundwater. Nitrate levels in groundwater under agricultural areas can be several- to 100-fold higher than levels under natural vegetation. Rural populations in agricultural areas may have a much greater likelihood of elevated nitrate...
exposures compared with those using public water supplies. Nitrate levels also can be high in streams and rivers due to runoff of nitrogen fertilizer from agricultural fields. Almost all public water supplies, however, have nitrate levels below the EPA Maximum Contaminant Level (MCL) of 10 mg/L.

Ingesting contaminated drinking water is the primary route of human exposure to nitrate from nitrogen fertilizers. Nitrate in drinking water is important because the most likely known mechanism for human cancer related to nitrate is the body’s formation of N-nitroso compounds (NOC), which have been shown to cause tumors at multiple organ sites in every animal species tested, including neurological system cancers following transplacental exposure. Nitrite, the reduced form of nitrate, reacts in the acidic stomach to form nitrosating agents that then react with certain compounds from protein or other sources such as medications to form NOCs. NOC formation is inhibited by dietary antioxidants found in vegetables and fruits, which may account in part for the observed protective effect of fruits and vegetables against many cancers.

In humans, nitrosamines and NOCs are suspected brain and CNS carcinogens. In addition, a cohort study of older women in Iowa found that those whose drinking water had higher long-term average nitrate levels had an increased risk of bladder and ovarian cancers. Other studies have had mixed results or shown no association with nitrate intake. Small numbers of epidemiologic studies of any one cancer site have been conducted; such research is needed to identify other potential nitrate-related cancer risks. Limited mechanistic studies suggest that nitrate at levels below the MCL could be carcinogenic. Further research into this question is warranted, particularly because nitrate levels continue to rise in groundwater as use of nitrogen fertilizers increases. With greater production of corn for fuel, nitrate levels in drinking water are likely to continue their upward trend.

Some research indicates that crop rotation and/or the use of cover crops (e.g., grass or legumes planted on a field between production seasons) can reduce or negate the need for nitrogen fertilizers without sacrificing crop yields. Legume cover crops can fix (capture) nitrogen, which preserves it for the next growing season and prevents nitrogen in the soil from leaching into groundwater.
Phosphate Fertilizers

Phosphate fertilizers are often contaminated with cadmium and are responsible for significant cadmium soil and water contamination. Fertilized soils have been found to have two to six times the cadmium concentration of nearby unfertilized land.245

In the food supply, cadmium is most highly concentrated in grains and seafood. For decades, residents of Southern Louisiana have had pancreatic cancer rates markedly higher than the national average.246 Research has demonstrated an association of rural residence, dietary factors (high consumption of rice, seafood, and pork), and cigarette smoking with higher pancreatic cancer risk, particularly among persons of Acadian (Cajun) ancestry.247 Cadmium appears to be the common factor in all of these variables. Rice fields in the area are treated with cadmium-containing phosphate fertilizers, which is taken up into the rice, the predominant starch in Acadian diets. After the rice harvest, the fields are again flooded, and crawfish, a staple seafood in the local diet, are farmed in the previously fertilized fields. Urinary cadmium excretion levels in studied Louisiana pancreatic cancer patients have been found to be more than four-fold higher than control subjects.247

Industrially, cadmium is used in manufacturing processes such as electroplating, production of polyvinyl chloride (PVC) products, and nickel-cadmium batteries. An estimated half-million manufacturing workers are exposed to cadmium.248

Phosphate fertilizers also accelerate the leaching of arsenic from soils into groundwater.249 The arsenic soil contamination is often the result of previous fertilization with arsenic-containing pesticides. Further, the addition of phosphates to soil has been found to increase arsenic accumulation in wheat.250

Veterinary Pharmaceuticals

Except for animals raised on organic farms, most livestock in feed lots and poultry farms are given antibiotics, growth hormones, and feed that may consist in part of animal tissue that itself may be contaminated by these drugs. When excreted, these medications become part of the toxic run-off from agricultural operations. The impact of this contamination on human cancer is unknown at this time, but there is speculation that the growth hormones may contribute to endocrine disruption in humans.

...agricultural exposures are very complex. We have talked a lot about pesticides but there are many other exposures that are agricultural as well and they are agricultural in an occupational setting but they expand into the general environment, and people are exposed through contaminated water. They are exposed through food, as well as the occupational exposures.

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