

# National Children's Study: Environmental Exposures in Waukesha County

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## ABSTRACT

The National Children's Study (NCS), launched in September of 2005, will investigate the effects of environmental exposures and children's health and development. Waukesha County, Wis was selected as 1 of 7 sites to spearhead this ambitious undertaking. Residents of Waukesha County may experience different kinds of environmental exposures from water, land, and air based on where they live, work, and play. A selected number of Waukesha County's environmental exposures described briefly in this report will serve the NCS well with their heterogeneity of potential exposures: from private well water and community water supplies that obtain water from both surface and groundwater; from the variable exposures to ambient air pollution from mobile sources, local industrial sources, and dis-

tant sources (ozone); and the different levels of exposures from soil and dust depending on the prevalence of pesticide use and lead-based paints. By combining data gathered from Waukesha County's participants with other study sites, a holistic picture of environmental exposures in the United States can be evaluated as it influences the health of our nation's children.

## INTRODUCTION

Congress authorized the implementation of the National Children's Study (NCS) to evaluate environmental influences on children's health and development. (See Trasande et al, p 50 and Hewitt et al, p 55 in this issue for details on the NCS.) Table 1 lists environmental exposures that will likely be included in the NCS protocol along with the areas of study addressed by each assessment. The following sections describe the 3 major media—water, land, and air—with special attention to Waukesha County's contribution to the NCS environmental exposure data.

## DOMESTIC WATER USE AND EXPOSURES

Wisconsin has an abundant supply of water, with over 33,000 miles of streams, 15,000 lakes, and about 1.2 quadrillion gallons of groundwater (equivalent to about one third the volume of Lake Superior).<sup>1</sup> Drinking water can be classified into 2 major categories: community water supplies (CWS) and private drinking water. (For this paper only data for municipal water supplies are reported.) The source of the water in both categories is either groundwater or surface water (eg, rivers or lakes). Private drinking water is almost always obtained from groundwater sources via wells of varying depth, depending on the underlying geology. In contrast, the source of CWS can be either groundwater or surface water. The significance of the source lies in the probability of detecting different kinds of contaminants and, for CWS, the typical treatment options.

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**Table 1.** Description of Environmental Contaminants, Areas of Study These Exposures Support, and Potential Health Outcomes of the National Children's Study

Environmental Medium and Contaminant	Areas of Study Supported*	Health Outcome
<b>Domestic Water Contaminants</b>		
Arsenic	1	Neurobehavioral
Perchlorates	8	Thyroid
Pesticides		
Atrazine	5	Puberty
Organophosphates	1,8	Neurodevelopmental, thyroid
Carbamates	1,8	Neurodevelopmental, thyroid
Pyrethroids	1,8	Neurodevelopmental, thyroid
Benzene	3	Asthma
Chloroform	1	Neurobehavioral
Lead	5	Puberty
Disinfection byproducts	1	Neurobehavioral
<b>Air Pollutants</b>		
Indoor Air Pollutants		
Formaldehyde	3	Asthma
Acrolein	3	Asthma
Endotoxins	2,3,4,7	Asthma
Nicotine, environmental tobacco smoke	2	Asthma
Lead	5	Puberty
Respirable PM	2,3,4	Asthma
Oxidants		
Ozone	2,3,4	Asthma
Nitrogen dioxide	2,3,4	Asthma
Polycyclic aromatic hydrocarbons in PM	3	Asthma
Outdoor Air Pollutants		
PM 2.5 (lead)	5	
Methyl and ethyl mercury	1,6	Neurodevelopmental, asthma, puberty
PM 2.5 (cadmium)	5	Puberty
Manganese	1	Neurobehavioral
<b>Land (Soil and Dust) Contaminants</b>		
Indoor dust		
Cat, dog, cockroach, mouse/rat urine	2,3,4	Asthma
Dust mite	2,3,4	Asthma
Mold	2,3,4	Asthma
Endotoxins	2,3,4,7	Asthma
Chromium		
Lead	5	Puberty
Outdoor soil		
Pesticides		
Organophosphates	1,8	Neurodevelopmental, thyroid
Carbamates	1,8	Neurodevelopmental, thyroid
Pyrethroids	1,8	Neurodevelopmental, thyroid
Metals (Cd, Pb)	5	Puberty

PM=particulate matter (2.5=2.5 microns in diameter).

\* Areas of study: see [www.nationalchildrenstudy.gov](http://www.nationalchildrenstudy.gov) for full description of hypotheses.<sup>2</sup>

1. Non-persistent pesticides and poor neurobehavioral and cognitive skills
2. Environmental exposures and genetic variation interactions and asthma
3. Indoor, outdoor air pollution and asthma risk
4. Asthma and physical environmental risk factors, psychosocial stress, and health related behaviors
5. Chemical environmental agents and the endocrine system and age at puberty
6. Genetics, environmental exposures, and type I diabetes
7. Early exposure to bacterial and microbial products and asthma risk
8. Maternal subclinical hypothyroidism

**Table 2.** Percent of Population Served in Waukesha County by Drinking Water Sources, Concentration Range of Selected Drinking Water Contaminants, and Place of Maximum Detect

	% Population Served	Nitrogen-Nitrate		Chloroform		Trihalomethanes	
		Range of Nitrogen-nitrate*	Source of Maximum Detect	Range of Chloroform†	Source of Maximum Detect	Trihalo-‡ methanes	Source of Maximum Detect
Community Water Supply‡							
Groundwater	53%	0.0 - 7.34	Prairie Village Water Trust	0.0 - 2.26	Oconomowoc Waterworks	0.03 - 3.67 0.0 - 13.85	Waukesha Water Utility
Surface water§	17%					0.0 - 1.48	Butler Waterworks
Total	70%						
Private Water Supply¶							
Groundwater	30%	0.0 - 44.9	Lisbon Township				
Surface water	0%						
Total	30%						

\* parts per million

† parts per billion

‡ Data from 1998 - 2002.<sup>3</sup>

§ Menomonee Falls Waterworks—surface water data missing; Environmental Working Group was not given these testing data in electronic format.<sup>3</sup>

¶ Data from 1988 - 2001; 16 studies quantified nitrogen-nitrate concentrations in approximately 700 wells.<sup>4</sup>

In Waukesha County, 70% of the population is served by CWS, predominately from groundwater (with only Menomonee Falls and Butler using purchased surface water). All the private water supplies are drawn from groundwater.<sup>5</sup> The 2005 Environmental Working Group report<sup>3</sup> ranked Wisconsin second in the country (after California) among the 42 states that provided data, in number of contaminants detected in its CWS (n=119). Of these contaminants, 50% were over the health limits, translating into approximately 3.5 million Wisconsin residents exposed.

Nitrate levels in drinking water illustrate the difference in the magnitude of exposure between CWS and private drinking water sources. The maximum concentration level was 7.34 ppm for CWS compared to 44.9 ppm for private water supply (Table 2). Further, concentration levels vary for disinfection byproducts, such as chloroform and total trihalomethanes (Table 2); these may be used in CWS but are not used in private water sources. Finally, some contaminants are equally likely to be found in both private and public water supplies owing to erosion of natural deposits (radioactive elements, arsenic) or composition of water pipelines (lead, copper).

### LAND USE AND CONTAMINANTS

Waukesha County encompasses 576 square miles with 7 cities, 18 villages, and 13 towns (townships). It is the third most populated county in Wisconsin (after Milwaukee and Dane Counties).<sup>6</sup> Waukesha County has experienced an average 490% population increase

from 1940 to 2000, which reflects notable land use changes and increased environmental burdens due to growth.<sup>6</sup> Further, high traffic volumes during the decades of leaded gasoline use have resulted in significant lead contaminated soils in Waukesha's urban core. In addition, houses built during the 1920s-1950s typically used lead-based paints,<sup>7</sup> with a tendency for exposure to lead-based paint to be more common in homes with poor upkeep, typically rentals. A pooled analysis of 12 cross-sectional studies indicated that the major source of lead exposure in young children is house dust from deteriorating paint and lead-contaminated soil tracked into the home.<sup>8</sup> For Waukesha County, 15% of the homes were built before 1950 and of these, approximately 2.4% are rentals.<sup>6</sup> The Department of Health and Family Services data from 2004 reported 6790 children age 1-5 years had been tested for lead exposure in Waukesha County and approximately 1% were found to have levels at or above 10 ppm.<sup>9</sup> Slightly more than half of these 61 children were Medicaid eligible, which reflects the child's increased likelihood of residing in old rental properties.

In contrast to lead exposure, which is more likely to be an urban problem in lower socioeconomic neighborhoods, pesticide exposure can affect children in urban, suburban, and rural-agricultural areas. Wigle reported that insecticides were used in over 90% of US households and in approximately 70% of homes with pregnant women or infants under 6 months.<sup>7</sup> Landrigan et al concluded that children who live in inner cities are at a disproportionately high risk of exposure to numer-

ous environmental toxins, including pesticides.<sup>10</sup> In agricultural areas, children have an increased likelihood of exposure to pesticides because of higher environmental levels in their indoor and outdoor environments—proximal to agricultural crop fields.<sup>7</sup> For Waukesha County, approximately 1% of the population has farm or farm-related jobs with increased likelihood of pesticide exposure to their children.<sup>6</sup>

Finally, use of pesticides on pets in the form of shampoos and flea collars, as well as broadcast indoor spraying, exposes children in all types of homes. For example, chlorpyrifos, a widely used insecticide applied to lawns, playgrounds, parks, and used in flea collars, appears to accumulate in polyurethane foam in pillows, toys, bedding, and mattresses, with very high reported uptake by young children.<sup>11</sup>

## AIR POLLUTANTS

Children in the United States spend over 90% of their time indoors.<sup>7</sup> Children inhale relatively high amounts of air per unit body weight per day and play at floor level, where contaminant concentrations may be relatively high. The US National Academy of Sciences (NAS) reviewed indoor air contaminants associated with asthma and assigned level of evidence. Not surprisingly, there is insufficient evidence to document an association between indoor air contaminants evaluated by the NAS and also selected by the NCS and childhood asthma (see Table 1).<sup>12</sup> Lanphear et al calculated a 39% population attributable risk for asthma in children with 1 or more of the following risk factors: family history of allergic disease, environmental tobacco smoke exposure, home use of gas stove or oven for heat, and presence of a dog in the household.<sup>13</sup> Further, volatile organic compounds such as formaldehyde, acrolein, and benzene, which can be found in paints, upholstery, spray cans, etc, have been identified as potential environmental risk factors. However, few data on amount used and/or bioavailability for uptake of these indoor air pollutants, with the exception of environmental tobacco smoke, are available for Waukesha County. Smoking is prevalent in Waukesha County, with an estimated 21% of the adult population smoking (national average is 23%) and 12% smoking indoors or in vehicles when others were present.<sup>14</sup> Further, an estimated 10% of women in Waukesha County smoked during pregnancy.<sup>15</sup>

Waukesha County had the third highest number of vehicle miles driven per day, estimated at 11,255,000 in 2003 (behind Milwaukee and Dane County, respectively).<sup>16</sup> The density of highways and popula-

tion growth influences the air quality by release of particulate matter and toxins from an increasing number of vehicles. The National Air Toxics Assessment measures 32 air toxics identified as posing the greatest public health threat.<sup>17</sup> For contaminants of interest to the NCS, the air toxin levels are below those for the nation as a whole, although all are above background levels.

In 2005, Waukesha County was ranked highest of the state's counties for fine particulate matter (PM) in ambient air at 13.1  $\mu\text{g}/\text{m}^3$  (9.9  $\mu\text{g}/\text{m}^3$  was the state average).<sup>18</sup> Waukesha County also had high ozone levels, largely attributable to winds carrying this pollutant from distant states, at 81.0  $\mu\text{g}/\text{m}^3$  (75.3  $\mu\text{g}/\text{m}^3$  was the state average).<sup>19</sup> The American Lung Association ranks Waukesha County as "orange," which means it is unhealthy for sensitive groups for both ozone and PM<sub>2.5</sub>.<sup>20</sup>

## CONCLUSION

The National Children's Study has the ambitious aim of evaluating the influence of environmental exposures during critical growth and developmental periods. Several contaminants have been selected for their potential association with the pre-defined health outcomes. Waukesha County's heterogeneous exposures from air, water, and land will contribute to this goal. Similar to most places in the United States, the environmental exposures in Waukesha County are typically within acceptable ranges (ie levels are below current regulatory standards). However, there is substantial public and scientific interest in understanding the influence of low-level, long-term exposures of mixed contaminants via multiple routes, especially to the fetus and during childhood. The participation of the residents of Waukesha County will contribute significantly to our understanding of the potential role of exposure to some environmental contaminants in the health of children.

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