Center *for*
Rural Health
University of North Dakota
School of Medicine & Health Sciences

Pesticide Exposure, Intelligence and Children: Preliminary Results

Patricia Moulton, Ph.D.

National Pesticide Forum

Washington, D.C.

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Pesticide Research Team

UND Faculty
Thomas Petros
Patricia Moulton
Ric Ferraro
Sally Pyle
Sue Offutt
Steve Hawthorne
Ruth Paur

CDC Pesticide Laboratory
Dana Barr
Charles Dodson
Ralph Whitehead

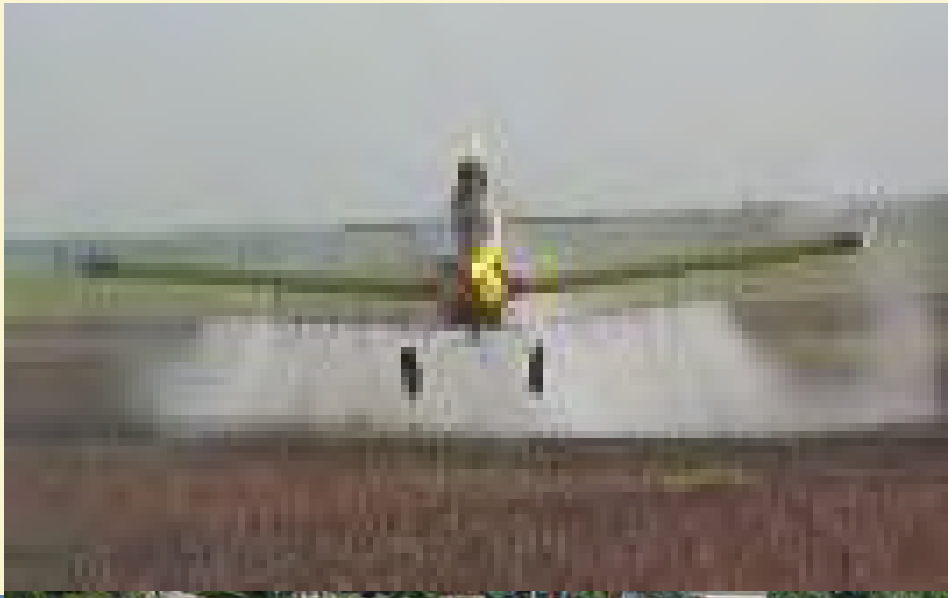
Phlebotomists
Sandie Antonson
Kristi Grove
Tara Johnso
Dawn Korynta
Naomi Sterf
Tara Waldal

Graduate Students
Holly Dannewitz
Matt Garlinghouse
Shyla Muse
Matthew Myrvik
Anna Marie Carlson
Jason Douglas
Patrick Kerr
Karyn Plumm
Kristi Sather
Caitlin Schultz
Jen Short

Undergraduate Students
Cassandra Lee
Silje Lynne
Ashley Olson
Bethany Reuter
Christine Wegner
Catherine Woell

What are Pesticides?

- Herbicides
- Insecticides
- Rodenticides
- Fungicides



Pesticide Exposure and Children

ELSEVIER

NeuroToxicology 26 (2005) 573–587

NeuroToxicology

A Summary of Recent Findings on Birth Outcomes and Developmental Effects of Prenatal ETS, PAH, and Pesticide Exposures

F.P. Perera[a,*], V. Rauh[a], R.M. Whyatt[a], D. Tang[a], W.Y. Tsai[a], J.T. Bernert[b], Y.H. Tu[a], H. Andrews[a], D.B. Barr[b], D.E. Camann[c], D. Diaz[a], J. Dietrich[a], A. Reyes[a], P.L. Kinney[a]

[a]Columbia Center for Children's Environmental Health, Mailman School of Public Health, Columbia University, New York, NY 10032, USA
[b]Centers for Disease Control and Prevention, National Center for Environmental Health, Division of Laboratory Sciences, Atlanta, GA, USA
[c]Southwest Research Institute, San Antonio, TX, USA

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Abstract

...r adverse birth outcomes and also more likely to be exposed to ...obacco smoke (ETS), benzo[a]pyrene B[a]P, other ambient ...residential pesticides. The Columbia Center for Children's... ...tive cohort study of 700 northern Manhattan pregnant women ...posure to these common toxicants on fetal growth, earl... ...ummarizes results of three published studies demonstratin... ...utcomes and/or neurocognitive development [Perera FP, Rau... ...ular evidence of an interaction between prenatal environmen... ...Environ Health Perspect 2004;12:630–62; Rauh VA, Whyat... ...Developmental effects of exposure to environmental tobacc... ...eurotoxicol Teratol 2004;26:373–85; Whyatt RM, Rauh V, Bar... ...insecticide exposures, birth weight and length among an urba... ...evaluate the effects of prenatal exposure to ETS, PAHs, an... ...d blood plasma (including biomarkers of ETS and pesticid... ...ve of PAHs). Self-reported ETS was associated with decrease... ...ant interaction between ETS and adducts such that combine... ...weight (P = 0.04) and head circumference (P = 0.01) afte... ...e neurotoxic effects of prenatal ETS exposure and postpartun... ...housing, and clothing) on 2-year cognitive development. Bot... ...nd there was a significant interaction such that children wit... ...reatest cognitive deficit (7.1 points). A third analysis found tha... ...lorpyrifos, diazinon, and propoxur-metabolite, were inversel... ...hese results underscore the importance of policies that reduc... ...lly adverse effects on fetal growth and child neurodevelopmen...

...aterial hardship; Birth outcomes; PAH; Prenatal

...4 1943.

...eserved.

Children's Health | Article

Variation in Organophosphate Pesticide Metabolites in Urine of Children Living in Agricultural Communities

William E. Lambert,[1] Michael Lasarev,[1] Juan Muniz,[2] Jennifer Scherer,[1] Joan Rothlein,[1] Juanita Santana,[3] and Linda McCauley[2]

[1]Center for Research on Occupational and Environmental Toxicology, Oregon Health and Science University, Portland, Oregon, USA; [2]School of Nursing, University of Pennsylvania, Philadelphia, Pennsylvania, USA; [3]Oregon Child Development Coalition, Wilsonville, Oregon, USA

Children of migrant farmworkers are at increased risk of exposure to organophosphate pesticides because of "carry-home" transport processes and residential location. Although this at-risk status is generally recognized, few available reports describe the extent of this exposure among agricultural communities. We quantified dialkyl phosphate (DAP) levels in serial samples of urine from 176 children, 2–6 years of age, in three Oregon communities hosting differing agricultural industries: pears, cherries, and fruit berries. Up to three spot samples of urine were collected from children at the beginning, mid-point, and end of their parents' work seasons. The median levels of dimethylthiophosphate (DMTP), the most commonly detected metabolite, was significantly higher in urine samples from children in each of the three agricultural communities (17.5, 19.0, and 41.0 ng/mL) relative to a reference group of children who lived in an urban community and whose parents did not work in agriculture (6.5 ng/mL; Kruskal-Wallis, $p < 0.001$). After controlling for age, sex, and weight, the median level of DMTP in children in the pear community was 1.92 times higher than the level in children of the berry community [95% confidence interval (CI), 1.14–3.25] and 1.75 times higher than the level in children of the cherry community (95% CI, 0.95–3.23). We observed increasing levels of DMTP across the work season only within the berry community. Levels decreased in the cherry community and remained constant in the pear community. Substantial temporal variation within the children followed demonstrates the need for multiple urine samples to most accurately characterize longer term and/or cumulative exposure. The observed variability in urinary DAP levels, between communities and over time, could be attributed to the types and amounts of organophosphate pesticides used, the timing of applications and degradation of residues in the environment, work operations and hygiene practices, the proximity of housing to orchards and fields, or the movement of these working families. Additional studies of variation in pesticide exposure across agricultural regions are needed. *Key words:* agriculture, children, farmworkers, pesticides. *Environ Health Perspect* 113:504–508 (2005). doi:10.1289/ehp.6890 available via *http://dx.doi.org/* [Online 10 January 2005]

Measurement of dialkyl phosphate (DAP) compounds in urine has been used to assess exposure to organophosphate pesticides (OPs) in children living in rural agricultural settings (Azaroff 1999; Curl et al. 2002; Koch et al. 2002; Loewenherz et al. 1997; Lu et al. 2000; Shalat et al. 2003) and more recently in urban communities (Curl et al. 2003; Lu et al. 2001). These biomarkers provide an integrated estimate of exposure received through ingestion, inhalation, and dermal absorption during the 24–48 hr preceding testing (Feldman and Maibach 1974; Loewenherz et al. 1997). Because the analytical method used to quantify urinary DAPs is relatively new and technically difficult (Moate et al. 1999), data on the extent of OP exposure in various types of communities are limited.

Children have been the focus of many exposure assessments because their activity patterns, behavior, and diet lead to increased risk of exposure relative to adults (Eskenazi et al. 1999). The sensitivity of developing organ systems, specifically the brain and central nervous system, and immature detoxification and elimination capacities further increase children's risk for adverse health effects (Faustman et al. 2000). In the United States, most children are probably exposed to OPs to some extent. Household surveys indicate extensive residential use of these compounds (Whitemore et al. 1994), and the potential for widespread low-level chronic exposure exists (Adgate et al. 2001). Children who live in agricultural communities are regarded to be at particularly high risk for exposure because of their proximity to fields and orchards where these chemicals are applied in high volume (Simcox et al. 1995). Additionally, children whose parents work in agriculture receive "carry-home" exposure via transport on their parents' work clothing and shoes (Lu et al. 2000). Our studies in Oregon have characterized these exposure pathways in children of migrant farmworkers and have demonstrated elevated levels of residues in their residences (McCauley et al. 2001).

In this report, we describe the occurrence of DAP compounds in urine samples collected from children of migrant farmworkers in three separate communities that host differing agricultural industries using varying types of OPs, and a reference group of children living in a urban area.

Materials and Methods

Study design. This study was conducted as a partnership between Oregon Health and Science University (OHSU) and the Oregon Child Development Coalition (OCDC), which is the grantee for Oregon Migrant Head Start. A cross-sectional design was employed to collect serial samples of urine from preschoolers attending Head Start programs at three centers operated by OCDC in the communities of Hood River, The Dalles, and Cornelius. For comparison purposes, a reference sample of preschool-age Hispanic children who lived in an urban area, Portland, and whose parents did not work in agriculture was also assembled. Urine was collected from the agricultural communities during June–September 2001, at the beginning, mid-point, and end of each work season. The timing of the sampling varied in each community depending on the time that the farmworkers began to arrive in the community, enrolled their children in Head Start programs, and started work harvesting crops. In the reference community group, samples of urine were collected during July and November 2001.

Survey sites. The communities selected for study are geographically separate and differ in the type of agricultural industry. Hood River primarily produces pears but also produces apples. Hood River is located along the

Address correspondence to L. McCauley, FAAN, Nursing Education Building, 420 Guardian Dr., University of Pennsylvania, Philadelphia, PA 19104-6096 USA. Telephone: (215) 898-9160. Fax: (215) 898-3056. E-mail: lmccaule@nursing.upenn.edu

We thank the children and the staff of the Migrant Head Start centers who participated in this study. We also acknowledge the data collection and technical contributions of R. Travers and J. Phillips of the Oregon Child Development Coalition, and those of G. Higgins, E. Mahoney, L. Pham, J. Richman, and K. Wu of the Center for Research on Occupational and Environmental Toxicology at Oregon Health and Science University.

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The authors declare they have no competing financial interests.

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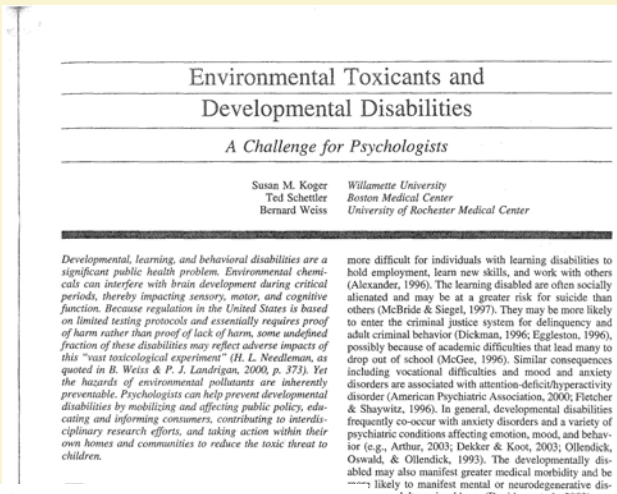


Environmental Toxicants and Developmental Disabilities

A Challenge for Psychologists

Susan M. Koger — *Willamette University*
Ted Schettler — *Boston Medical Center*
Bernard Weiss — *University of Rochester Medical Center*

Developmental, learning, and behavioral disabilities are a significant public health problem. Environmental chemicals can interfere with brain development during critical periods, thereby impacting sensory, motor, and cognitive function. Because regulation in the United States is based on limited testing protocols and essentially requires proof of harm rather than proof of lack of harm, some undefined fraction of these disabilities may reflect adverse impacts of this "vast toxicological experiment" (H. L. Needleman, as quoted in B. Weiss & P. J. Landrigan, 2000, p. 373). Yet the hazards of environmental pollutants are inherently preventable. Psychologists can help prevent developmental disabilities by mobilizing and affecting public policy, educating and informing consumers, contributing to interdisciplinary research efforts, and taking action within their own homes and communities to reduce the toxic threat to children.

more difficult for individuals with learning disabilities to hold employment, learn new skills, and work with others (Alexander, 1996). The learning disabled are often socially alienated and may be at a greater risk for suicide than others (McBride & Siegel, 1997). They may be more likely to enter the criminal justice system for delinquency and adult criminal behavior (Dickman, 1996; Eggleston, 1996), possibly because of academic difficulties that lead many to drop out of school (McGee, 1996). Similar consequences including vocational difficulties and mood and anxiety disorders are associated with attention-deficit/hyperactivity disorder (American Psychiatric Association, 2000; Fletcher & Shaywitz, 1996). In general, developmental disabilities frequently co-occur with anxiety disorders and a variety of psychiatric conditions affecting emotion, mood, and behavior (e.g., Arthur, 2003; Dekker & Koot, 2003; Ollendick, Oswald, & Ollendick, 1993). The developmentally disabled may also manifest greater medical morbidity and be ...likely to manifest mental or neurodegenerative dis... ...rs as adults or in old age (Davidson et al., 2003).

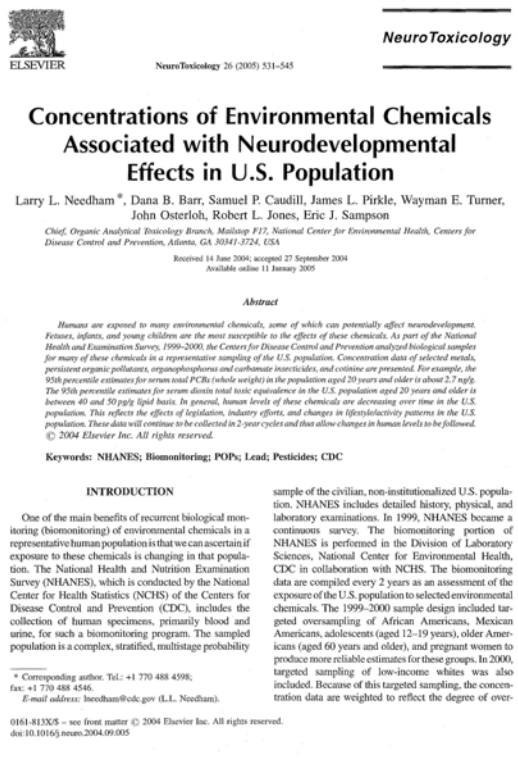
In addition, the families of children with disabilities ...serious emotional and financial costs (Wilton & Re... ...1986). For example, having a disabled child can ...usly strain family dynamics (Dyson, 1996), motivat... ...the family to seek professional counseling; parents, ...cially mothers, often present with depression (Smith, ...centi, Boyce, & Smith, 1993); and utilizing special ...ational and therapeutic services (e.g., psychological,

...M. Koger, Department of Psychology, Willamette University; Ted ...ller, Science and Environmental Health Network, Boston Medical ...r; Bernard Weiss, Department of Environmental Medicine, Univer... ...f Rochester Medical Center.

...ortions of this article were presented by Susan M. Koger (SMK) at ...2th Annual Convention of the American Psychological Association, ...lulu, Hawaii, July 2004. We appreciate the comments of Deborah Du ...Winter and Jim Friedrich on earlier versions of this article, and ...acknowledges the receipt of Atkinson Faculty Development and ...Time Awards from Willamette University, which partially sup... ...t this work.

...Correspondence concerning this article should be addressed to Susan ...ger, Department of Psychology, Willamette University, 900 State ..., Salem, OR 97301. E-mail: skoger@willamette.edu

Throughout this article, the generic term *developmental disabilities* collectively to these three categories of disabilities.



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NeuroToxicology 26 (2005) 531–545

NeuroToxicology

Concentrations of Environmental Chemicals Associated with Neurodevelopmental Effects in U.S. Population

Larry L. Needham *, Dana B. Barr, Samuel P. Caudill, James L. Pirkle, Wayman E. Turner, John Osterloh, Robert L. Jones, Eric J. Sampson

Chief, Organic Analytical Toxicology Branch, Mailstop F17, National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, GA 30341-3724, USA

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Abstract

Humans are exposed to many environmental chemicals, some of which can potentially affect neurodevelopment. Fetuses, infants, and young children are the most susceptible to the effects of these chemicals. As part of the National Health and Examination Survey, 1999–2000, the Centers for Disease Control and Prevention analyzed biological samples for many of these chemicals in a representative sampling of the U.S. population. Concentration data of selected metals, persistent organic pollutants, organophosphorus and carbamate insecticides, and cotinine are presented. For example, the 95th percentile estimates for serum total PCBs (whole weight) in the population aged 20 years and older is about 2.7 ng/g. The 95th percentile estimates for serum dioxin total toxic equivalence in the U.S. population aged 20 years and older is between 40 and 50 pg/g lipid basis. In general, human levels of these chemicals are decreasing over time in the U.S. population. This reflects the effects of legislation, industry efforts, and changes in lifestyle/activity patterns in the U.S. population. These data will continue to be collected in 2-year cycles and thus allow changes in human levels to be followed.

Keywords: NHANES; Biomonitoring; POPs; Lead; Pesticides; CDC

INTRODUCTION

One of the main benefits of recurrent biological monitoring (biomonitoring) of environmental chemicals in a representative human population is that we can ascertain if exposure to these chemicals is changing in that population. The National Health and Nutrition Examination Survey (NHANES), which is conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC), includes the collection of human specimens, primarily blood and urine, for such a biomonitoring program. The sampled population is a complex, stratified, multistage probability sample of the civilian, non-institutionalized U.S. population. NHANES includes detailed history, physical, and laboratory examinations. In 1999, NHANES became a continuous survey. The biomonitoring portion of NHANES is performed in the Division of Laboratory Sciences, National Center for Environmental Health, CDC in collaboration with NCHS. The biomonitoring data are compiled every 2 years as an assessment of the exposure of the U.S. population to selected environmental chemicals. The 1999–2000 sample design included targeted oversampling of African Americans, Mexican Americans, adolescents (aged 12–19 years), older Americans (aged 60 years and older), and pregnant women to produce more reliable estimates for these groups. In 2000, targeted sampling of low-income whites was also included. Because of this targeted sampling, the concentration data are weighted to reflect the degree of over-

* Corresponding author. Tel.: +1 770 488 4598; fax: +1 770 488 4546.
E-mail address: lneedham@cdc.gov (L.L. Needham).

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Pesticide Exposure and Cognitive Ability in Children

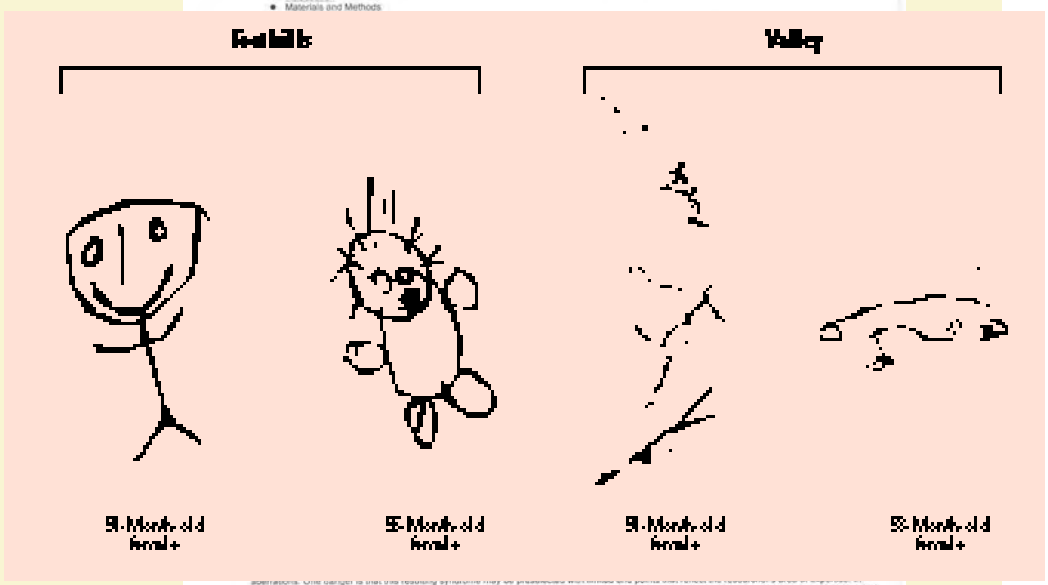
Environmental Health Perspectives Volume 106, Number 6, June 1998

An Anthropological Approach to the Evaluation of Preschool Children Exposed to Pesticides in Mexico

Elizabeth A. Guillette,[1] Maria Mercedes Meza,[2] Maria Guadalupe Aquilar,[2] Alma Della Soto,[2] and Idalia Enedina Garcia[2]

[1]Bureau of Applied Research in Anthropology, University of Arizona, Tucson, AZ 85721 USA
[2]Direccion de Investigacion y Estudias de Postgrado, Instituto Tecnológico de Sonora, Obregón, Sonora, México

- Introduction
- Materials and Methods



addition, it is easy to assume that the child has experienced no additional deleterious exposures, especially with longitudinal studies involving the initial study cohort. Studies performed in this manner indicate that *in utero* and lactational exposure to polychlorinated biphenyls (PCBs) impairs mental and motor abilities, including a lowering of intelligence (*1*). Multiple birth defects also have been associated with maternal exposure to chlorpyrifos (Dursban) (*2*).

Other studies take an analytical epidemiological approach, investigating health changes over a period of time. This avoids single agent paradigms, instead substituting environmental change as the causative factor. Assorted population changes, ranging from a decline in the proportion of males being born in Denmark to a temporal rise in general cancer rates among younger children (*3*) have been investigated with this approach. Other studies indicate apparent increases in cryptorchidism and testicular cancer over time, during which unknown environmental change has occurred (*4*). Contamination is a suspected major environmental contributor, but cannot be definitively identified (*5*). Also, each population under study incorporates a host of varied biological, social, and technological factors that influence the environment.

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NeuroToxicology 26 (2005) 589–598

NeuroToxicology

Neurobehavioral Performance in Preschool Children from Agricultural and Non-Agricultural Communities in Oregon and North Carolina

Diane S. Rohlman[1,*], Thomas A. Arcury[2], Sara A. Quandt[2], Michael Lasarev[1], Joan Rothlein[1], Rachelle Travers[3], Alys Tamulinas[1], Jennifer Scherer[1], Julie Early[2], Antonio Marín[2], Jacki Phillips[3], Linda McCauley[4]

[1]*Center for Research on Occupational and Environmental Toxicology, Oregon Health & Science University, 3181 Sam Jackson Park Road, Portland, OR 97239, USA*
[2]*Wake Forest University School of Medicine, Winston Salem, NC, USA*
[3]*Oregon Child Development Coalition, Wilsonville, OR, USA*
[4]*University of Pennsylvania, PA, USA*

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Abstract

Organophosphate (OP) pesticides produce acute toxic effects but little is known about low-level chronic exposures. Latino children of agricultural workers have a high risk of exposure to pesticides because of the close proximity of their homes to fields where pesticides are applied and from take-home exposure. Neurobehavioral performance of preschool children from agricultural (AG) communities was compared to performance of those from non-agricultural (Non-AG) communities in Oregon and North Carolina. Seventy-eight children aged 48–71 months completed a battery of neurobehavioral tests two times, approximately 1 month apart. Multiple regression revealed that the AG children performed poorer on measures of response speed (Finger Tapping) and latency (Match-to-Sample) compared to the Non-AG children. These results demonstrate modest differences in AG children compared to Non-AG children that are consistent with functional effects seen in adults exposed to low concentrations of OP pesticides. Just as was the case following early research on adults poisoned by pesticides, this study points to the need for additional investigations to test the hypothesis that low-concentration OP exposures affect acquisition of test performance, response speed and latency in children of agricultural workers.

Keywords: Neurobehavioral tests; Children; Agriculture; Latino; Hispanic

INTRODUCTION

Children can experience chronic low-concentration pesticide exposures that may cause effects not evident in routine clinical examinations (Landrigan, 2001). Children are particularly vulnerable to effects of pesticide exposure because of the rapid development of their organ systems and specific behaviors (e.g., increased time spent crawling and hand to mouth activity) that may increase their exposure (CDC, 2002; Cohen Hubal et al., 2000; Reed et al., 1999). Pesticide exposure can come from a variety of sources including diet, drinking water (Fenske et al., 2000; MacIntosh et al., 1996) and both indoor and outdoor residential use (Azaroff, 1999; Fenske et al., 2002; Lu et al., 2001).

* Corresponding author. Tel.: +1 503 494 2514; fax: +1 503 494 4278.
E-mail address: rohlmand@ohsu.edu (D.S. Rohlman).

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Objectives of Current Study

1. **Examine the impact of chronic routine exposure to pesticides on cognitive and motor performance in children between 7 and 12 years of age, including memory performance, executive function performance, motor performance, and performance on school-related achievement tests.**

2. **Measure the concentration of several pesticides and cholinesterase in the blood or urine in children between 7 and 12 years of age and examine associations between pesticide and cholinesterase concentration and cognitive and motor performance.**

Red River Valley

Pesticides in North Dakota

Participants

Pesticide Group= 64 children and their parents living on or next to an active farm or field

Control Group= 68 Children and their parents living at least one mile from an active farm or field

Measurements- Children

Physiological

Height and Weight
Blood and Urine- pesticides, cholinesterase, trace minerals

Motor

Grooved Pegboard Test
Benton Visual Retention Test
Finger Tapping Test
Hand-eye Coordination Test

Cognitive

Wechsler Intelligence Scale for Children-IV
California Verbal Learning Test for Children
Verbal Fluency Test
Continuous Performance Test
Wisconsin Card Sorting Test
Wechsler Individual Achievement Test- 2nd ed- Reading & Listening Comprehension

Measurements- Parents

Cognitive

Wechsler Adult Intelligence Scale-III
Vocabulary & Block Design

Behavioral

Child Behavior Checklist
ADHD Rating Scale-IV

Nutritional Status

NIH Diet History Questionnaire
Food Security module
24-Hour Dietary Recall

Developmental

Tanner Pubertal Development Test
Developmental Milestones

Environmental

Pesticide use and exposure questionnaire
Surveys on family and child medical history, sleep, occupation, income, education level

Measurements- Teachers

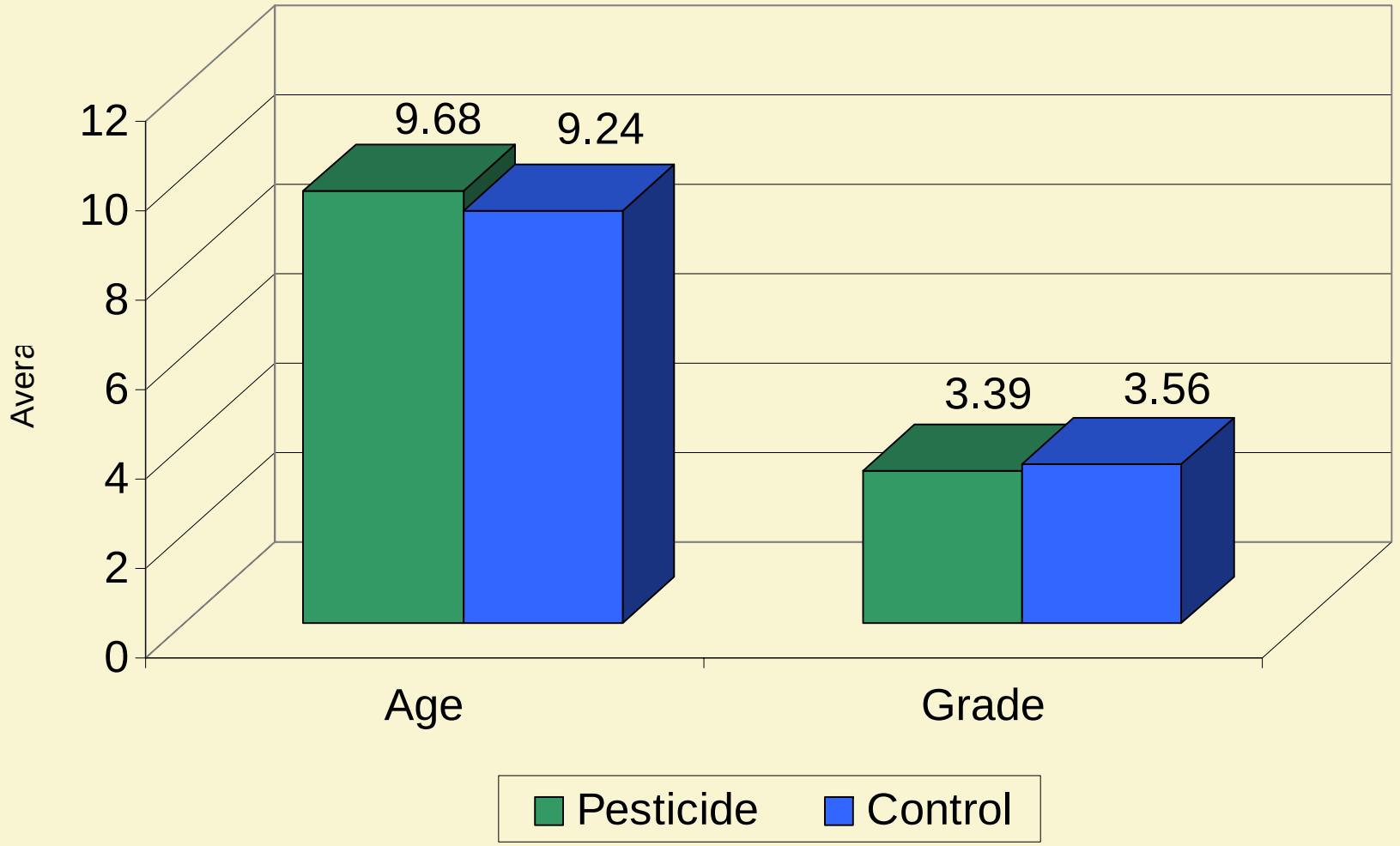
Behavioral

Teacher Report Form for Child Behavior Checklist

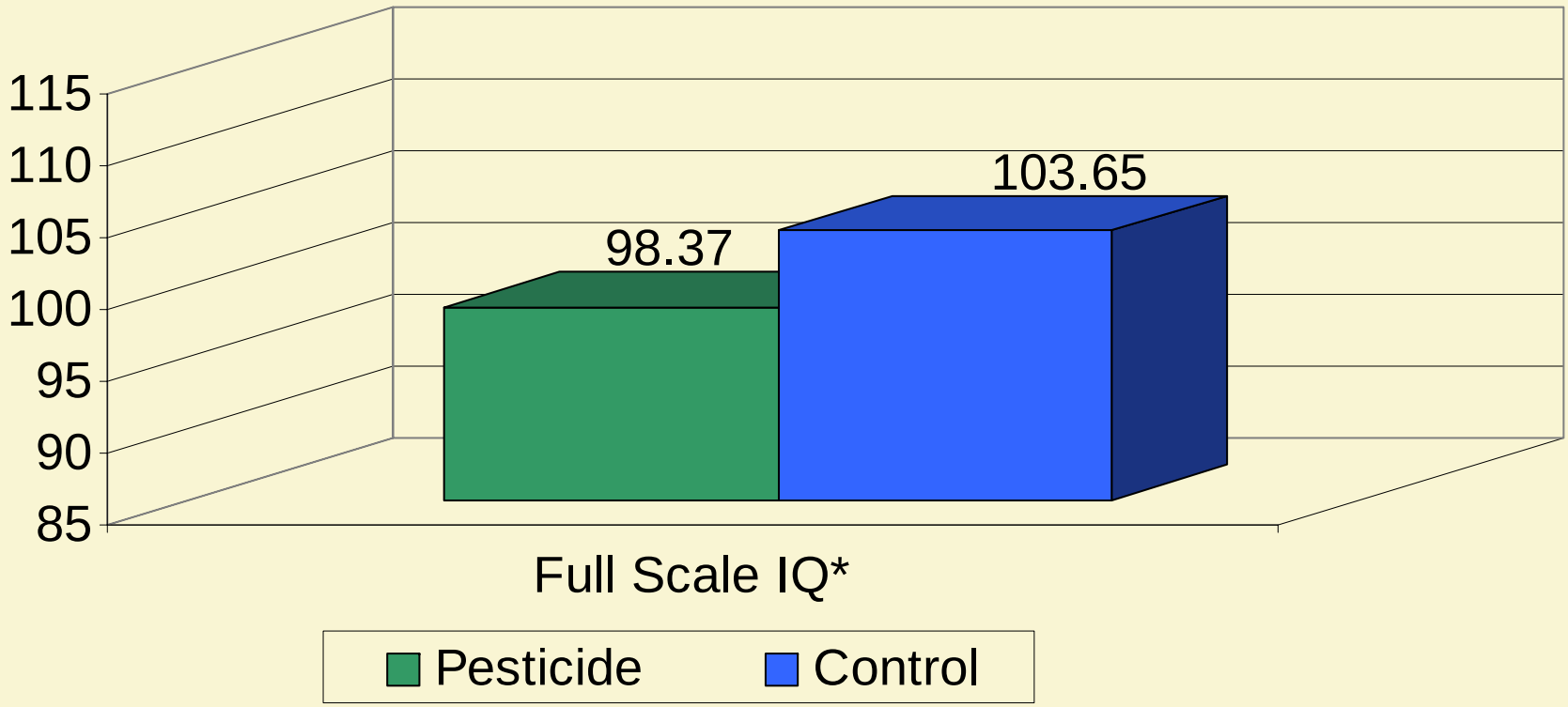
Teacher Report Form for ADHD Rating Scale-IV

Preliminary Intelligence Test Results

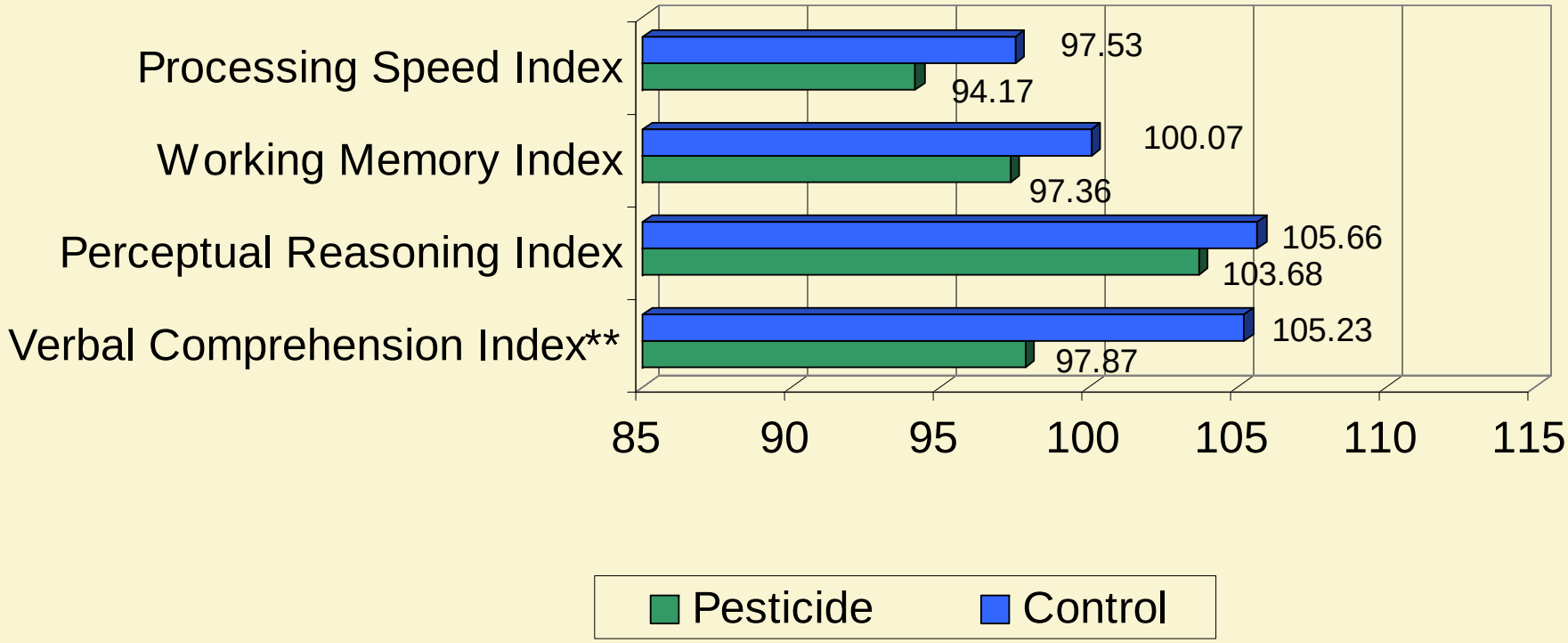
Child Demographics



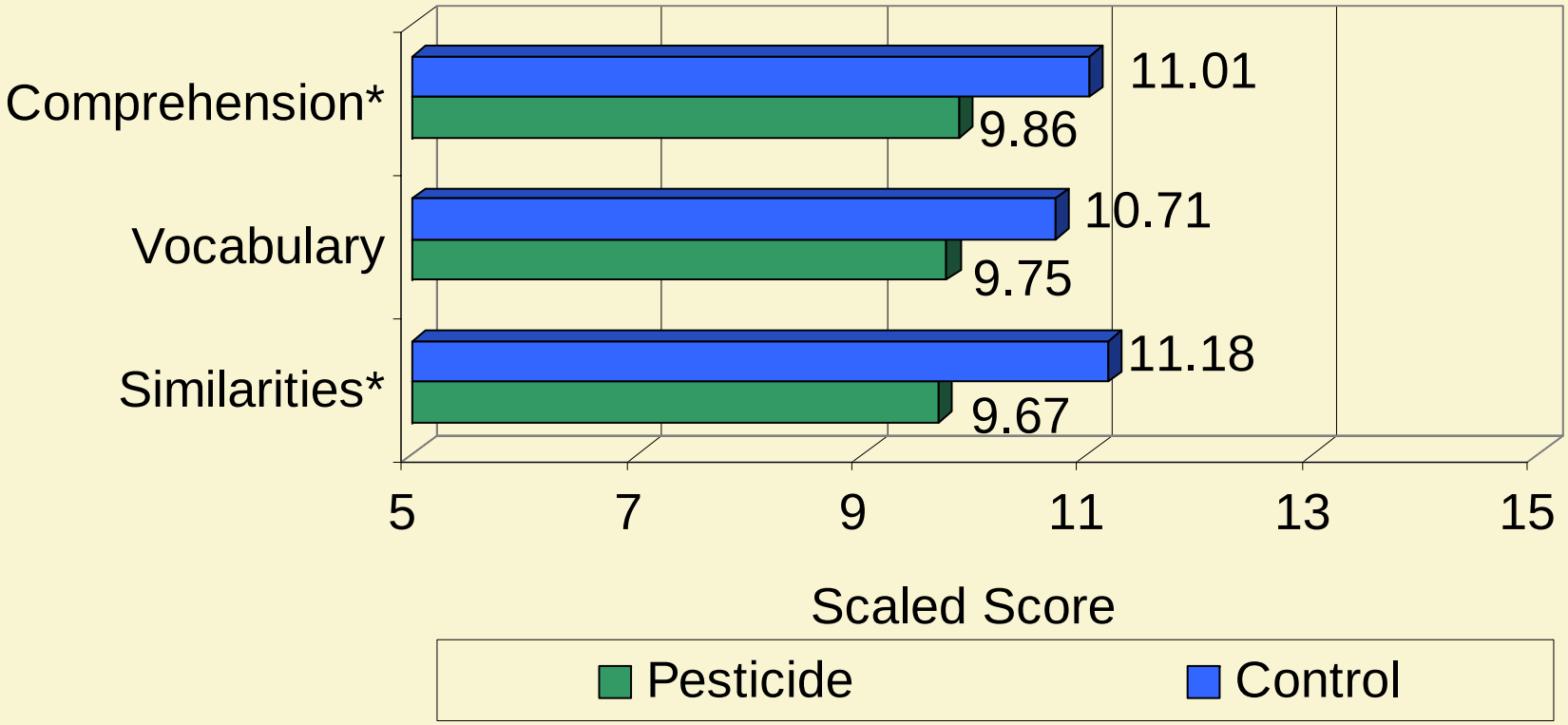
Child Full-Scale IQ



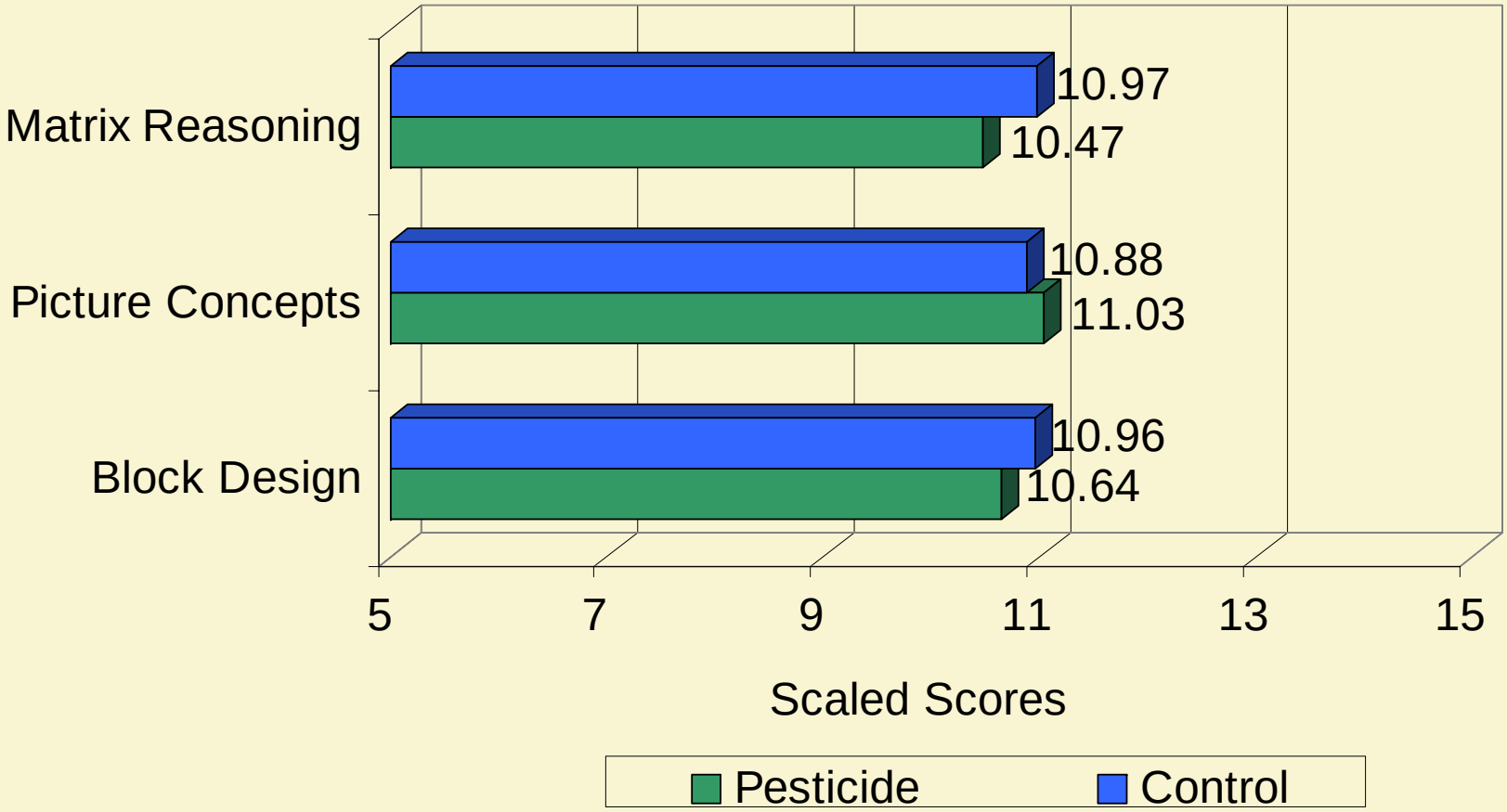
Child IQ Composite Scores



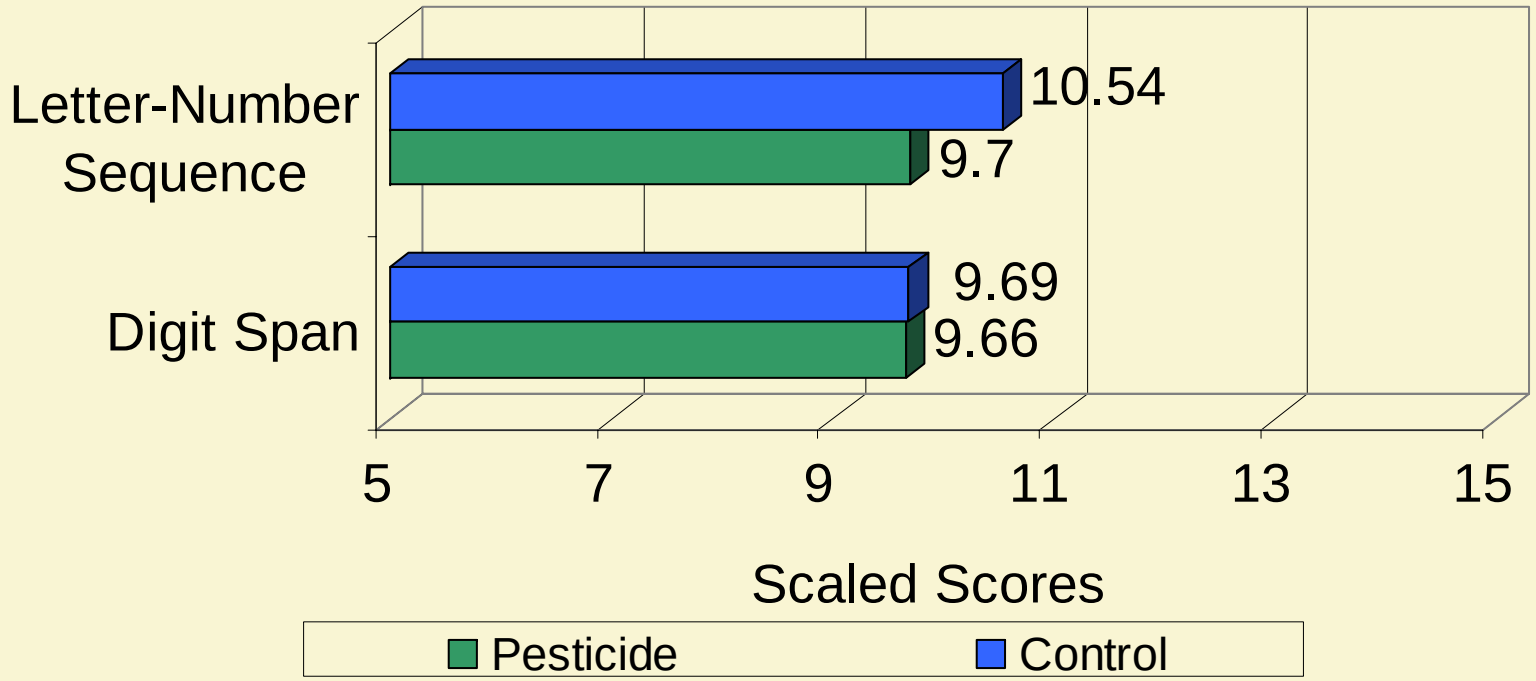
Verbal Comprehension Scores



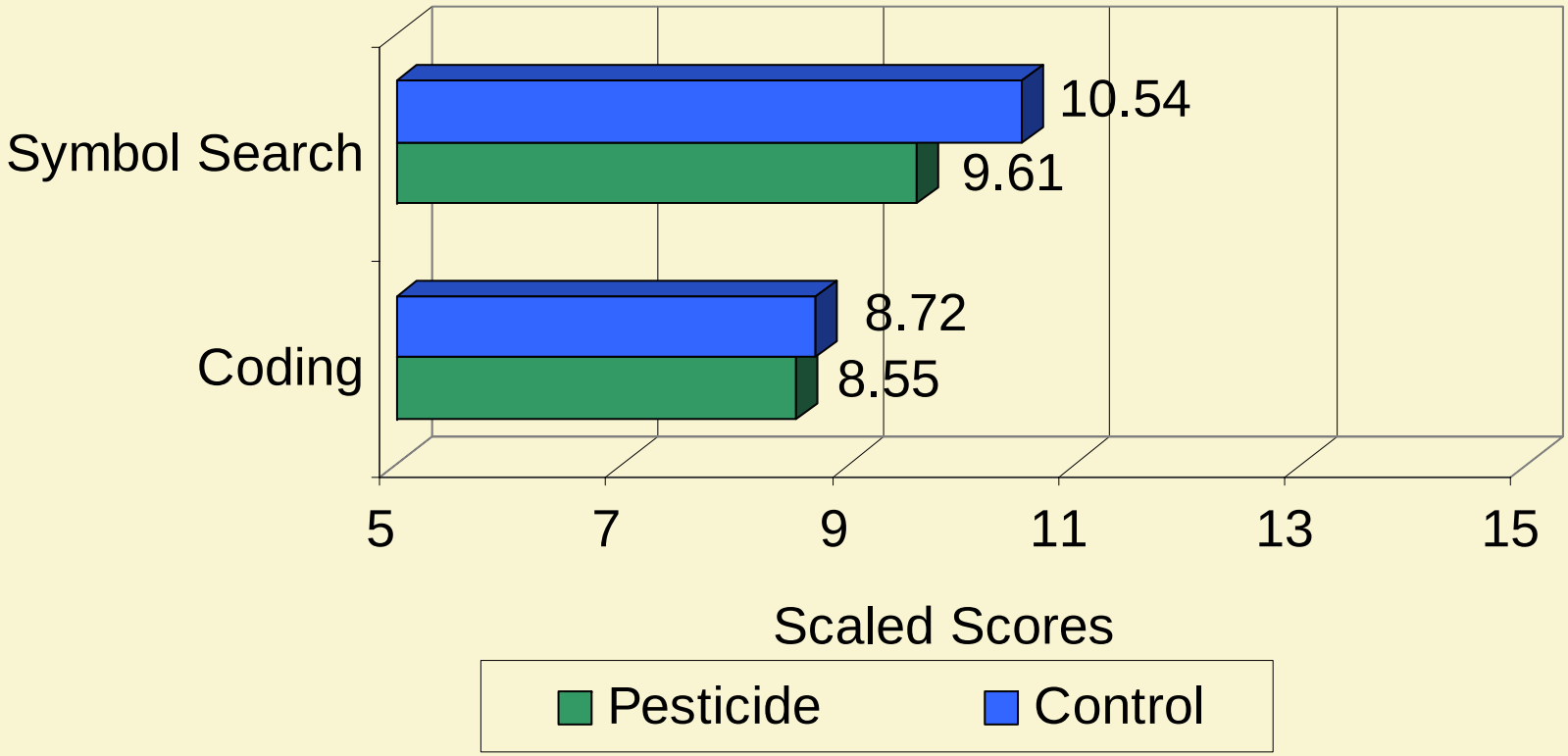
Perceptual Reasoning Scores



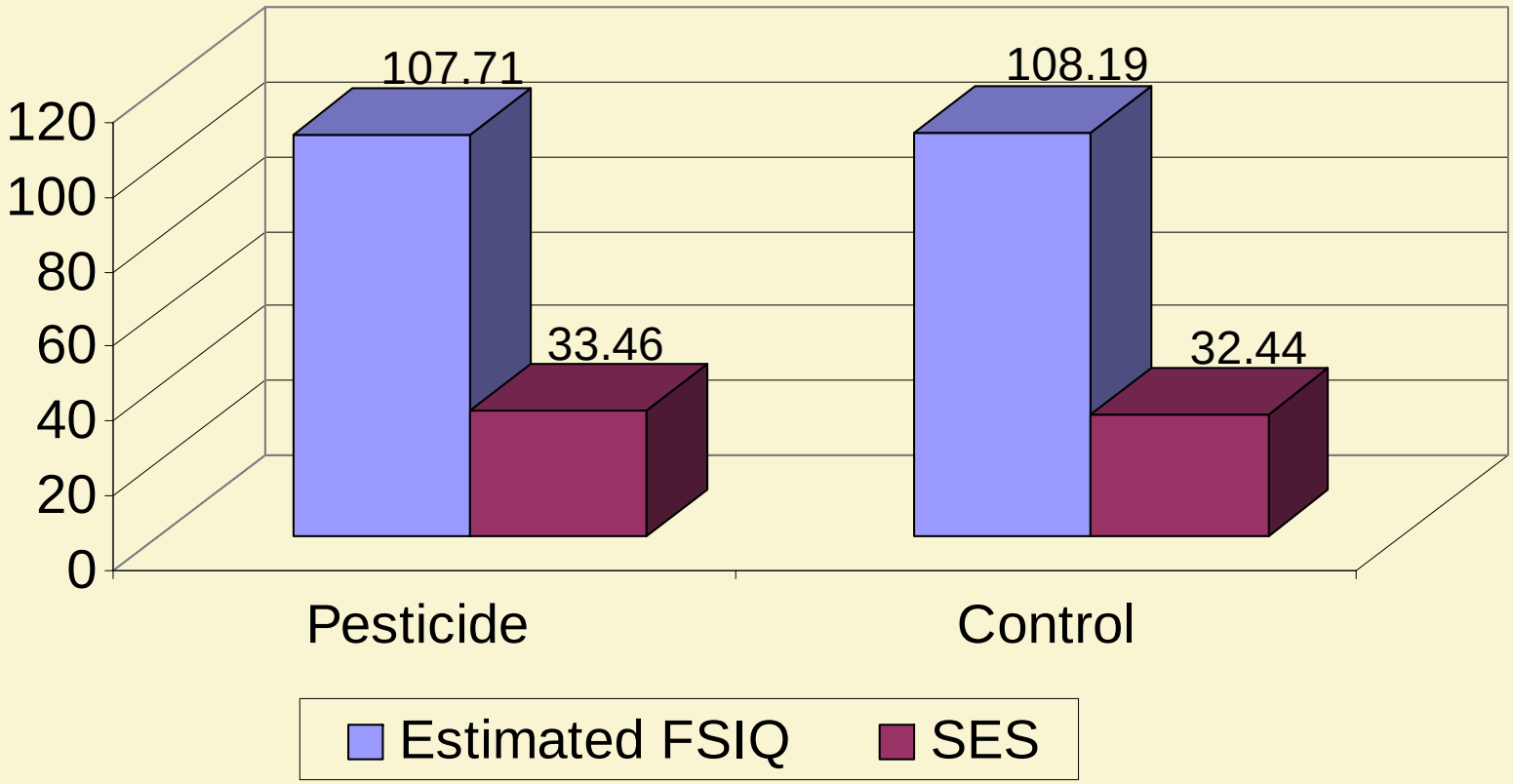
Working Memory Scores



Processing Speed Scores

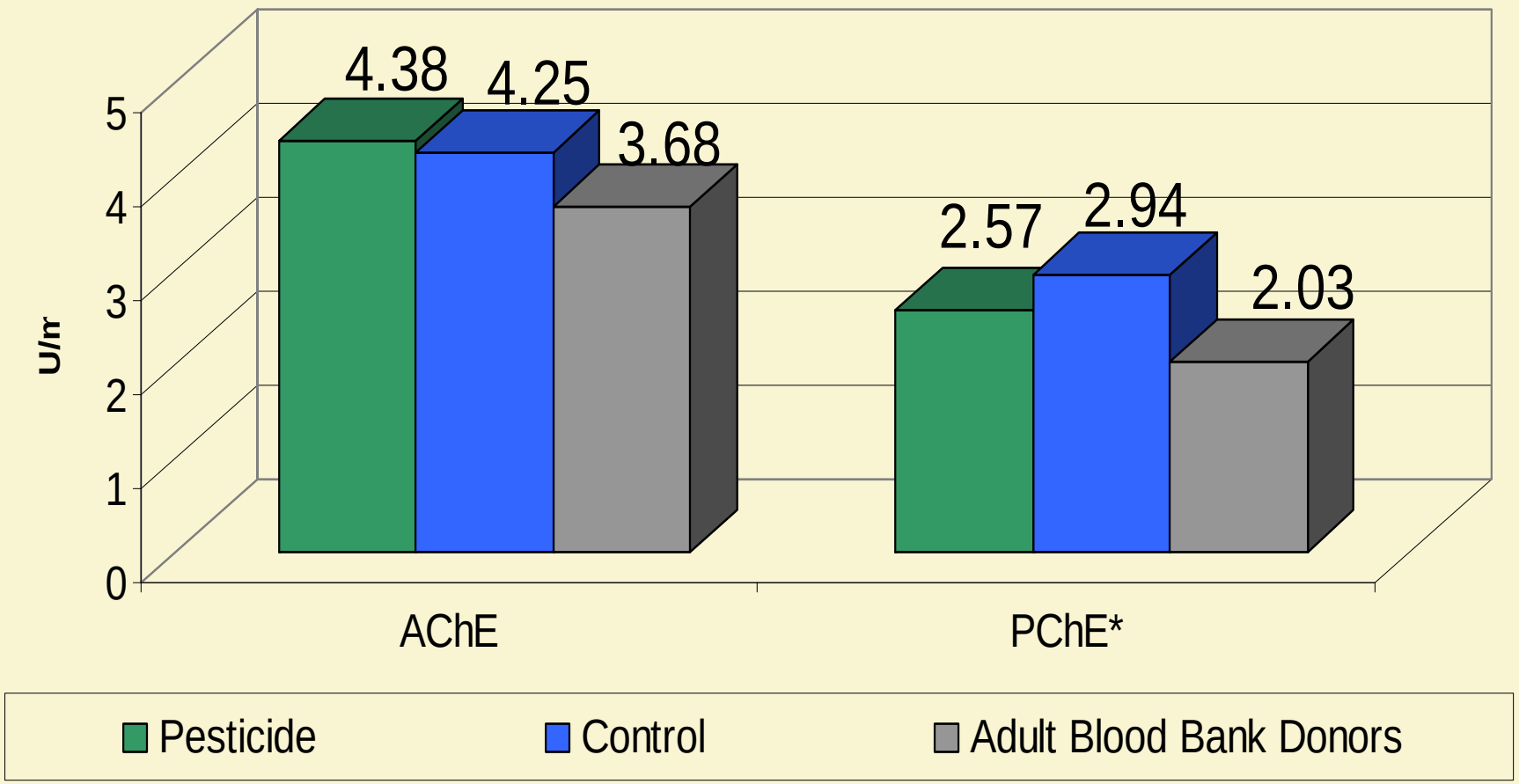


Parents Estimated Full Scale IQ

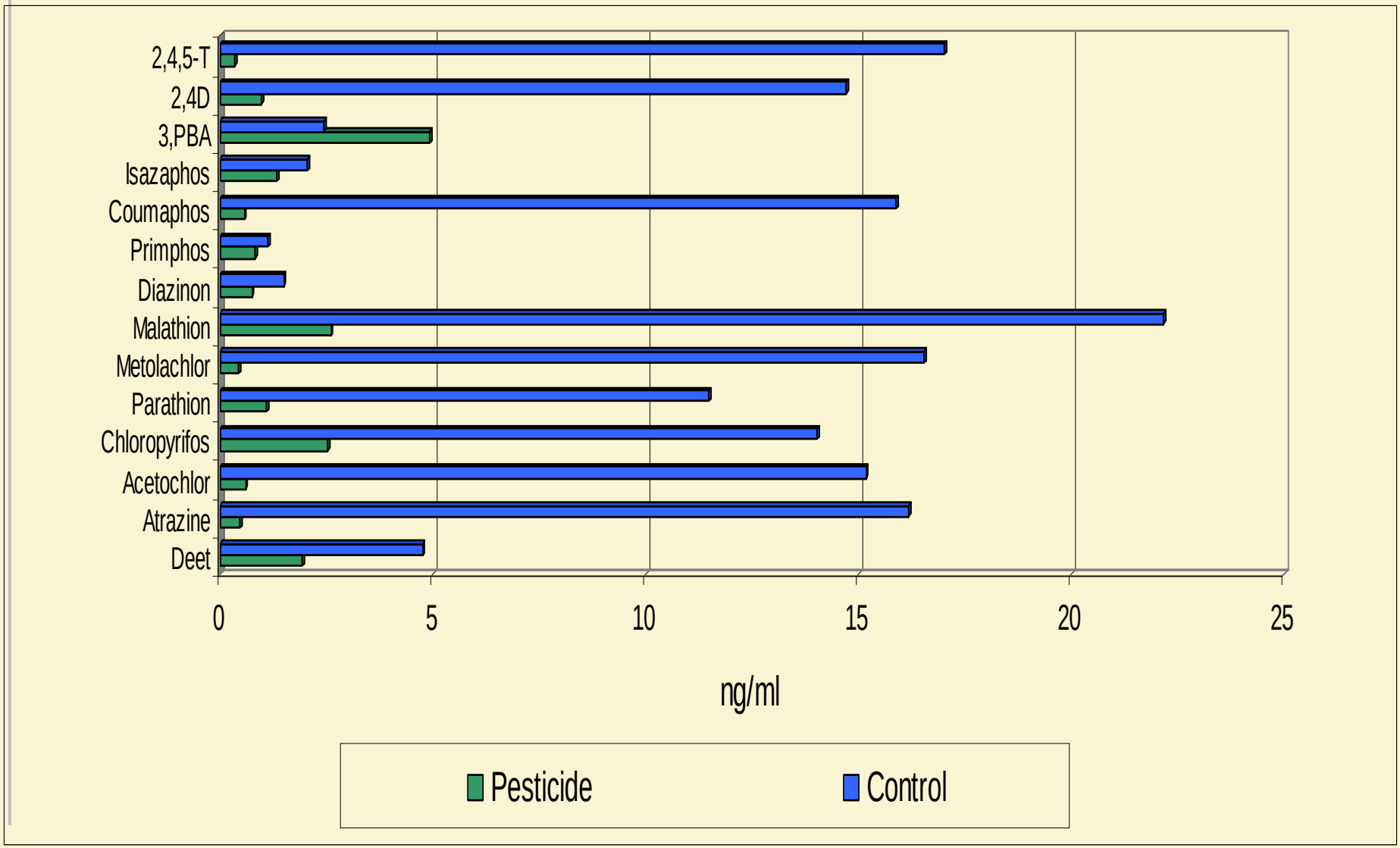


Preliminary Biological Measurements

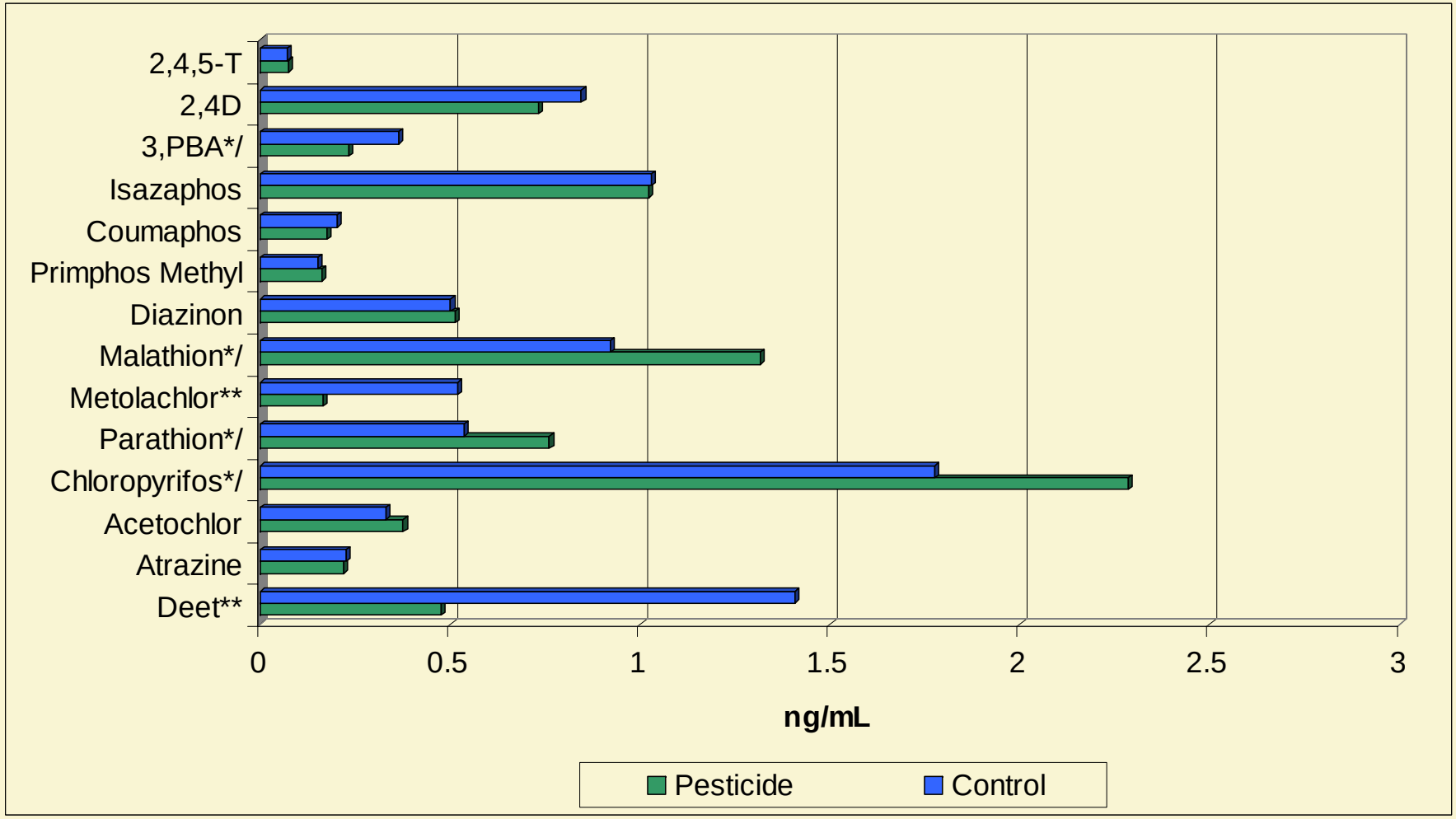
Cholinesterase Concentrations



Acute Pesticide Analysis (Means)



Acute Pesticide Analysis (Corrected Means)



Preliminary Conclusions

- A decrease in IQ was found in children living in areas of a great amount of pesticide use.
- This decrease was independent of parents IQ and their socio-economic status.
- There is evidence of exposure to pesticides based on acute urine measurements.
- Once the chronic blood pesticide measurements are available we will have a clearer picture.

Center *for*
Rural Health

University of North Dakota
School of Medicine & Health Sciences

For more information contact:

Center for Rural Health
University of North Dakota
School of Medicine and Health Sciences
Grand Forks, ND 58202-9037

Tel: (701) 777-3848

Fax: (701) 777-6779

http://medicine.nodak.edu/crh

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