Effects of Pesticide Exposure on Developmental Task Performance in Indian Children[1]

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Abstract

This paper presents the results of an investigation into chronic effects of pesticides on rural children in India. The study assessed the effect of pesticide exposure on the abilities of children to perform developmental tasks. The research subjects were divided into six study groups (high pesticide exposure with multiple exposures to multiple compounds), matched with five control groups (minimal pesticide exposure). In all, 1,648 children were individually tested using a rapid assessment tool that measured children's memory, stamina, analytical, motor, and tactile perception abilities through various games and activities. The study controlled for major confounding factors such as socio-economic background, maternal education, schooling, media exposure, and the like. In more than 80 percent of the tasks tested, children heavily exposed to pesticides performed significantly worse than the less-exposed children.

Keywords: **pesticides**, **environmental health**, **children**, **India**, **developmental tasks**

Background

Pesticide exposure can cause a variety of human health problems, both chronic and acute. Chronic effects are typically the result of low levels of exposure over a long period of time. These can occur even if there are no acute or immediate effects. Major health impacts from chronic exposure include cancers, reproductive and endocrine disruption, neurological damage, and immune system dysfunction (Sanborn et al. 2004; Moses 1999). According to the World Health Organization (WHO), long-term regular exposure to pesticides causes approximately 772,000 new cases of diseases every year (WHO and UNEP 1990).

There are very few studies on the long-term human health impacts of pesticides in India. Many of the studies on pesticides in India relate to pesticide residues in food, water and human bodies (ICMR 2001; Toxics Link 2000). Bio-monitoring and body burden studies provide important evidence of the quantity of exposure and amounts of residues present in a given population. While residues of organochlorine pesticides have been detected in human environments and human bodies the world over, studies show that the levels of residues in human blood, fat and milk samples in India are very high by comparison (ICMR 2001). Studies on acute poisoning effects in India show that organophosphorus (OP) pesticides are involved in most cases (Dewan and Saiyed 1998).

With regard to long-term human health effects, documentation from the Kasargod district in the Indian state of Kerala points to the chronic impact of endosulfan on the communities living alongside the cashew plantations there. Many congenital defects were caused by continuous aerial spraying of endosulfan in that area (Quijano 2002; Thanal Network 2001).

Here, increased numbers of children born with congenital anomalies, mental retardation, physical deformities, cerebral palsy and mental ailments such as epilepsy are reported. Other problems such as hydrocephalus, cancer, infertility, hormonal irregularities and high rates of miscarriage are also reported. A recent study suggests that endosulfan exposure in male children may delay sexual maturity and interfere with sex hormone synthesis (Saiyed et al. 2003). Other studies comparing the reproductive performance of couples where the males were pesticide sprayers to that of unexposed couples found the following incidence rates: spontaneous abortions – 26 percent for exposed couples and 15 percent for unexposed couples; stillbirths – 8.7 percent vs. 2.6 percent; neonatal deaths were at 9.2 percent in the exposed couples and 2.2 percent in the case of unexposed couples (Rupa, Reddy and Reddy 1991). There is also an ongoing study of the causes of the high cancer incidence in the Bathinda region of Punjab state by the department of Community Medicine of the Post Graduate Institute of Medical Education and Research, Chandigarh, and results are forthcoming.

While data on chronic effects of pesticides on human health in India are scarce, researchers have found ample evidence in other contexts that pesticide exposure is linked to both acute and chronic neurological damage. Potential neuro-psychiatric effects of pesticides include effects on memory, judgment and intelligence as well as personality, moods and behavior (Moses 1999). Moses (1999) points out that endocrine disruptor pesticides can affect hormone levels at critical periods of development of the brain at very low levels of exposure that were previously thought to be not harmful. While pesticides in general impair the neurological system, organophosphorus and carbamate pesticides are particularly neuro-toxic (Jamal 1997; Abou-donia 2003; Sanborn et al. 2004). Common neurotoxicity symptoms include impairment of intellectual abilities such as intelligence, attention, concentration, abstract reasoning, academic skills, cognitive efficiency and flexibility (dementia) (Hartmann 1988). Impairment of motor coordination due to neurotoxicity includes effects on fine motor speed, fine motor coordination, gross motor coordination and gross motor strength. Sensory and visuo-spatial effects include visual disturbances, difficulty drawing or constructing, auditory disturbances, numbness and tingling, and touch sensation disturbances. Memory—short-term memory and learning (encoding) as well as long-term memory—can also be affected.

Even without evidence of clinical toxicity, neurobehavioral deficits were found in pesticide-exposed workers (Weiss 2004). Associations between previous pesticide poisonings, particularly from OP and carbamates, and decrements in current function have been found to be consistently positive (Sanborn et al. 2004).

Children are particularly vulnerable to the effects of exposure to pesticides (Landrigan et al. 1993). Pound-for-pound, they breathe more air, drink more water and eat more food than adults. The rapidly developing organ systems of children are highly susceptible to effects of toxins. Children's ability to detoxify and excrete toxic compounds is lower. Their playing close to the ground and hand to mouth activity also contribute to their greater vulnerability. Finally, because children have more future years of life than adults, they are more susceptible to chronic, multistage diseases that may be triggered by early exposures.

In this context, it is important to consider the current regulatory systems related to pesticides in India. While the Insecticides Act of 1968 under the Ministry of Agriculture governs the registration, production, sale, export and import of pesticides (referred to as Insecticides in the legislation), it is the Prevention of Food Adulteration (PFA) Act 1954 under the Ministry of Health and Family Welfare and Bureau of Indian Standards which regulate food and water quality. Tolerance limits either in the form of Acceptable Daily Intake (ADI) of a pesticide or a Maximum Residue Limit (MRL) on food commodities are not legally fixed at the time of a pesticide's registration and, therefore, not all registered pesticides have a tolerance limit set. While the Insecticides Act mandates registration of pesticides, the PFA Act sets MRLs. However, out of 180 pesticides registered in India as of 2003, MRLs had been set for only 71. Also, the PFA Act does not set ADIs which are more directly connected with safety levels, but only concerns itself with MRLs—another illustration of the lax standards with regard to pesticides in India. MRLs do not specifically address children's unique vulnerability or the situation of complex cocktail exposure on the ground. There is no enforcement mechanism for ensuring recommended agricultural pesticide practices.

Need for the Study

The researchers and advising experts involved in this study recognized the need for systematic scientific investigation of pesticide effects on children in India, based on several facts:

- Cotton in India is grown on 5 percent of the country's cultivated land, but the crop consumes nearly 54 percent of the pesticides used in the entire country. While studies have pointed out the economic and ecological impacts of such high intensity of pesticide use, data on the human health impacts are scarce.
- Most studies on pesticides in India are restricted to pesticide residues in food, water and human bodies without making the links to health impacts from such residues and heavy body burden. Further, these studies view the problem from the perspective of consumers rather than that of the users of pesticides, such as those working in the farming community.
- The few reports (including media reports) that focused on effects on farming community members have documented mostly acute effects on sprayers, rather than chronic effects associated with long-term exposure (Anon. 2002; Dewan and Saiyed 1998; Agarwal 1993).
- Children are far more vulnerable to pesticides than adults. However, impacts of pesticides in the environment on children have not been studied systematically.

This study, therefore, focuses on the potential chronic effects of pesticide exposure on children of farming parents in six states in India's cotton belt: Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Punjab, and Tamil Nadu. Pesticides can involve direct and indirect exposure. They could be tracked in from application in the fields, by working or playing in or near the fields, pesticide drift, pesticide residues in water and food and so on. Rural children's exposure to pesticides, especially in cotton growing areas of India, occurs therefore through numerous avenues.

The main objective of the study was to assess possible chronic effects of pesticides on developmental tasks performance by children in cotton growing areas of India. Children from two age groups—4 to 5 years and 9 to13 years—were chosen for the study. The younger age group represents a critical window of exposure in human growth and development, while the older age group was chosen to see if children learned to compensate for deficits or were able to catch up with non-exposed peers.

Study Design, Methodology and Tools Employed

A study in Mexico (Guillette et al. 1998) that compared Yaqui children who were exposed to large amounts of pesticides with children who lived in the foothills, where pesticide use is avoided, found that functionally, the exposed children demonstrated decreases in stamina, gross and fine eye-hand coordination, 30-minute memory and the ability to draw a human figure. This study used a rapid assessment tool for preschool children to measure growth and development. The present study in India has drawn significantly from the design and methodology of the Mexican study to conduct an investigation into long-term effects of pesticides on developmental tasks of children. The researchers adapted the tools used in the Mexican study to the Indian context after pre-tests with a small sample of children.

The present study compared the abilities of children in six study groups (high pesticide exposure) to perform developmental tasks with the abilities of children in five matched control (minimal pesticide exposure) groups to perform the same set of developmental tasks.

Selection of Study and Control Locations

The study and control locations were chosen to ensure that the study and control groups were comparable except for their exposure to pesticides.

Ability to perform developmental tasks as studied could be influenced by many factors other than pesticides, including socio-economic background (income, diet, village social structures), maternal education, exposure to media, schooling, and other contaminants. The locations and children were chosen with care to control the effects of these major confounders.

We started by studying data on cotton cultivation extents and use of pesticides, to narrow in on the six states of Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Punjab and Tamil Nadu. Once we identified the relevant states, we collected pesticide consumption and cotton cultivation information from the state department of agriculture for the districts within the state. Districts that were among the top five in terms of pesticide consumption and cotton cultivation were chosen as those from which the study villages would be drawn. District selection was also influenced by informal or media reports about pesticide-related problems reported earlier. Control locations were chosen within the same region of the state[2] in areas of minimal pesticide use that matched the study areas socio-culturally. We also obtained advice from the agriculture department officials to make these selections.

Within each district, we focused on the highest cotton-cultivating block,[3] based on the extent of cotton cultivated within the total cultivable area of that block, in the past five years. Cotton cultivation was used as a proxy indicator for amount of pesticides consumed in the block since data on pesticide consumption is recorded only at the district level, if at all. At this stage, consultations with pesticide dealers also helped to assess whether the right block was being chosen. A similar process was used to select three study villages within the block. To select control villages, a similar process of zeroing in on a block—this time with less pesticide consumption—was used. Once again, consultations with local agriculture officials and with the pesticide dealers helped in the selection.

After selecting the three study villages in each state, researchers made preliminary visits to understand the socio-economic structures, crop-planting patterns, diets, housing, and other patterns within these villages. Visits were then made to possible control locations until locations were found that were comparable on the basic parameters of socio-cultural composition of the communities, diet, income levels, ethnicity and presence of other variables such as the presence of contaminating industries.[4]

Information on official classification of families into the Below Poverty Line (BPL) income group or the Above Poverty Line (APL) income group was also obtained, though there are differing views on whether this is a true indicator of a family's income. Caste and community structures in the study and control locations were matched. A predominantly-upper caste group was not compared with a tribal group, for instance. Socio-economic background was controlled for between the study and control groups, by using anthropometric measurements of height, weight and head circumference as proxy indicators for income and diet. We also ascertained media access and exposure at the village/group level. Similarly, data on maternal education was obtained through interviews with mothers. Except in the case of Punjab, the maternal education levels in the study groups were higher than the control groups in the other states.

Given below is the list of the study villages:

- Warangal district in Andhra Pradesh: Atmakur, Oglapur and Peddapur villages
- Raichur district in Karnataka: Khanapur, Manjerla and Poorthipli villages
- Bathinda district in Punjab: Bangi Nihal Singh, Jajjal and Mahi Nangal villages
- Bharuch district in Gujarat: Halder, Kavitha and Samlod villages
- Yavatmal district in Maharashtra: Dehlatandi, Kopamandvi and Sunna villages
- Theni district in Tamil Nadu: Rassingapuram, Silamalai and Visuvasapuram villages

Table 1 has full details of the study and control villages, state-wise.

Table 1. Study and control group locations in each of the six states

State	Study Group Location			Control Group Location		
	District	Tehsil / Block	Villages	District	Tehsil / Block	Villages
Andhra Pradesh	Warangal	Atmakur	Atmakur, Oglapur, Peddapur	Medak	Narayankhed	Abbenda
Karnataka	Raichur	Raichur	Khanapur, Manjerla, Poorthipli	Same as above	Same as above	Same as above
Punjab	Bhatinda	Talwandi Sabo	Bangi Nihal Singh, Jajjal, MahiNangal	Ropar	Anandpur-sahib	Dher, Gambhirpur, Surewal
Gujarat	Bharuch	Bharuch	Halder, Kavitha, Samlod	Bharuch	Wagra	Bhesali, Rahiyad
Maharashtra	Yavatmal	Pandarkauda	Dehlatandi, Kopamandvi, Sunna	Yavatmal	Darwa	Bhandegaon
Tamil Nadu	Theni	Bodi	Rasinghapuram Silamalai, Visuvasapuram	Madurai	Uslampatti	Ayodhyapatti

Sample Details
From each of the study villages, 25 children who were 4 to 5 years of age were chosen from *Anganwadis* (pre-school day care centers, meant for children in this age group). Similarly, 25 children were chosen from the population of school-going children in each study village in the 9- to 13-year age group. The children were selected from different parts of the village to ensure fair representation of different communities and socio-economic status, as well as sexes and ages within each age group. The methods followed for selection were the same in the study and control locations. Thus, from each location, for each age group, a ”study group” of approximately 75 children and a corresponding “control group” of similar number were drawn.

The study analyzed data from a sample of 899 children in both age groups in the study locations (448 in the younger age group and 451 in the older age group) and 749 children in the control locations (374 in the younger age group and 375 in the older age group). Table 2 provides details on the sample size, location and age groups.

Table 2. Sample size, location and age groups

Location	4-5 year age group		9-13 year age group	
	Study Group	Control Group	Study Group	Control Group
From Andhra Pradesh	73	74	74	75
From Gujarat	75	75	75	75
From Karnataka	75		77	
From Maharashtra	75	75	75	75
From Punjab	75	75	75	75
From Tamil Nadu	75	75	75	75
Total	448	374	451	375

Developmental Tasks
Researchers used a Rapid Assessment Tool comprised of analytical, motor, and memory and concentration tests to measure children's ability to perform a wide range of developmental tasks. Analytical tests measured children's cognitive capacity to solve simple jigsaw puzzles, and to recognize shapes and sizes through tactile perception. Motor tests measured children's eye-hand coordination, gross and fine motor skills, and stamina. Tests also assessed children's sense of balance, ability to concentrate and short-term memory capacity. The tests were designed as games in order to be child-friendly, and were administered verbally and individually to each participating child. Researchers used the children's local dialect when working with them and when recording data. The following section describes each of the tests.

Analytical Ability Tests

Mental ability tests with wooden blocks: Researchers asked the children to replicate two-dimensional printed shapes in three dimensions, using wooden blocks of different sizes and shapes. Four such tests for 4- to 5-year-old children and five tests for 9- to 13-year-old children were administered, with each successive test becoming increasingly complex.

Jigsaw puzzles: The puzzles used birds/animals, flowers and fruits that the children could identify, made out of two, three, four and five pieces. For both age groups, initial demonstrations of the concept of jigsaw puzzles used a circle and a picture of a fish. This series also had an element of increasing levels of complexity, where children who performed a puzzle successfully were encouraged to take on the next one and so on.

Tactile perception tests with wooden blocks: Researchers used two games to assess children's tactile perception, called Tactile Perception Test 1 and Test 2 for the purposes of the study. In Test 1, children were asked to close their eyes, and the researcher placed a wooden block (of a particular shape and size) in one of their hands. After feeling the block, the child was asked to find its identical match by feeling many wooden blocks of different sizes and shapes hidden behind a small screen. In Test 2, they were again asked to close their eyes, and using both hands to search behind a small screen, were asked to pick up two identical blocks placed amongst many blocks of different sizes and shapes.

Non-verbal cognitive ability, as manifested in drawing a human figure: Children in the 4- to 5-year age group participated in a test that assessed non-verbal cognitive abilities. Researchers asked the children to draw a human figure, and to identify its various parts. They scored the drawings with one point each assigned for a head drawn, facial features drawn, a trunk drawn, two hands drawn and two legs drawn. Where needed, the children were allowed to first draw things that they wanted to, such as a flower or a house and then moved on to the "test."

Motor Ability Tests

Gross motor skills: Gross motor abilities of 4- to 5-year-old children were tested through a ball-catching exercise with first a large ball and then a tennis ball. The game included catching a ball five times each at distances of one meter, two meters and three meters. The 9- to 13-year-old children used only the tennis ball, catching it at distances of two meters, three meters and four meters. Researchers recorded the number of times that the ball was caught successfully out of five throws at each distance.

Fine motor skills: Another test, of dropping raisins/peanuts with one's fingers from a specified height into a bottle lid placed on the floor, assessed fine motor abilities. Here, younger children did the test with their hand or wrist placed on a one-foot stool, while the height of the stool for the older children was one and one-half feet. Each child was given 10 raisins/peanuts to drop into the lid, and researchers noted the score as the number of raisins/peanuts successfully dropped into the lid out of 10 attempts.

For the 9- to 13-year-old children, researchers used another test called “nose-tapping” or body awareness to assess fine motor skills. Here, each child attempts to touch the tip of the middle finger to the tip of the nose, with eyes closed, by bringing in outstretched arms alternately to the nose, 25 times

Stamina test: Assessment of motor abilities also consisted of a stamina test using “Jumping Jacks.” Researchers encouraged children to push themselves until they were breathless or exhausted (they were asked to stop whenever they felt breathless and tired). Among 4- to 5-year-old children, coordination between hands and legs was missing, more often than not. However, children were encouraged to continue the exercise until they wanted to give up. The time period was recorded with a stop watch.

Sense of Balance Tests

For the 4- to 5-year-old children, researchers administered three such tests:
1. standing on one foot with eyes open,
2. standing on one foot with eyes closed, and
3. walking on a thin plank, toe-to-heel and walking back without putting a foot down.

For the first two tests, results were recorded as the number of seconds (shown by a stop watch) that children were able to perform the test successfully. The third test recorded the percentage of children able to complete the test successfully. For the 9- to 13-year-old children, only the last two tests were administered.

Tests for Concentration and Memory

Researchers administered two games for assessing the children’s abilities related to concentration and memory. One was an instant recall test (with six familiar objects shown to 4- to 5-year-old children and eight familiar objects shown to 9- to 13-year-old children). After each child identified the objects, the objects were quickly hidden behind the researcher in a pouch, and the child was asked to recall the objects seen. Researchers used the same objects in all cases. In the second test, researchers promised to give each child a colored object, but did not give it right away. Thirty minutes later, the researchers asked the child to recall the object promised. Those who could recall both the color and the object half an hour later were considered to have performed the test successfully.

In all, the tool consisted of 23 tests for the 4- to 5-year-old age group and 20 tests for the 9- to 13-year-old age group. The tests (games) and the materials used in the games were standardized across the six states, and between the study and control groups for comparability. The tests were designed to be age-appropriate. Tests for the 9- to 13-year-olds were more complicated than those for the 4- to 5-

year-olds. The tool was approved for its suitability for Indian rural children by child psychologists and pediatricians consulted for the purpose.

In addition to these tests, researchers administered a questionnaire to the mothers of participating children, which collected data on the child as well as the family's background (income, health, diet, housing, education of the mother, and the like).

Administration of the Tests

The participating researchers orally administered all of the above tests/games to individual children in their local language and dialect. Researchers demonstrated the materials before the tests began, especially for the 4- to 5-year-old children. They took care to present these tests as normal play to the children, to put them at ease and stimulate their motivation. The researchers spent some time playing with the children in their schools or preschools before they administered the tests, to reduce initial inhibition and fear. The participating children played the games in the presence of family members and/or teachers. To avoid a buildup of frustration and anxiety, researchers administered only the first level of a given test if a child could not successfully complete it. If children were either hesitant or uncomfortable with a particular exercise, they were not forced to perform it.

The same researchers administered the test to study and control groups in three states—the tests were first done in the study location, followed by the control location. In the other three states, two researchers each administered the tests in the study and control locations in a parallel fashion. The researchers were trained both in the classroom and using pilot field studies, with the first such training being overseen by one of the Advisors, Dr. Elizabeth Guillette.[5] The researchers were from local areas and diverse backgrounds such as human biology, agricultural science, sociology, extension, etc. They were regularly supervised in the field by the lead investigator and the field investigator. Researchers did not have access to what other researchers were finding elsewhere. Pre-testing was done with children in one village in Bhatinda district in Punjab with the help of one Advisor and significant changes were consequently made to the original checklist.

Data Analysis

Data were recorded for each test and for each child either in a "Yes" or "No" format to indicate success of performance, or in terms of number of seconds (length of time), or as a numerical score ("x" number of times out of a maximum "y").

All records from the three study villages in each state constitute one study group for 4- to 5-year-old children, and another study group for 9- to 13-year-old children. These study groups have their corresponding control groups (see Table 2).

The data were analyzed to measure the performance of each study group and corresponding control group, for each of the tests. The group performance was measured as described below:

- as percentage of children who could perform the test successfully out of the total number of children who took the test (for the jigsaw puzzles, for the

mental ability tests, for the tactile perception tests, for the memory test, for the sense of balance test on a plank), or
- as the average length of time for which a test could be done (stamina test, balance test on one leg with eyes open and eyes closed)
- as the average points scored out of a maximum set of points (gross and fine motor abilities, concentration test and non-verbal cognitive ability test)

The group performance of each study location was then compared with that of the corresponding control location to ascertain difference in performance, if any. Statistical significance tests were conducted on such differences using either Chi-Square tests or T-Tests.

These comparisons between the study and control groups are presented for each test, for each age group in two forms:

- collated as the national level picture
- presented for each study group compared against its corresponding control group

At the national level, the collation is presented in the form of "comparative results" for a "set of tests," all of which measure a particular developmental task. For instance, Mental Ability for 4- to 5-year-old children constitutes 24 "comparisons" consisting of four games each for each pair of the six study-control groups. Such a "comparison" is used to ascertain the number of times a study group performed better than the control group or vice-versa for a developmental task.

Results[6]

This section presents overall results from all six study-control groups. We elaborate on the Punjab results, to provide a detailed case study of one area.

Overall Results

Table 3 gives findings for the 4- to 5-year-old age group in the form of comparative results for a set of tests, all of which measure a particular developmental task. The table illustrates which results favor the control groups and which were statistically significant.

In percentage terms, the results show that in 86 percent of the cases, the control groups performed better than the study groups; further, in 70.8 percent of the cases, the results were statistically significant.

The tests that did not favor the control groups did not necessarily favor the study group children, either. For example, as Table 3 shows, gross motor abilities in ball-catching (large ball and tennis ball) showed better performance by the control groups, but only in 50 percent of the cases did they perform significantly better. In the case of 30-minute memory tests, the study groups performed better, but they did so with very little margin and thus with low significance. Results went conclusively in favor of the study group children only in 6.6 percent of tests in this age group.

Table 3. Results for the 4- to 5-year old age group for all six locations

Type of Test 4-5 year old children	**Number of "Comparisons" (No. of Study-Control group pairs X No. of tests for the ability)**	**No. of times results show better performance by Control groups**	**No. of times better performance by Control group, with statistical significance**
Analytical Abilities			
Mental Ability, using wooden blocks	24	24	24
Tactile Perception, using wooden blocks	12	12	9
Jigsaw puzzles, using birds, flowers and animals	17	14	12
Cognitive ability in the form of human drawing	6	6	5
Motor Skills			
Gross Motor Skills: Eye-hand Coordination with large ball	18	16	9
Motor Skills: Eye-hand Coordination with tennis ball	18	13	9
Stamina test with Jumping Jacks	6	5	4
Fine Motor Skills			
Eye-Hand Coordination with Raisins	6	5	5
Sense of Balance tests	18	15	12
Concentration and Memory			
Ability to Concentrate: Immediate Recall test	6	5	5
Memory test: 30-minute recall	6	3	3
OVERALL	**137**	**118**	**97**

Table 4 presents the overall results from all the six locations for the children in the 9- to 13-year-old age group. Here, 20 tests were administered in each location.

Table 4. Results from all six locations for 9- to 13-year old age group

Type of Test: 9-13 year old children	**Number of "Comparisons" (No. of Study-Control group pairs X No. of tests for the ability)**	**No. of times results show better performance by Control groups**	**No. of times better performance by Control group, with statistical significance**
Analytical Abilities			
Mental Ability, using wooden blocks	30	26	20
Tactile Perception, using wooden blocks	12	8	5
Jigsaw puzzles, using birds, flowers and animals	18	16	15
Motor Skills			
Gross Motor Skills: Eye-hand Coordination with tennis ball	18	17	11
Stamina test with Jumping Jacks	6	5	5
Fine Motor Skills			
Eye-Hand Coordination with Raisins	6	5	5
Nose-tapping for Body Awareness	6	6	6
Sense of Balance tests	12	9	8
Concentration and Memory			
Ability to Concentrate: Immediate Recall test	6	5	5
Memory test: 30-minute recall	6	4	4
OVERALL	**120**	**101**	**84**

A trend similar to the younger children's results was found for the older group: in 84.2 percent of the cases, the control group children performed better than the study group children; in 70 percent of the instances, the results were statistically significant. Once again, the remaining results did not automatically go in favor of the study group children. In 15.8 percent of the cases, the study group performed better, but only in 4.2 percent of the cases were the results significantly better. For example, in this age group, though most of the control group children performed better in tactile perception tests, only 50 percent of the instances were statistically significant.

In Tamil Nadu, Punjab and Andhra Pradesh, for the 4-5 year age group, in 74 to 90 percent of the tests, the control group performed better to a statistically significant degree. The performances were similar in the 9- to 13-year-old control groups, from Punjab, Tamil Nadu, Maharashtra and Gujarat.

The Case of One Study-Control Group Comparison: Results from Punjab

Punjab is easily the longest pesticide using location amongst the six locations. Pesticide-related problems are reported in NGO reports on various endemic problems in the state, such as suicides, disabilities, infertility, cancer incidence and the like (Anon, 2001b). Bathinda is an important cotton-growing area of the state; we chose this area as our study location and drew the control population from the Ropar district. Ropar is not fully free of pesticides either, but because the main crops are wheat and rice in this area, fewer pesticides are used, and the overall chemical burden is lower.

The female literacy rate is higher in Ropar than in Bathinda, so it was difficult to control for this factor completely. However, a sub-sample analysis for the children of uneducated mothers in the control location was done for comparison with the group average. The data surprisingly showed better performance by these children, compared to the whole group's results. This leads us to conclude that the female literacy rate is not a major influencing variable in this case, probably because the education levels of mothers who have attended schools is still not very high.

Tables 5 and 6 present a profile of the children in both samples, including physical growth measurements as proxies for diet and income. Table 5 illustrates the characteristics of the 4- to 5-year-old age group, and Table 6 illustrates the characteristics of the 9- to 13-year-old age group.

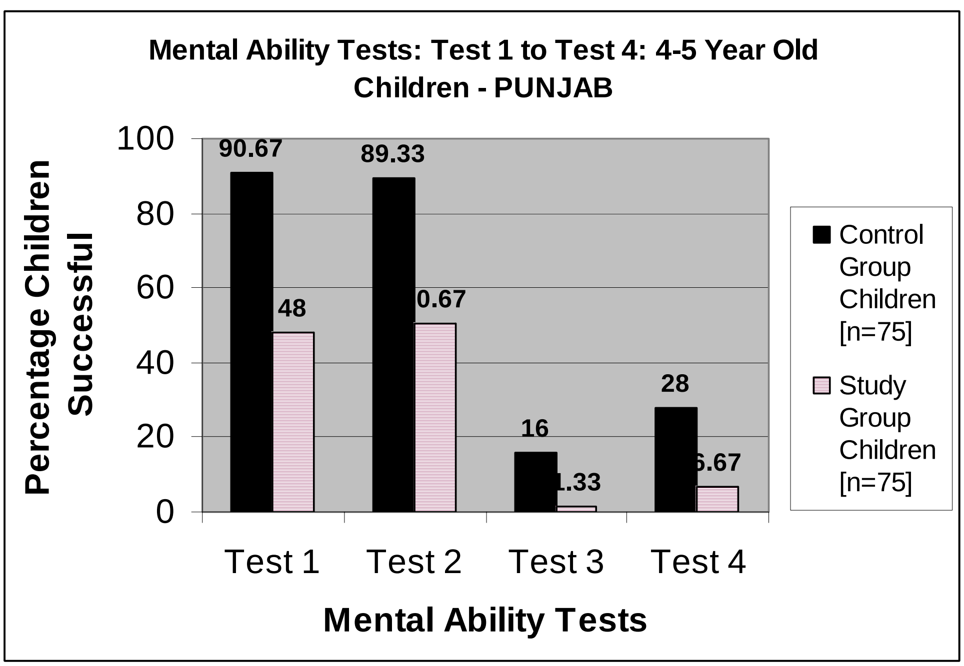
Table 5. Profile of the sample for 4- to 5-year old age group, Punjab:

Location (sample size)	Mean age	Gender distribution	Boys: 4-5 years			Girls: 4-5 years		
			Height	Weight	H.C.	Height	Weight	H.C.
Punjab Study (N=75)	4.57 ± 0.49	40 Boys + 35 Girls	103.17 ± 6.28	13.96 ± 2.62	50.1 ± 1.51	100.91 ± 4.30	13.06 ± 1.88	48.8 ± 1.63
Punjab Reference (N=75)	4.52 ± 0.50	43 Boys + 32 Girls	99.79 ± 4.37	13.65 ± 1.93	49.7 ± 1.52	99.53 ± 4.96	13.47 ± 2.10	48.6 ± 1.21

Table 6. Profile of the sample for 9- to 13-year old age group, Punjab

Location (sample size)	Mean age	Gender distribution	Boys: 9-13 years			Girls: 9-13 years		
			Height	Weight	H.C.	Height	Weight	H.C.
Punjab Study (N=75)	11.89 ± 1.2	36 B + 39 G	142.6 ± 12.7	30.2 ± 7.1	52.8 ± 1.6	145.4 ± 10.0	32.0 ± 7.1	52.7 ± 1.7
Punjab Reference (N=75)	11.25 ± 1.1	37 B + 38 G	136.9 ± 5.77	28.2 ± 4.47	52.6 ± 1.03	140.8 ± 8.0	29.5 ± 6.5	52.3 ± 1.5

Figure 1. Mental Ability Tests, Punjab, Test 1 to Test 4 for 4- to 5-year old age group



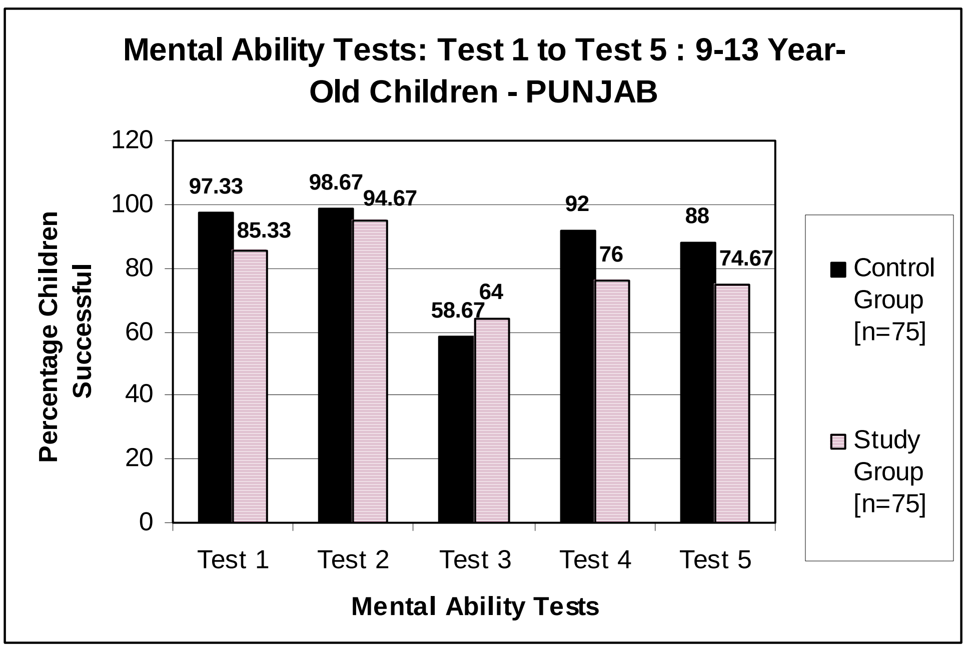
Analytical Tests

Mental ability tests

As Figure 1 shows, in the case of the 4- to 5-year-old children, each of the four mental ability test results favor the control group, with statistical significance in all four cases ($p<0.001$ in all four cases). There was no discernible trend to increasing or decreasing difference in abilities as the tests moved from one level to the next.

In the case of the 9- to 13-year-old children (Figure 2), a higher percentage of the study group children were successful than the control group children on the third test. However, this result is not statistically significant ($p=0.348$). The four other tests favor the control group. As in the case of the younger children, there was no discernible pattern of increasing or decreasing ability.

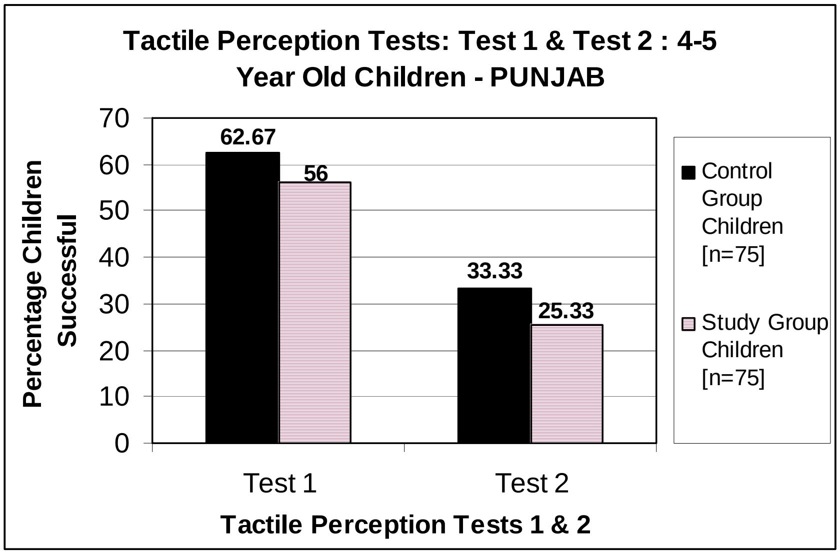
Figure 2. Mental Ability Tests, Punjab, Test 1 to Test 5 for 9- to 13-year old age group



Tactile perception tests

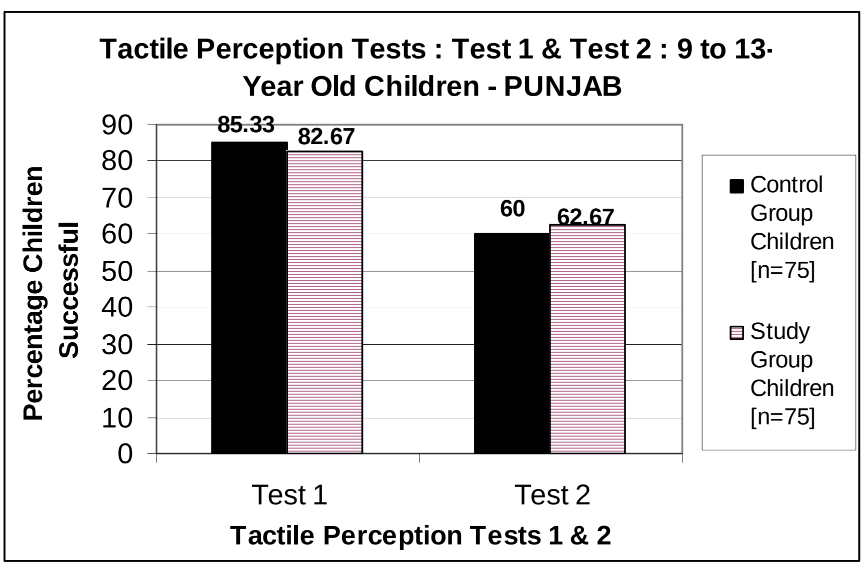
In the case of the 4- to 5-year-old children, in both of the tactile perception tests, the control group performed better than the study group but without any statistical significance (p value = 0.233 and 0.142 in Tactile Perception Test 1 and Test 2, respectively). Here, the margin of difference in the ability to perform increased from Test 1 to Test 2. This is illustrated in Figure 3.

Figure 3. Tactile Perception Test 1 and Test 2, Punjab for 4- to 5-year old age group



The tactile perception test results of the 9- to 13-year-old age group are very different (Figure 4). Here, the control group performed better than the study group in Test 1, and the result was reversed in Test 2 where the study group children performed better than their control counterparts. However, both the results lack statistical significance (p values = 0.5138 and 0.637, respectively). Therefore, one could say that in both the age groups, these test results are inconclusive.

Figure 4. Tactile Perception Test 1 and Test 2, Punjab for 9- to 13-year old age group

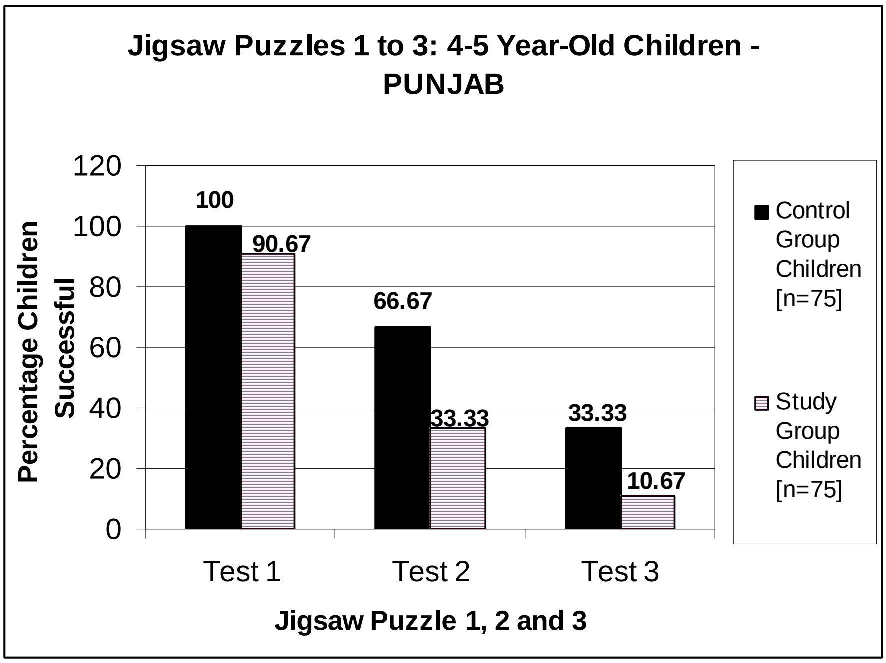


Jigsaw puzzles

Researchers administered three jigsaw puzzles to each child in each age group in both samples.

In the case of both age groups, the control group children performed better than the study group. In the younger age group (Figure 5), the statistical significance of the differential ability is very high (p value <0.001 in all three tests). In the older age group (Figure 6), the control group children performed Jigsaw Test 1 better than the study group, however p values were less than 0.001 in all three iterations.

Figure 5. Jigsaw Puzzle Test 1 to Test 3, Punjab for 4- to 5-year old age group



Non-verbal cognitive abilities

In this test administered only to the 4- to 5-year-old children, the control group performed better by 1.33 average points over the study group, out of a total of 5 average points (control = 3.48 ± 1.91, and study = 2.15 ± 2.03 (see Table 9a)). The p value was <0.001.

Motor Abilities

Eye-hand coordination with large ball

Only the 4- to 5-year-old children performed this test of catching ability. In the three tests administered at different distances, the control groups performed better. As the distance increased, the ability gap between the control and study groups of children also increased. Statistical significance with *alpha* fixed at 0.05 levels was missed narrowly in the first test (p=0.07), with the difference being 0.23 average points out of 5. At the second distance, p value was 0.056, and at the third distance, p value was 0.0006 (Table 9a).

Figure 6. Jigsaw Puzzle Test 1 to Test 3, Punjab for 9- to 13-year age Group

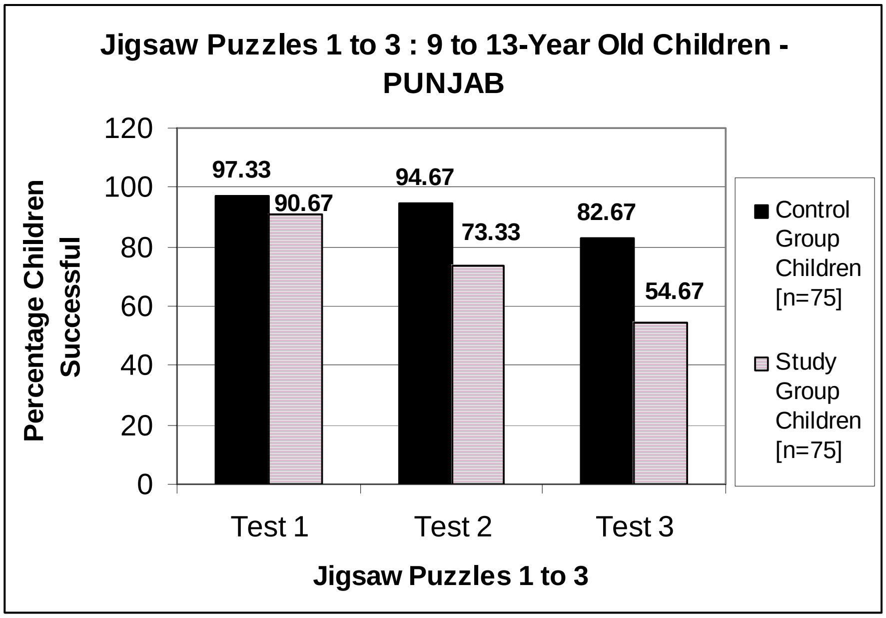
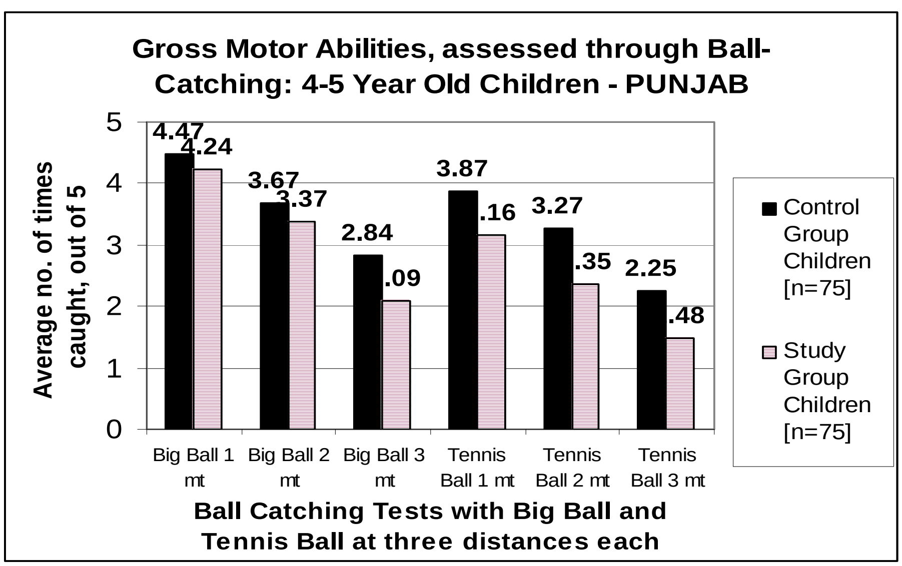


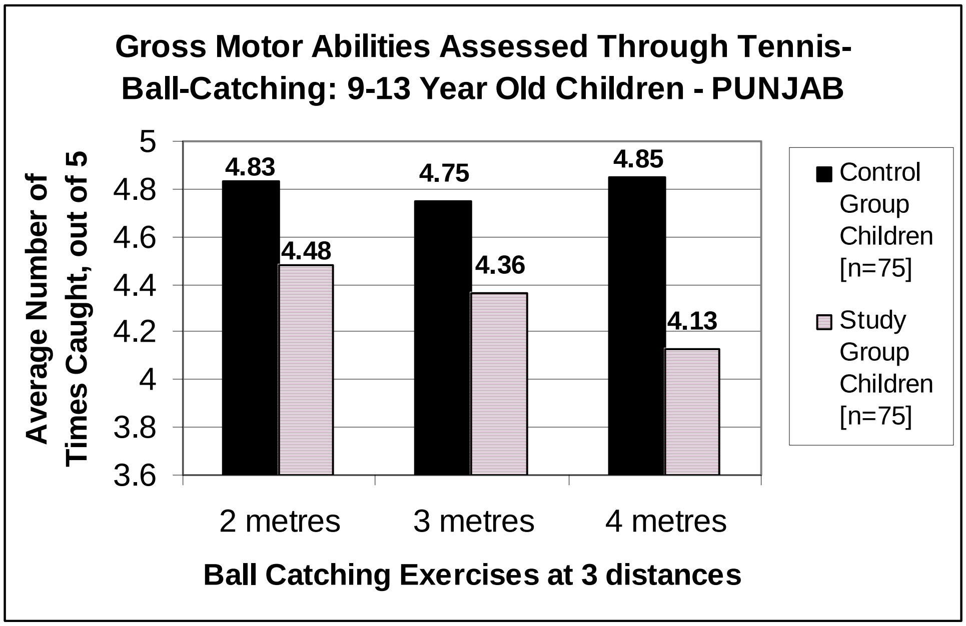
Figure 7. Gross Motor Ability Tests 1 to 3 with Big Ball and Tests 4 to 6 with Tennis Ball, Punjab, 4- to 5-year old age group



Eye-hand coordination with tennis ball

This test was administered at three different distances to both groups of children. Once again, researchers recorded and analyzed the number of successful catches out of five throws at each distance. In these tests, for both age groups, children in the control group performed better than those in the study group (Figures 7 and 8). The results are highly statistically significant.

Figure 8. Gross Motor Ability Tests 1 to 3 with Tennis Ball, for 9- to 13-year old age group, Punjab



In the case of the 4- to 5-year-old children, there is no clear trend regarding the ability to perform, as the distance changed (the difference was 0.71, 0.92 and 0.77 average points out of five, for distances of 1 m, 2 m and 3 m, respectively). The corresponding p-values are 0.00035, <0.0001 and 0.00033.

In the case of the 9- to 13-year-old children, the difference in ability increased as the distance increased, with better performance by the control group. The difference in ability at 2 m, 3 m and 4 m was 0.35, 0.39 and 0.72, respectively. The p-values in these three cases were: <0.0001, 0.001 and <0.0001.

Sense of balance

The 4- to 5-year-old children took part in three balance tests, and the 9- to 13-year-old children participated in two tests.

Among the 4- to 5-year-old children, the control group performed significantly better than the study group on all three tests. In the first test, standing on one foot, the control group children stood for 6.62 seconds longer than their study counterparts on an average, and on the second test, they stood for 2.27 seconds longer on an average. In the third test, walking on the plank, 30 percent more children could do the test successfully in the control group, compared to the study group. The p-values for each test were 0.004, <0.0001 and <0.0001, respectively.

In the older age group, the control group children could stand on one foot, with their eyes closed, for nearly 11 seconds longer on an average than the study group. Similarly, 40 percent more children could do the plank test successfully in the control group.

Table 7. Balance Tests, as percentage of children fitting into specific time brackets in seconds, for 4- to 5-year old age group and 9-13 age group, Punjab

State: Punjab Particular time brackets in seconds	**4-5 year old children**				**9-13 years**	
	Eyes Open (%)		**Eyes Closed (%)**		**Eyes Closed (%)**	
	Study	**Control**	**Study**	**Control**	**Study**	**Control**
0 – 30 seconds	96	92	100	100	81.3	69.3
31 – 60 seconds	4	4	0	0	10.7	14.7
61 – 90 seconds	0	1.3	0	0	5.3	9.3
91 – 120 seconds	0	1.3	0	0	1.3	2.7
> 120 seconds	0	1.4	0	0	1.3	4.0

Note: The first two tests, in which children were encouraged to balance on one foot with their eyes closed or open, did not have a prescribed time limit, and some children could do it much longer than others. Therefore, results from these tests are presented as percentages of children in particular time brackets of performance.

As Table 7 shows, among the 4- to 5-year-olds, all the study and control group children performed the test of standing on one foot with eyes closed for less than 30 seconds. When the children kept their eyes open, some in the control group were able to stand for more than 120 seconds. The study group children, however, stood for no longer than 60 seconds.

Among the 9- to 13-year-olds, many study group children surpassed their younger peers' standing times. However, it is apparent that more children from the older control group were able to stand longer than their study group peers.

Fine motor abilities

In both the age groups, the dexterity in the control group was significantly better than in the study group, with similar differential abilities demonstrated within both age groups [Tables 9a and 9b].

In the 4- to 5-year-old group, the results were: 4.16 average points ± 2.05 for the control and 3.41 ± 2.06 for the study group, with a p-value of 0.014. The difference is 0.75 average points out of 10 attempts. Among 9-13 year old children, the results were: 5.31 average points ± 2.24 for the control and 4.37 ± 2.08 for study group, with the difference being 0.94 average points. Here, the p-value is 0.005.

With the 9- to 13-year-old children (Table 9b), researchers used the additional nose-tapping test to assess fine motor abilities. Once again, the control group children performed better, with the statistical significance being $p < 0.0001$. The results, recorded in terms of the number of times out of 25 that a child misses the tip of the nose are: 8.0 ± 6.16 for the control group and 17.73 ± 6.37 for the study group. The greater the number of such misses, the lesser the fine motor ability, according to our test.

Stamina

Stamina was assessed through the length of time that a child could do jumping jacks without being tired out. In Punjab, in both the age groups, the control groups performed this test for significantly longer periods of time than the study groups, with the average difference in ability being quite stark (29.72 seconds longer in the 4-5 year age group and 37.33 seconds longer in the 9-13 age group on average). The p-values are also low (<0.0001 for both the younger and older age groups). However, the standard deviation values for these tests revealed that some children performed for much longer periods than the rest of the group (in both samples), so data were analyzed percentage number of children in specific time brackets (Table 8).

Table 8. Stamina Test results, both age groups, Punjab

Time brackets, in seconds	4-5 year old children: Punjab (%)		9-13 year old children: Punjab (%)	
	Study	Control	Study	Control
0 – 50 seconds	80	37.3	61.3	16.0
51 – 100 seconds	18.7	49.3	28	53.3
101 – 150 seconds	1.3	12.0	6.7	22.7
151 – 200 seconds	0	1.3	0	2.7
> 200 seconds	0	0	4	5.3

The stamina difference between study and control groups is apparent in both age groups. Among the 9- to-13 year old children, while a majority of the study group could do the jumping jacks for less than 50 seconds, a majority of the control group could do it for up to 100 seconds. Similar trends were found for the younger age group. This is in spite of the better physical growth parameters observed in the study group.

Tests for Concentration and Memory

Both age groups show very similar trends in tests of concentration and memory in Punjab, consistent with results from other tests.

In the instant recall tests, in both the younger and older age groups, the control group performed significantly better than the study group. The difference in ability is greater among the older children, calculated in terms of average number of objects recalled (0.72 average points higher performance out of 8 by the control group; 0.61 average points higher performance out of 6 by the younger control group).

The results are: 4.5 ± 1.00 for control group and 3.87 ± 0.98 for the study group in the younger age group (p value = 0.0001); 6.6 ± 1.03 for the control group and 5.84 ± 1.04 for the study group, among the older children (p-value <0.0001) (see Table 9a and 9b).

With the 30-minute memory tests, this trend persists. The control group is far ahead of the study group (38 percentage points higher in the 4- to 5-year old age group and 33 percentage points higher in the case of the 9- to 13-year old age group). The test results for each age group are shown in Tables 9a and 9b, with standard deviations and statistical significance p-values.

Overall performance (Table 9a) indicates that in all of the 23 tests administered to the younger group of children, the control group performed better, and did so with statistical significance in 21 out of the 23 tests (91.3 percent).

In the case of the 9- to-13 year old age group, a similar trend is observed (Table 9b). Overall, for the older age group, out of 20 tests administered, in 18 the control group performed better than the study group. Further, in 17 of these tests, the differential ability was statistically significant.

Table 9a. Results for all tests for 4-5 year age group, Punjab

	Control	Study	P value
Analytical Abilities			
1. Mental Ability 1: %age	90.7	48	<0.001
2. Mental Ability 2: %age	89.3	50.7	<0.001
3. Mental Ability 3: %age	16.0	1.3	<0.001

4. Mental Ability 4: %age	28.0	6.7	<0.001
5. Tactile Perception 1: %age	62.7	56.0	0.233
6. Tactile Perception 2: %age	33.3	25.3	0.142
7. Jigsaw 1: %age	100	90.7	<0.001
8. Jigsaw 2: %age	66.7	33.3	<0.001
9. Jigsaw 3: %age	33.3	10.7	<0.001
10. Cognitive ability: Avg. score/ 5	3.48 +/- 1.91	2.15 +/- 2.03	<0.001
Motor Abilities			
11. Gross Motor [big ball, 1 meter]: avg catches/5	4.47	4.24	0.07
12. Gross Motor [big ball, 2 meters]: avg catches/5	3.67	3.37	0.056
13. Gross Motor [big ball, 3 meters]: avg catches/5	2.84	2.09	0.0006
14. Motor – tennis ball, 1 meter: avg catches/5	3.87	3.16	0.00035
15. Motor – tennis ball, 2 meters: avg catches/5	3.27	2.35	<0.0001
16. Motor – tennis ball, 3 meters: avg catches/5	2.25	1.48	0.00033
17. Balance: one foot, eyes open: avg. no. of seconds	15.31 secs	8.69 secs	0.004
18. Balance: one foot, eyes closed: avg. no. of seconds	4.60 secs	2.33 secs	<0.0001
19. Balance: plank walk, toe to heel: %age	69.33%	40.0%	<0.0001
20. Fine Motor: Raisins into a lid – avg points/10	4.16 +/- 2.05	3.41+/- 2.06	0.014

21. Stamina: no. of seconds	63.55+/-30.02	33.83+/-22.29	<0.0001
Abilities of Concentration and Memory			
22. Instant recall: avg points/5	4.5 +/-1.00	3.87+/-0.98	0.0001
23. 30-minute memory test: %age	68.00	30.00	<0.0001

Table 9b. Results of all tests, for 9-13 age group, Punjab

Analytical Abilities		Control	Study	P value
1.	Mental Ability 1: %age no. of children successful	97.3	85.3	<0.001
2.	Mental Ability 2: %age no. of children successful	98.7	94.7	0.002526
3.	Mental Ability 3: %age no. of children successful	58.7	64.0	0.3483
4.	Mental Ability 4: %age no. of children successful	92.0	76.0	<0.001
5.	Mental Ability 5: %age no. of children successful	88.0	74.7	<0.001
6.	Tactile Perception 1: %age no. of children successful	85.3	82.7	0.5138
7.	Tactile Perception 2: %age no. of children successful	60.0	62.7	0.637
8.	Jigsaw 1: %age no. of children successful	97.3	90.7	<0.001
9.	Jigsaw 2: %age no. of children successful	94.7	73.33	<0.001
10.	Jigsaw 3: %age no. of children successful	82.7	54.7	<0.001

11.	Motor – tennis ball, 1 metre [average no. of catches out of 5]	4.83	4.48	0.00019
12.	Motor – tennis ball, 2 metres [average no. of catches out of 5]	4.75	4.32	0.00112
13.	Motor – tennis ball, 3 metres [average no of catches out of 5]	4.85	4.13	<0.0001
14.	Balance: one foot, eyes closed [avg. length of time in seconds]	31.36 secs	20.63 secs	0.01
15.	Balance: plank walk, toe to heel [percentage successful]	82.7%	42.7%	<0.0001
16.	Fine Motor: Average Raisins into a lid (out of 10 attempts)	5.31	4.37	0.0045
17.	Fine Motor: Nose-tapping: Average Misses out of 25	8.00	17.73	<0.0001
18.	Stamina: Average no. of seconds	95.80	58.47	<0.0001
19.	Concentration: Instant Recall [Avg. No. of objects out of 8]	6.6	5.84	<0.0001
20.	30-minute Memory: %age successful	94.7	61.3	<0.001

Discussion

This study has consistently shown similar trends across six different locations and across the two age groups studied. The control group significantly out-performed the study group in most cases. The study group children in both age groups displayed lower abilities in cognition, memory, stamina, motor skills and concentration (significantly lower in some abilities, and marginally so in some others).

Though there were some minor variations in the study and control environments between the states (diet, social structures, ethnic background), the results displayed the above pattern fairly consistently across states, irrespective of possible confounders. Expected confounders such as maternal education did not seem to play a part, and other major environmental contaminants were ruled out in project areas through literature search. Child psychologists consulted also pointed out that tests for stamina, fine eye-hand coordination, nose-tapping for body awareness, sense of balance etc., were unlikely influenced by external confounders like media exposure in any case, especially for the older children. The large sample size (n=1648) further strengthens the findings.

The findings also conform to expected results given the known effects of certain kinds of pesticides (e.g., organophosphorus compounds, which are used eight to nine times more than other kinds of pesticides in these locations, are known to be neurotoxic).

The methodology used in this project is a scientifically accepted approach adapted from an earlier study from Mexico (Guillette et al. 1998). An experimental design would have posed serious ethical challenges, particularly given that this study focuses on children. Further, the above results confirm findings from other studies such as the Guillette et al. Mexican study.

While it is obviously very difficult to address all the potential confounding variables and establish cause and effect definitively using epidemiological designs, the data from this study provide solid ground for concluding that a real difference exists between the control and study groups. It is also beyond doubt that there is greater pesticide exposure in the underperforming study group.

Given that major confounders have been accounted for and that there are consistent results across locations, the findings lead us to conclude that pesticide exposure is the most likely reason for the lower mental and physical abilities of the study group children. At the very least, this study established a strong correlation between pesticide exposure and lower developmental task performance. The findings also indicate that the lower performance persists even as exposed children grow up.

Further investigations are needed to confirm correlations between pesticide load/years of use and exposure/types of pesticides and the results obtained here, to understand better the differences in results between the different locations and across age groups. For instance, in Punjab, which has had the longest length of exposure in the population, in almost all tests, in both age groups, the control group performed better. In Andhra Pradesh, however, the study location of Warangal has farmed cotton only (relatively) recently (about 15 years, per discussions with farmers). Pesticide use appears to have reached high levels in Warangal starting from the late 1990s (according to data by the district agricultural office). In this location, the results are more starkly in favor of the control group in the younger children than in the older children. This pattern is not so clear, however, in Karnataka which is reducing the extent of cotton cultivation and pesticide use in the Raichur area.

Similarly, results across tests need further understanding for some interpretations to be made. For instance, in the 4- to 5-year old age group, in the case of 30-minute memory test, the study and control groups showed nearly equal performance. In the 9- to 13- year old age group, in the tactile perception tests, the study group also performed well in four instances out of 12. These findings need to be better understood, perhaps in terms of understanding children's abilities to overcome the disadvantages caused by pesticide exposure.

Conclusions

This study presents significant findings regarding consequences of children's exposure to pesticides in important cotton farming areas of India. High levels of a variety of pesticides are applied to cotton crops, exposing farm workers and their families to dangerous chemical "cocktails." Farming community members (including ones who are not direct users of pesticides) are exposed in many ways to innumerable different formulations of pesticides. Data show high quantities of organophosphorus pesticides being used in these cotton belts, followed by carbamates and organochlorine pesticides. Such pesticides are known neurotoxins. Several of these have been banned in other countries, particularly in the developed world, and they also belong to WHO class 1a and 1b categories.[7]

In India, more than 60 percent of commonly used pesticides have been registered without any assessed tolerance limits. Tolerance limits are legal limits of pesticide residues allowed in or on a raw agricultural commodity or in processed foods. However, such tolerance levels are fixed based on "good agricultural practice" rather than health considerations. Much remains unknown about the potential effects of these chemicals, even the ones that have been evaluated for tolerance levels. Another issue is that of "formulants," which are added to the active ingredients in pesticides. These are not necessarily inactive and could cause their own health effects. No tests are currently conducted to assess such possible effects.

The nature of the health effects from pesticides depends on the type of pesticide, dose, timing and duration of exposure, as well as the particular susceptibility of the exposed individual. Farming community members have little or no control over several or all of these factors. For children, the possible exposure routes are many, both direct and indirect. Exposure could begin *in utero*, or even before conception (male sprayers being impacted first, for example). Exposure could take place through toxic residues present in mothers' milk. It could be through residues in food and water, or contaminants left in the soil and air. In many study villages, exposure could result from the use of cooking fuel in the form of dry stalks from the cotton crop on which pesticides have been sprayed, coupled with the fact that most kitchens are small, unventilated rooms. Further, the children may also get directly exposed to the sprays of pesticides given that they live in agricultural communities.

The approach of risk assessment and risk management that is typically adopted to evaluate pesticides clearly does not hold ground in situations like these since it does not take into account the real-life situations of complex synergistic effects of pesticides and other chemicals in children's environments.

The findings demonstrate that basic child rights of survival, growth and development are being violated and denied by technologies such as pesticides. In 1989, when the Convention on the Rights of the Child (CRC) came into force with nearly all countries of the world, including India, ratifying it, standards concerning children were brought under a single international legal instrument. Maximum Survival and Development are enshrined for all children under Article 6 of the Convention. Given the data available on pesticides and the potential to affect children right from the fetal stage, such rights are clearly being violated.

On the positive side, alternatives to chemical pesticides have been successfully established for cotton and are being practiced by farming communities in many parts of India (CICR 2000; Menon 2003). Encouragement and support for such initiatives needs to be stepped up.

Endnotes

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   The author was advised in the study design and implementation by an International Advisory Board consisting of (a) Dr. Elizabeth Guillette – Assistant Scientist, Department of Anthropology, University of Florida who undertook a similar study in the Yaqui valley of Mexico, (b) Dr. Romeo Quijano – Professor of Pharmacology and Toxicology in the College of Medicine, University of Philippines, (c) Dr. Vijaya Raman – Assistant Professor, Department of Clinical Psychology, St. John's Medical College and Hospital, Bangalore (d) Dr. S G Kabra – Physician and Visiting Faculty, Indian Institute of Health Management Research, Jaipur, (e) Dr. Ravi Narayan and Dr. Francis – Epidemiologists, from People's Health Movement and Community Health Cell, Bangalore.

   This was a study done by Greenpeace India and the complete report is available at **http://www.greenpeace.org/india/press/reports/arrested-development-the-imp**

2. States in India have historically and socio-culturally been divided into various regions; for example, the regions of Coastal Andhra Pradesh, Rayalaseema and Telangana constitute the state of Andhra Pradesh

3. A block is a large sub-unit within a district. In states where the block is coterminus with a tehsil, the block could comprise 400-600 villages. Alternatively, 2-3 blocks could be formed into one tehsil.

4. In the case of Karnataka, resource constraints required that we use an area of low pesticide exposure in Andhra Pradesh (the control for AP), as the control location for Karnataka as well. This is a border district between Karnataka and Andhra Pradesh, so

is appropriate to use as a control for both states. Therefore, the study relied on six study locations and five control locations in all. These control locations were in different districts than the study districts in three cases (Punjab – Bathinda as Study district and Ropar as the Control; Andhra Pradesh – Warangal as Study district and Medak as Control; in Tamil Nadu – Theni as the Study district and Madurai as Control). In two instances, the control locations were in different blocks of the same district as the study group (two blocks within Bharuch district of Gujarat had Study and Control villages; similarly, two blocks of Yavatmal district of Maharastra).

5. The primary role of the advisory board for this study was to ensure that it was scientifically rigorous. Members of the advisory board actively contributed at all stages of the study, especially to

   - The designing of the study
   - Training and pre-testing
   - Confirming the appropriateness of the tool to the conditions
   - Data analysis and interpretation

   The advisory board members were drawn from relevant fields of expertise like toxicology, applied anthropology, clinical psychology and epidemiology.

6. The data used for final analysis was not produced by researchers who were "blinded." However, one blind researcher was sent to one study and one control location in each of the states of Maharashtra, Gujarat and Tamil Nadu towards the end of the field study and the group averages from the sub-samples there were matched with that of the participating children. There was an agreement of around 90 percent in the data. Also, researchers in one location had no access to the findings emerging from other locations.

   The study did not do any analysis of the body burden of the participating children or take up analysis of water samples in the study and control locations in order to address the possibility of heavy metals and/or industrial contaminants in water as possible confounders. However, through literature search, such contamination (e.g., arsenic, mercury) was ruled out. Information about the types of industries in the vicinity of study and control locations and reported drinking water quality were also used to rule out other contaminants.

   There is lack of true baseline data in a sense as it is likely that all children, in both study and control locations, are exposed to some sort of endocrine disrupter. Even within the study locations, it was a cocktail situation of high pesticide usage. However, data on total pesticide load/consumption over the past five years was obtained at the district level as a proxy indicator for exposure in the study locations. This data shows that the largest quantities of pesticides used are organophosphorus compounds, followed by carbamates and organochlorine pesticides.

7. The World Health Organisation classifies pesticides into different categories based on acuteness of toxicity (LD50 values). The classification is Class 1a: Extremely Hazardous; Class 1b: Highly Hazardous.

Kavitha Kuruganti *is an independent researcher and writer and worked with Greenpeace India as a Sustainable Agriculture Campaigner (2002-2003).*

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