U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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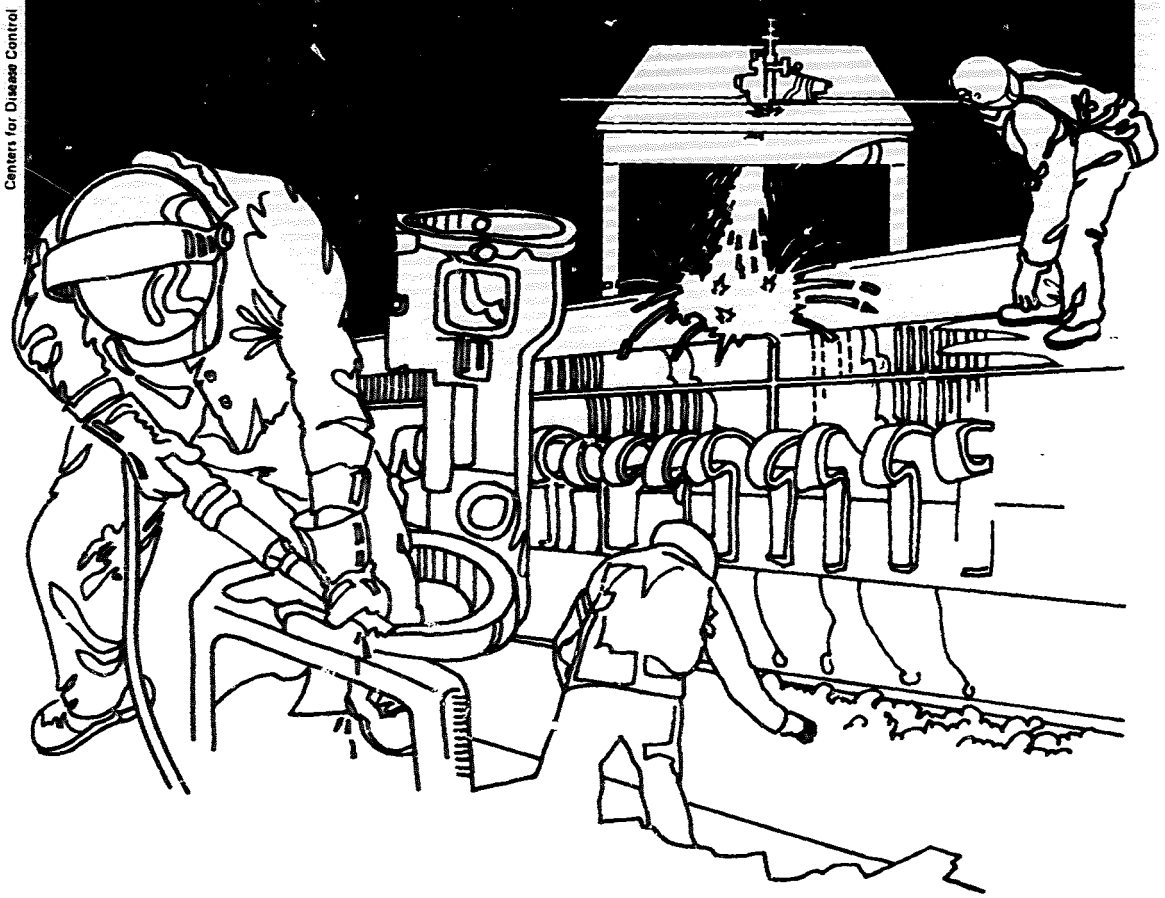
NIOSH



Health Hazard Evaluation Report

HETA 81-463-1477
COLORADO RIVER INDIAN RESERVATION
PARKER, ARIZONA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 81-463-1477
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COLORADO RIVER INDIAN RESERVATION
PARKER, ARIZONA

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I. SUMMARY

In October 1981, the National Institute for Occupational Safety and Health (NIOSH) was requested to evaluate pesticide exposures to mechanical cotton picker operators, Rood™ cotton picker operators, cotton cart workers (trompers) and cotton gin workers on the Colorado River Indian Reservation. Workers' health complaints included eye, skin, throat, and respiratory irritation. Previous NIOSH evaluations conducted during the 1980-1981 cotton season found pesticide exposures and depressed cholinesterase levels in cotton gin workers.

NIOSH investigators conducted industrial hygiene and medical evaluations for the 1981-1982 cotton harvesting season. Personal and area air samples, wipe samples from workers' skin and work surfaces, as well as bulk samples were obtained. The personal protective program and general hygiene conditions were also evaluated at each of the work sites. The medical evaluation consisted of medical questionnaires and blood cholinesterase tests. Indian Health Service (IHS) and NIOSH cooperated in the medical evaluation of a unexposed control group of individuals living on the reservation or in the Parker area.

The bulk samples evaluated indicated the presence of DEF, Lorsban, Pydrin, Nudrin and Aldicarb. Disulfaton was evaluated, but not found in any of the samples collected. Wipe samples taken from the employees' skin showed numerous pesticides at various levels: DEF ranged from 0.44-63,000 ug/sample, Lorsban from non-detectable(ND) to 55 ug/sample, and Pydrin ranged from ND to 1.10 ug/sample. The only pesticides detected on the personal breathing zone samples was from the defoliant DEF (range 0.02-0.55 mg/M^3).

Mean red blood cell cholinesterase levels at the beginning of the study were 0.754 $\pm$ 0.113 ph units for the control group, and 0.800 $\pm$ 0.110 ph units for the cotton workers. End of study means were 0.654 $\pm$ 0.086 ph units for the controls and 0.628 $\pm$ 0.083 units for the cotton workers. This data indicated a mean drop of 11.7% $\pm$ 11.2 for the controls and of 18.2% $\pm$ 14.9 for the cotton workers. No statistically significant difference was seen between the mean cholinesterase drop in workers and controls, although there were some differences between the various groups. In all, 36% of the controls and 63% of the cotton workers dropped their cholinesterases more than the 15% which is considered the limit of normal variation.

Based on the environmental and medical data obtained in this investigation, it was determined that a health hazard existed to the workers evaluated at each of the job sites from exposures to various pesticide residue laden materials. There also appears to be a similar effect (cholinesterase depression) to some of the local comparison groups we evaluated in this study. Recommendations to assist the field and gin operators to improve workers' health are included in Section VIII of this report. Information is also presented regarding potential community health concerns.

KEYWORDS: SIC 0131 (Field Crops, Except Cash Grains-Cotton), pesticide residue laden materials (PRLM), organophosphates, carbamates, DEF®, Folex®, Lorsban®, Azodrin®, Nudrin®, Disulfaton® Aldicarb®, methyl parathion, ethyl parathion, parathion, paraquat, Dimethoate®, cholinesterase, mechanical cotton picker and Rood™ opera- tors, cotton cart workers (tromper), and cotton gin workers.

II. INTRODUCTION

On September 14, 1981, the Executive Director of the Colorado River Tribal Council-Tribal Health Department, Parker, Arizona, submitted a health hazard evaluation request to evaluate the potential exposures to over forty different pesticides used and found in cotton field and ginning operations on the reservation. The Tribal Health Department is responsible for overseeing the health concerns for both environmental and occupational matters on the reservation. In a previous NIOSH Health Hazard Evaluation which evaluated three cotton gins on the reservation (HETA 80-245, 246 and 247), it was determined that the gin employees were being exposed to excessive noise, cotton dust and pesticide exposures (shown by a decrease in red blood cell cholinesterase level over the ginning season). The pesticides evaluated at the time included DEF, Azodrin, Methyl parathion and Lorsban.

The current request stated that a potential health hazard also existed to approximately 100 additional employees who work various operations in cotton harvesting and production on the reservation. These employees included mechanical cotton pickers and Rood operators and cotton cart trompers. NIOSH also re-evaluated one of the gins evaluated the previous year.

Environmental studies were conducted during November 10-13, 1981, January 5-7, 1982, and February 2-6, 1982. These time periods corresponded to the three phases of cotton picking that are performed in this area (i.e., First, Second and Third picking). After each environmental evaluation, recommendations were given to the cotton manager and/or owners of the cotton fields or gin and to the Tribal Health Department. Control subjects were recruited by IHS who obtained blood specimens on September 17-25, 1981, October 30-November 6, 1981, and February 2-5, 1982. The NIOSH medical investigations were performed on November 4-5, 1981, December 16-17, 1981, and January 14-15, 1982. Blood specimens were obtained from the workers at that time. Individuals were contacted by mail regarding their medical results. An environmental and medical Interim Report was presented to the Tribal Health Department and the cotton field and gin representatives in December, 1982.

III. BACKGROUND

Cotton growing and ginning is a major agricultural process that exists in many countries throughout the world. In the United States there are numerous cotton growing fields located primarily in the southern states. There are approximately 2,000 gins in this country with Texas, California, New Mexico, and Arizona producing the majority of cotton. In these states, as well as others, cotton harvesting and cotton ginning normally occurs from August to February. During the peak of the cotton harvesting and ginning season there are usually 15 to 20 employees (pickers and trompers) involved in field harvesting operations and 15-20 employees (two shifts) at a gin. For 6 to 8 months each year it is estimated that there are approximately 20,000 employees working in the cotton ginning industry and approximately the same number in cotton harvesting operations.

The Colorado River Indian Reservation is one of the major cotton growing areas in Arizona and is located along the Colorado River south of the Parker Dam. It is principally in Yuma County, Arizona, the northern tip extending

into the Riverside and San Bernardino Counties in California. The reservation has approximately 265,000 acres and approximately 78,000 acres are devoted to agriculture. Cotton is the primary agricultural crop. Other major farm crops produced are alfalfa, wheat, melons, and lettuce. It was determined by NIOSH that cotton in this area is in some phase of production year round; that is, from the tilling, planting, cotton picking, to the final cotton ginning and retilling, there are only a few weeks each year when some phase of the cotton production is idle in this valley. At present there are three cotton gins on the reservation: Parker Valley Gin, Colorado River Gin, and the Plantation Gin.

The following is a general description of pesticide usage for cotton fields, cotton harvesting operations, engineering controls, personal protective equipment, personal hygiene concerns, employees at risk and other concerns evaluated at CRIT farms and the Parker Valley gin:

A. Pesticide Usage On Cotton

Since World War II, the use of pesticides in the United States has expanded in many ways and the demand for these products in agricultural development has grown tremendously. As a result of this large demand hundreds of compounds as well as thousands of formulations have been developed to meet the needs of the various crops produced in this industry.

Like other agricultural crops, pesticides are used in various ways in the cotton industry. Unlike most agricultural crops, however, cotton is normally treated with a much larger variety of pesticides and it is not uncommon during a given season to find cotton fields sprayed with dozens of different pesticides. Table I is an example of a portion of the different pesticides used in the Parker Valley during NIOSH's investigations.

In general, pesticides are often described or referred to as economic poisons. That is, under the Federal Insecticide, Fungicide, and Rodenticide Act, economic poison is defined as "any substance or mixture of substances intended for preventing, destroying, repelling, or migrating any insects, rodents, nematodes, fungi, weeds, or any other forms of life declared to be pests; and any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant." In this report, however, the term pesticides will only be used to describe that group of chemicals which include insecticides, herbicides, fungicides and plant growth regulators.

Insecticides fall into six general categories according to the way in which they affect insects. This includes: stomach (toxin ingested by the insect), contact (kills via external portion of the body), residual contact (remains toxic for log periods), fumigant (sufficient vapor pressure to produce lethal concentrations), repellent (keeps insects away) and systemic (absorbed into the plant, whose parts become insecticidal).

Hericides are primarily chemicals which are intended for killing plants or interrupting their normal growth (e.g., a weed, grass, or brush

killer). Herbicides are used in five general ways: preplanting (applied prior to seeding), preemergence-contact (just after seeding), preemergence-residual (during seeding, kills other weeds and seedlings), postemergence (after emergence of crop) and sterilant-nonselective (complete kill of all treated plant life).

Fungicides are used on crops preferably as protective rather than curative treatments, being applied to the surface of the plant in water suspension or as dusts before attack of a fungus.

Plant growth regulators are chemicals which in minute amounts, alter the behavior of plants through physiological (hormone) rather than physical action. They may act to accelerate or retard growth, to prolong or break a dormant condition, to promote rooting, or other similar ways.

These pesticides are typically applied by ground or aerial techniques. The applications normally start shortly after the last cotton harvesting with a layby or preplant application and end the season with a defoliating application. The other types of pesticides described above are applied at various times during the season. The largest concentration of pesticide spraying occurs from May to December with defoliation used in the greatest quantities in comparison to the other pesticides used.

B. Cotton Harvesting Operations

Harvested cotton is normally a mixture of cotton, cotton seed, leaves, sticks, bract, unopened bolls, and dirt. CRIT Farms and the Parker Valley gin normally harvest and process three different stages (phases) of cotton. These stages will be referred to as First Picking, Second Picking, and Third Picking (which is also called Rood/Ground Picking). The first stage in the cotton harvesting process is the initial picking of the crop which removes approximately 85-90 percent of the plant's matured cotton bolls. This picking also accounts for about 50-65 percent of the plant's total cotton. The cotton plant is left to continue maturing the remaining cotton bolls on the plant and a few weeks after the initial cotton harvesting, the fields are picked a second time.

Both first and second picked cotton were picked with two-row cotton harvesting machines at those fields NIOSH evaluated. Two tractor models were used during these harvesting operation and the drivers' cabs were somewhat similar in both models. There were enclosed cabs with access doors on each side. After mid-morning, the operators would frequently open the doors and windows in these cabs in order to cool off. However, this would then allow dust to enter the cabs environment which in turn would become quite dusty by the end of the work shift.

The last stage in the harvesting process--Rood/Ground Picking--requires a special machine called a Rood Picker which removes all the remaining cotton on the plant as well as much of the cotton on the ground. Although the Rood picker separates much of the trash from the cotton as it picks, much of the dirt and trash still remains with the cotton. This last stage accounts for approximately 3-5 percent of the plant's

cotton material and is considered marginally profitable. The Rood machine is primarily a rotating cylinder/brush which in general sweeps up the remaining cotton and pushes it into a large screen like basket. The machine is pulled by a tractor and these were the open type and did not provide operators protection from the dust which was stirred around during this harvesting operation.

C. Gin Process Description

Characteristically, as these three stages of picking are processed in the gin, the first harvest is normally clean in terms of production and generation of airborne materials. However, the second picking is much dirtier and the last picking is very dirty in terms of airborne dust concentrations produced during the harvesting as well as the ginning process.

Depending on the cotton yield and weather conditions through the season, the gins normally will operate two 12-hour shifts from the mid-ginning season (August-September) and through the end of the season (January February). The Parker Valley gin normally operates 6-7 days per week from August to February.

The ginning process at the Parker Valley gin is similar to most other ginning operations in this area. However, the Parker Valley gin has recently automated a portion of their ginning process. In general, the addition of new equipment improved much of the overall operation and reduced some of the airborne dust particulates that were particularly noticed by the NIOSH investigators.

Ginning operations are a series of separation processes beginning with receiving raw cotton material from the fields and culminating with relatively clean bales of cotton free of seeds and trash. The cotton seed removed from the boll is sold for cotton seed oil, or in some states, as animal feed. The process flow in a gin is as follows:

1. Cotton modules or large trailers filled with cotton are transported from the fields to the gins. Cotton modules are raw picked cotton which is pressed into blocks in the fields and transferred to the gins for processing.

2. Cotton is sucked from the trailers or modules positioned beside the building into the initial ginning process.

3. Once inside the building a preparation box receives the raw cotton which provides for an evenly regulated flow into the remaining cleaning processes.

4. The cotton then goes through a horizontal or vertical dryer which removes moisture from the raw material.

5. Next the material goes through a Burr/Stick machine and up an Incline Cleaner where dirt, sticks, and leaves are removed.

6. The material goes through another dryer and then through a second Incline Cleaner for further leaf and dirt removal.

7. The material is now predominantly cotton boll and begins its stripping process in the cotton gin.

8. Most gins have numerous gin stands which are designed, via stripping blades, to remove the cotton seed and bract (outer shell/hull of the pure cotton) from the boll.

9. Once this stripping process takes place the extracted seed is transferred via a pipe (called a sucker pipe) to a seed pile outside in the gin yard.

10. The stripped cotton then goes to a Moss Cleaner where low grade cotton material is separated and sent to a mote (low grade material) baler. This material is used primarily in upholstery manufacturing.

11. The higher grade cotton continues on until it is received at the Bale Press station. Here the finished cotton is pressed into finished bales of clean cotton, wrapped in fiber bags, and bound with wire.

12. Once a finished bale is wrapped it is removed from the baling press, transferred to a trailer, and placed outside in the gin yard.

Further information on gin processes operations and health hazards associated with this industry (e.g., noise, cotton dust, and pesticide laden dust) are discussed in NIOSH's previous Health Hazard Evaluations (HETA 80-245, 246 and 247), as well as references contained in those publications.

D. Enginneering Controls

The cotton harvesting machines described earlier had enclosed cabs and some had air conditioning systems. However, the majority did not and of those that did many were not working. Again, the Rood harvesting process was performed with open cab tractors that had no means to reduce airborne dust to the tractor operators.

As previously discussed, the Parker Valley gin had recently updated its equipment, however, there were no engineering controls, per se, designed to reduce the airborne particulates found in the gin. In general, the sources of dust generated in gins are numerous and typically difficult to control by current engineering controls.

E. Personal Protective Equipment

During the survey periods, the only personal protective equipment were hard hats and disposable paper respirators, which were not NIOSH approved and these were worn by only a few workers at the gin (about 10 per- cent of the work force). One worker was seen wearing hearing protec- tion; however, no hearing conservation program existed at this gin and, as was described in NIOSH's previous report, noise was considered a real health hazard at each of the gins evaluated. There was no indication of any other personal protection available at the gin, such as protective clothing, safety shoes, hearing protection and/or a hearing protection program.

The cotton harvester operator and trompers wore only street clothes and wore no personal protective clothing during the harvesting operation. One tractor operator wore a respirator mid way into the season after he was notified by NIOSH that his cholinesteras level was down dramatically. This respirator was in disrepair and was not NIOSH/MSHA approved.

F. Personal Hygiene Concerns

Pickers and Rood operators, as well as trompers and gin employees, normally work 10 to 12 hours per day under conditions that are frequently very hot and dusty. Because of these conditions the employees usually wore only jeans and T-shirts and it was not uncommon to find the employees' arms, hands and face covered with dirt. It was also determined that the employees in the fields did not have any way to wash themselves properly, and therefore, they would normally go through the day with dirt all over themselves. This type of situation was also true with those gin operations NIOSH evaluated in the valley, that is, the majority of field and gin operators did not have adequate washing or showering facilities.

G. Employees at Risk

The employees considered to be at risk to the exposures evaluated in this study were all employees who work directly with the cotton harvesting process (e.g., picking and Rood operators, trompers, and tillers) and the employees involved in ginning production. This includes the head ginners, assistant ginners, standwalkers, pressmen, and suction and outside operators. All of these employees normally work 10-12 hours per day, 6-7 days per week for the entire season. The fact that these employees work 60-70 hours per week places them at higher risk when comparing exposure criteria and/or standards which are designed for 8 to 10 hours per day, 40 hours per week.

H. Other Concerns

Other sources of potential pesticide dust laden exposures to the workers evaluated in this report were from cleaning and maintenance operations performed on the harvesting machines and in the gin. This included cleaning the various parts and filters on the cotton harvesting machines with high pressure hoses, laying in the picked cotton during breaks while eating their lunches and using high pressure hoses and brooms to clean-up the gin at the end of the work shift. Each of these types of activities increases a worker's exposures to pesticides and may contribute to lowering a persons cholinesterase levels.

IV. EVALUATION DESIGN AND METHODS

Pesticide Residue Laden Materials (PRLM) were defined by the project officers in NIOSH's previous study as any material (e.g., cotton fiber, bract, dust, etc.) which is laden with a pesticide residue (i.e., insecticide, herbicide or plant growth regulators, etc.) and where such materials have the potential to adversely effect the health of the worker by contamination through inhalation of airborne substances and/or skin contact by such mater-

ials. Approximately 40 different pesticides, e.g., insecticides, herbicides, and defoliants, were used during the cotton growing season in 1981-82 at the operations under study (Refer to Table 1). Based on NIOSH's previous investigations and a general understanding of the type of work performed by the workers in the current study, it was decided to perform similar environmental and medical tests as were performed in NIOSH's prior evaluations. The following is a description of the techniques used:

A. Environmental

A variety of environmental sampling techniques were used to evaluate the suspected contaminants at each of the operations evaluated. This included personal, area and bulk sampling methods and personal and area wipe sampling techniques.

Due to both the large number of pesticides determined to exist in this agricultural crop (over forty) and the variety of pesticides present in these operations, we choose to reduce the number of pesticides evaluated to a reasonable size. The selection was based on the following considerations; available sampling and analytical techniques, the potential relationships between the environmental and medical results, if a standard or criteria existed, if there was any toxicity concerns regarding a particular pesticide (e.g., carcinogenic, mutagenic, teratogenic or oncologic concerns) and time of year and dose sprayed (refer to Tables I and II). Therefore, NIOSH selected only those pesticides that were primarily organophosphates or carbamates which have sampling and analytical methods and can correlate with cholinesterase depression (e.g., DEF, Folex, DDVP, Lorsban Nudrin, Pydrin, Disulfaton, Aldicarb, etc.).

1. Environmental Sampling Techniques

Personal and area samples consisted of drawing air at 1 liter per minute (lpm) through 13 millimeter (mm) glassfiber filters mounted in closed face cassettes and chromosorb tubes.

2. Personal Wipe Samples

Personal and surface wipe samples were also collected at each of the work operations evaluated. Employees' skin contamination by pesticide dust laden material was studied by obtaining wipe samples from the hands/wrist and forehead of the workers. Suspected contamination from various work surfaces in both the tractors and in the gin was also evaluated. The surface area samples size was approximately 75-100 cm^2 for the palm and forehead surface of each person seen. When appropriate, the same area was wiped for each of work surfaces evaluated. The wipe samples were collected on Whatman smear tabs which were moistened with distilled water.

3. Bulk Samples

Bulk samples were collected around areas where employees work (e.g., the inside of the gin, tractor cabs and tractor trailers). All of the wipe and personal samples were initially analyzed for those organophosphates and carbamates described earlier. It should be

noted that there was a considerable effort devoted to the development of the sampling and analytical procedures used in this study. It was necessary to verify each step of the procedure in the particular matrix (cotton) for the requested compounds. For those without standards this was accomplished by adding known amounts of the compounds to clean cotton and analyzing. Gas chromatography/mass spectrometry (GC/MS) was used as needed to verify the presence of some of the compounds.

B. Medical

The medical evaluation performed in this study on the potential pesticide exposures was similar to that performed in NIOSH's previous study. This included interviews with the workers, medical questionnaires, and drawing of blood for cholinesterase determinations. Unlike NIOSH's previous studies in the Parker Valley, however, a control population was included in the current study. The study population, both workers and controls, is characterized in Table III.

1. Population Selection

a. Controls -- The control group was recruited from several groups living and working on the Reservation (in the Valley) or in the town of Parker. An attempt was made to have about equal proportions of controls with "swamp coolers" (evaporative coolers) as with "refrigeration" units (mechanical air conditioners); who lived in the Valley as lived in Parker; and who worked in the Valley as worked in Parker. Also about equal numbers of men and women were desired. Controls did not work with pesticides either regularly or in the recent past. It was desired that they not have been exposed to aerial spraying in the recent past, but this was not always possible.

As selected, 34 (64%) of the controls worked in the Valley and 31 (58%) lived in the Valley. Thirty-two (60%) of the controls had only refrigeration for cooling, 20 (38%) had swamp coolers, and 1 (2%) had no cooling system at home. Workplaces had refrigerative cooling. Most (17/22 -- 77%) of those living in Parker had refrigerative cooling.

No replacements were added to replace drop-outs in the control groups once the study was started. However, there were several who were available for the third blood drawing who missed the second blood drawing.

b. Workers -- All picker operators and trompers at the CRIT Farm and all gin workers at the Parker Valley Gin were included in the study. Several workers were added to the study at the

second visit. Also not all workers were willing to have specimens taken at every visit. The manager and a utility worker at the CRIT Farm and the Supervisor at the Parker Valley Gin had specimens obtained, but their results were not included in the analysis because their jobs were sufficiently different from the rest of the workers to prevent meaningful comparisons.

All of the workers worked in the Valley. All 19 CRIT Farm workers lived in the Valley at the time of the study. Thirteen (68%) had swamp coolers and 6 (32%) had refrigerative cooling only. Nine (53%) of the 17 gin workers lived in the Valley, 4 (24%) lived in Parker, and another 4 (24%) lived in communities near the Reservation. Seven of the gin workers living in the Valley, all those living in Parker, and one of those living off reservation had swamp coolers. The rest had refrigerative cooling only.

2. Sample Collection

Because of problems of distance, multiple specimens to establish a baseline were not feasible. An attempt was made to obtain the first specimen early in the season before appreciable exposure had occurred. This was difficult with the worker groups because of the uncertainties of weather and crop maturation. Red blood cell (RBC) cholinesterases were determined by Laboratory Procedures, Inc., Woodland Hills, California, using the California State Department of Health mandated delta pH Michael method. (This is the same laboratory which was used for the NIOSH 1980-1981 study in the gins in this valley).

a. Controls -- Blood specimens were obtained by IHS personnel September 17-25, 1981; October 30-November 6, 1981; and February 2-5, 1982.

b. Workers -- Blood specimens were obtained by the NIOSH physician at the work site November 4-5, 1981; December 16-17, 1981; and January 14-15, 1982.

3. Questionnaires

a. Controls -- Were administered a questionnaire by IHS personnel in the beginning of the study. Besides demographic data on the individual, information was obtained on smoking habits, the cooling systems at work and home, the water supply at home, the distance from the cotton fields at work and home, and when the last spraying occurred near both places. The questionnaire also served to identify those who were unsuitable for inclusion in the control group either due to pesticide exposure or because of recent job or residence change.

Because of unexpected cholinesterase depressions on the last drawing when aerial spraying was at a minimum, a second ques-

tionnaire was mailed along with the individual test results to all controls who participated in the February blood drawing. With a follow-up letter and telephone contacts it was possible to obtain responses from 11 of 16 with depressed cholinesterases and 25 of 28 whose cholinesterases remained at normal levels. The follow-up questionnaire asked specifically about spraying or burning of fields near home or work, pesticide use, cotton "trash" use, dust exposures, use of local produce and fish, milk sources, and outside activity during January and early February 1982.

b. Workers -- Were administered a questionnaire similar to that use with the control population on the initial visit with more emphasis on the occupational history and past medical history. As all workers were to be included, the questionnaire did not serve a screening function. Follow-up questionnaires were administered at subsequent visits to identify health complaints and job changes, particularly as it might relate to pesticide exposure.

V. EVALUATION CRITERIA AND TOXICOLOGY

A. Environmental

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both

NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based solely on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

Pesticides

Of the over 40 pesticides originally considered in this investigation (refer to Table 1) only eleven had criteria or standards and these are listed below:

	Permissible Exposure Limits 8-Hour Time Weighted Exposure Basis (mg/M^3)		
Substance	NIOSH	OSHA	TLV(ACGIH)
Carbaryl (Sevin).....	5.0	5.0	5.0
Methyl Parathion.....	---	---	0.2
Parathion.....	0.5	0.11	0.1
Malathion.....	15.0	15.0	10.0
Methomyl (Lannate, Nudrin).....	---	---	2.5
Demetron (Systox).....	---	0.1	0.1
Toxophene.....	---	---	0.5
Azodrin.....	---	---	0.25
Bidrin.....	---	---	0.25
Azinphosmethyl (Guthion).....	---	0.2	0.2
Paraquat.....	---	0.5	0.5

mg/M^3 = milligrams of substance per cubic meter of air.

B. Pesticide-Organophosphates/Carbamates

The most immediate effect of an organophosphate pesticide exposure is inhibition of cholinesterase, an enzyme necessary to "reset" nerves after they have carried an impulse. Chronic low level exposure can lead to progressive depression of cholinesterase until a level is reached where symptoms occur. Symptoms can include respiratory tightness, sweating, nausea, vomiting, abdominal cramps, constriction of the pupils of the eyes, muscular fatigue and weakness, twitching, muscle cramps,

anxiety, headache, emotional instability, confusion, unsteady gait, slurred speech, convulsions and, in the extreme case, circulatory and respiratory depression and death.

Some organophosphates have also caused delayed toxic effects on the nervous system, manifested as peripheral neuritis and paralysis.

Carbamates can also cause cholinesterase inhibition, but it is more readily reversible than that caused by organophosphates. Symptoms of acute toxicity would be the same.

As the plasma cholinesterase level is affected sooner and recovers sooner after exposure, the red cell cholinesterase level is the more important measure of cumulative effects of exposure to cholinesterase inhibiters, such as organophosphates. Red cell cholinesterases were used in this study. The ideal measure is to establish a base line for the individual before exposure. Subsequent values are then compared to this base line. Values below 70 percent of baseline show an unacceptable exposure to cholinesterase inhibiting substances and values below 60 percent of base line call for removal and medical observation.

In the absence of a base line, values can be compared to laboratory normals, in this case 0.44 - 1.09 pH units for red cell cholinesterase.

VI. RESULTS

A. Environmental

Employee exposures to suspected concentrations of pesticide residue laden materials thought to effect the health of workers during cotton picking and rood harvesting, cotton tromping, tilling and ginning operations were evaluated. Due to the large number of different pesticides potentially present at these job sites NIOSH selected only a portion of those pesticides that meet the criteria presented in the Design and Methods section of this report (refer to page 8).

The study involved the analysis of bulk, personal and area samples. The samples were collected as bulks (in plastic bags), on smear tabs, filters and solid sorbent tubes. Many problems were encountered during the processing of the samples, including difficulties with extraction of the pesticides and numerous interferences. Because of the inordinate amount of time involved in the development of extraction and cleanup techniques, it was determined that the sequence would be more appropriately analyzed at tne Special Analytical Measurements Laboratory at the Center for Disease Control. Due to this delay approximately six to ten weeks had transpired from the original sampling dates until the majority of samples were analyzed.

The results indicated that DEF was the major contaminant; Lorsban, Pydrin and Nudrin were present to a lesser extent; the presence of Aldicarb was questionable and Disulfaton, if present at all, was not found at the lower detection level. The following are the results of the current evaluation:

1. Pesticide Residue Laden Materials

Based on the results of the bulk sample analysis, evaluation of Disulfaton was eliminated from further study. The bulk and wipe samples were then analyzed for the remaining analytes. The bulk samples consisted primarily of dust materials collected from inside the cabs of the tractors and in the gin at those locations where the employees worked. DEF ranged from 5.5 to 65.4 parts per million (ppm) per sample, Lorsban 0.8 to 27.6 ppm per sample, Pydrin from non-detectable (ND) to 14.6 ppm per sample and Nudrin which ranged from ND to 6.4 ppm per sample (refer to Table IV).

The personal wipe samples obtained during the study from the arms, hands and face of the workers did indicate pesticide exposures. These included DEF which ranged from 0.44 to 63,900 micrograms (ug) per sample, Lorsban which ranged from ND to 55 ug per sample, Pydrin which ranged from ND to 1.0 ug per sample. Nudrin was not detected (refer to Table V).

DEF was found on all the personal, wipes and bulks samples. DEF was by far the most abundant organophosphorous compound detected in the samples. There is evidence that some of the DEF detected may have come from Folex. Rafter samples, accumulated dust particles which are found on elevated surfaces, were also collected in the gin. These samples were collected at about 5-7 feet off the ground where the employee would be working and could be considered in the employees breathing zone.

2. Air Samples

A total of sixty (60) air samples were obtained during the three surveys NIOSH performed, twenty samples for each sampling period. It was determined that only a portion of these samples would be analyzed and based on the results obtained from the initial analysis additional samples would then be evaluated. Twenty five samples were analyzed for the same analytes described above. Each of the personal airborne samples indicated non-detectable levels for all those pesticides evaluated except DEF. Those samples containing DEF ranged from 0.02-0.55 mg/M^3 for the field samples and 0.03 to 0.16 mg/M^3 for the gin samples (refer to Tables VI and VII). Selected samples from the remaining group also showed non detectable levels for those other pesticides studied.

Again, it should be noted that all the personal samples were analyzed weeks after they were collected and their true qualitative, as well as quantative value should be considered low or potentially even non-detectable. This concern was discussed in NIOSH's HHE 80-245, 246 and 247 and recently by the United States Envirnmental Protection Agency who had similiar problems with a study they performed on pesticides in soil and water samples collected at the Colorado River Indian Reservation in the Parker area. These problems and other concerns regarding NIOSH's current study will be discussed later in this report.

B. Medical

1. Cholinesterase Findings for Controls and Cotton Workers

Tables VIII A & B give mean red blood cell (RBC) cholinesterase levels for controls and cotton workers respectively. Table VIII B also contains data from a 1980-1981 season study which is roughly comparable to date from this study. In comparing the seasons it should be noted that the 1980-1981 ginning season was longer than the 1981-1982 season, and that the earlier study involved all three gins whereas the current study involved only the cleanest of the three gins. Statistically significant findings are indicated on the tables, but only a few of the statistically insignificant findings are indicated. Statistical insignificance can be due to lack of difference and/or small sample size.

Tables IX A & B give data on the mean per cent change in cholinesterase levels for controls and workers. Again data from the 1980-1981 season are included in Table IX B. Sample size is reduced because this compares each individual's results with his own results. Table X compares results, both RBC Cholinesterase levels and percent change, between controls and cotton workers.

Tables XI-A, XI-B, and XI-C give the number of individuals in each group with drops in cholinesterase levels greater than 15%, and greater than 30% of the earlier level used for comparison. Table XI-A shows controls, Table XI-B workers, and Table XI-C a comparison of the two.

a. Controls

On the initial drawing (Table VIII A) there were no significant differences between the means of the four control groups. Because the Police and Wildlife workers have a variable exposure depending on their activity, the other three control groups were compared among themselves. Workers in the two schools, located in the Valley, had a mean cholinesterase level of 0.726 pH Units (S.D. $\pm$ 0.064). This was statistically significantly lower than the mean for the IHS Hospital ($t = 2.591$, d.f. = 43, $p = 0.0069$). Comparing living in the Valley to living in town, or use of refrigeration only vs. use of a swamp cooler, showed no significant differences. Thus it appears likely that those controls working in the Valley had already received exposure to a cholinesterase inhibitor by the time the study started. Aerial spraying had occurred during the previous week.

In looking at changes over the season (Tables VIII-A, IX-A, & XI-A) mean drop in % of initial values (-0.1 % $\pm$ 14.1) did not show statistically significant differences between the September and October-November blood drawings. The number with drops greater than 15% (6 of 46) represented only 13% of the control group and also did not show any statistically significant differences between groups. In the case of Police and Wildlife this was probably due to the small number of cases. Mean drop was 10.6 % $\pm$ 19.3 with 2 of 5 having drops greater than 15 %.

The two schools should significantly greater mean percentage drops between the last two drawings than between the first two drawings (change of -12.2 % + 8.1 and + 7.0 % + 7.9 respectively for the Head Start School; and -11.8 % + 12.9 and -1.3 % + 14.8 for the Le Pera School). In February there were no longer any statistically significant differences between the cholinesterase levels of the various control groups (overall mean 0.654 + 0.088 pH Units) and the drops over the season as a whole were rather similar (Mean change -11.7 % + 11.2). In looking at the numbers with drops greater than 15% the Police and Wildlife showed no drops specifically confined to the latter part of the season whereas this is when the rest of the group had most of their drops.

b. Cotton Workers

On the initial drawing (Table VIII B) the inside gin workers had a significantly lower mean cholinesterase level (0.700 pH Units + 0.053) than the other groups of workers (0.835 pH Units + 0.103). This probably reflects the effects of about 2 weeks work before the specimens were obtained. It should be noted that both groups of gin workers (and total gin workers also) had higher mean levels than were found in the early season cholinesterase tests of the previous season, probably because the specimens were obtained earlier this season.

In looking at changes over the season (Tables VIII-B, IX-B, & XI-B) by the December blood drawing the differences in mean cholinesterase levels among the worker groups was no longer significant. All of the workers dropped their levels, the Rood Operator the most (change of -31.3 %) and the inside gin operators the least (mean percentage change of -10.7 % + 12.9). The majority (67%) of the field workers had levels more than 15% below their November levels. Of the three inside gin workers drawn in both November and December, two did not show clinically significant drops, but the other did. The two not showing the drops regularly used disposable dust masks of the 3-M type, the other did not use protection. Unfortunately, the outside gin workers did not participate in this drawing.

The Rood operator who showed a 31.3% drop in his cholinesterase (to 0.55 pH units) was strongly urged to take measures to reduce his dust exposure. He did this and by the January drawing his cholinesterase level had returned to 0.70 pH units (88% of his initial value). Because of the intervention, his January results are not included in the analysis.

Over the 1981-1982 season all the cotton workers except the inside gin workers showed a progressive decrease in mean cholinesterase level over the three drawings. (It should be remembered that the inside gin workers started at a lower level than the others.) For the field workers final levels were 19.6 % + 12.0 lower than initial levels; for inside gin workers 10.5 % + 20.6 lower; and for outside gin workers 27.5 % + 6.0 lower. The

field workers did most of their dropping between the first and second drawing (mean change -17.5 % ± 6.7 November to December, -5.0 % ± 10.7 December to January).

In comparison with the previous season, the outside gin workers were at about the same levels (0.600 pH Units + 0.050 for 1981-2 vs. 0.575 + 0.042 for 1980-1), whereas the inside gin workers had statistically significantly higher cholinesterase levels at the end of the 1981-1982 season (0.617 ± 0.129 vs. 0.500 ± 0.057). A likely explanation is that we were dealing with the cleanest gin in 1981-1982.

The field worker with a January cholinesterase level 36.4% below his November level reportedly had a bad reaction several hours after the blood was drawn. Symptoms included sweating and upset stomach. As he did not seek medical attention, it was not determined if this was due to the drop in his cholinesterase level, or to some other problem. His cholinesterase was repeated in February at the time the controls were evaluated. His level had risen slightly (from 0.70 to 0.75 pH units). His February results are not included in the analysis.

c. Worker-Control Comparisons (Tables X & XI C)

On the initial drawing the field workers and outside gin workers had statistically significantly higher mean cholinesterases than did the inside gin workers and the controls (difference in means 0.114 pH Units ± 0.089). This probably reflects the short time in the Valley for some of this group of workers and less intense exposures in the open air than occur within the gin building. Neither group would be particularly involved in aerial spraying as about two weeks must elapse between the time the defoliant is sprayed and the time the field is ready for picking.

In the last drawing the various groups showed no statistically significant differences in mean cholinesterase levels, nor did they show one in percent drop between the October-November drawing and the January-February drawing (mean change -12.6 % ± 15.0). The Head Start School and Police and Wildlife had the least numbers with excessive drops between the two sets of drawing (17 %), the Le Pera School and inside gin workers more (42 %), and the PHS Hospital, field workers and outside gin workers the most (64 %).

2. Cholinesterase Depressions as They Relate to Initial Level.

Those with higher initial cholinesterase levels had greater percentage drops over the season (Table XII). For those with an initial cholinesterase level less than 0.75 pH Units, both controls and cotton workers showed similar average drops (-12.0 & -12.1% respectively). Also for those with an initial cholinesterase of 0.85 pH Units or more the average drops were -44.8 and -44.5% respectively. In between these initial figures the controls were similar to the initially low group (-11.6%) and the cotton workers were part way

between the two groups (-29.0%). Tables XIII and XIV examine the initial cholinesterase level in relation to the length of time in the area before the initial cholinesterase was drawn and the percent change in cholinesterase over the season respectively. Although not reaching statistical significance, there are differences between the various groups involved in the study. In Table XV the time in the area before the initial cholinesterase is examined by group. A significantly greater number of gin workers were recent arrivals (12 of 16 had been in the valley 1 month or less). Most of the controls had been in the area for 3 months or more (43 of 53). The cotton field workers fell in between. Six (6) of 18 had been in the valley 1 month or less and 11 had been there 3 months or more.

3. Review of Initial and Follow-up Questionnaires

No significant factors to explain the cholinesterase drops among the control group were found from either the initial or follow-up questionnaires. Working in the valley as opposed to working in town, living in the valley as opposed to living in town or elsewhere, use of swamp coolers as opposed to refrigerative cooling only, various outside activities, and diet were all considered. It was suggested that engaging in dusty sports or eating locally caught fish (except trout) could be a factor but numbers were too small for meaningful comparisons. Factors involving type of residence became clouded by the time the individual was in the area before the initial cholinesterase was obtained, and by place of work. A sufficiently large number of controls drawn from the two schools and the PHS Hospital who had been in the area at least 3 months were available for analysis. No statistically significant differences were found either between initial cholinesterases or in percentage change over season.

4. Summation

In view of the variety of pesticide residues found and the reduced cholinesterase levels determined to exist in the control group it appears that everyone in the valley is receiving some exposure. To get a reliable cholinesterase baseline on either workers or control, it will be necessary to obtain the specimens very shortly after the individual returns from a period away from the valley of at least two weeks. Otherwise a working baseline could be obtained prior to the cotton harvesting season. Judging from the time the controls showed significant drops in cholinesterase levels, it appears the dusty processes of harvesting the cotton and plowing the fields are major factors in the general exposure. The data also suggests that the dusty processes in working with the cotton are important in the workers' findings. The fact that during this season the outside gin workers showed a greater drop than the inside gin workers whereas in the previous season the inside workers showed the greater drop reflects a cleaner gin, and probably also relates to the fact that the outside gin workers had their initial blood drawn sooner after starting work and therefore their initial cholinesterases were closer to a true baseline.

VII. DISCUSSION AND CONCLUSIONS

It is believed by the environmental and medical officers that all of the employees evaluated during the current NIOSH survey were being exposed to those pesticides addressed in this report and that a portion of these employees' health was and is being affected adversely. The following are the environmental and medical conclusions:

A. Environmental and Medical

Working in the harvesting and ginning of cotton exposes the workers to pesticide residue laden materials which cause a lowering of RBC cholinesterase, occa- sionally to a clinically significant degree. The dustiness of the processes appears to be the best guide to the degree of exposure. Resi- dents of the valley are also affected by the pesticide residues, partic- ularly during the harvesting and plowing season.

Based on the pesticide concentrations found on the various samples analyzed, the results are suggestive that the chemical with the greatest likelihood of producing the depressed cholinesterase levels, especially in the later part of the harvesting season is DEF. This does not, however, eliminate the possible contribution from other chemicals evaluated by NIOSH. This would include Azodrin, methyl parathion, Lorsban and those other pesticides found in this and other studies investigated by NIOSH in this area. It is also felt that the time between sample collection and analysis may have biased the final environmental results on all of the samples collected by NIOSH. Therefore, if less time had elapsed between sampling and analysis (less than 48 hours as suggested by the EPA study in the Parker area) higher levels and/or additional chemicals may have been found.

It was determined that those employees considered to be at highest risk are the cotton picker and rood operators and those employees involved in tromping operations.

Adequately determining important factors in these exposures, particularly exposures of non-cotton workers, will require a study in which good baselines are obtained very shortly after the individual has returned to the valley after an absence of at least two weeks. As an alternative, a working baseline could be obtained during the summer, but the two types of baseline should not be combined without determining comparability.

B. Other Concerns

1. Mechanical Harvesting Equipment

In an article from the Proceedings published by NIOSH in 1976 on Pesticide Residue Hazards to Farm Workers, one contributing author Maddy, K.T., stated that new types of mechanical harvest equipment greatly reduce the number of persons exposed to harvest time residues, but there are a few pieces of equipment that may increase the potential for exposures for the equipment operators. One of these is cotton picker operators exposed to organophosphates (as well as organocholorine and

paraquat) residues. He states that the hazards associated with these occupations need to be further evaluated in order to determine the full extent of this possible health hazard. NIOSH's findings support these concerns and illustrate that this is a real health hazard which needs further study. This should include all those occupations associated with this phase of the cotton industry.

2. Potential Control Group Exposures

During NIOSH's current study it became apparent that the workers involved in the study were showing medical problems similar to those found in NIOSH's previous studies. One concern that was not anticipated was that of the control group's cholinesterase levels dropping in a manner similar to that of the worker population. Because of this concern and NIOSH's inability to perform studies beyond occupational hazards, it was recommended that additional assistance be sought by groups who could address these concerns and thus attempt to determine if the pesticide residue laden material problem was ubiquitous in this area (e.g., EPA, State and/or Local Health agencies or Universities).

In 1982, the United States Environmental Protection Agency (EPA) in Region IX was requested to evaluate these concerns by the Tribal Council. Under a Work Assignment (No. R-09-012) the EPA contracted with a private company to perform surveys in the cotton growing areas in the Parker Valley.

Two studies were performed on soil and water samples in various locations in this area. The first evaluation was concluded in July 1983 with a report to the EPA entitled " Program Management Assistance: Soil and Water Sampling at the Colorado River Indian Reservation, Parker, Arizona - Phase One." The second investigation is still under study, however, the results and conclusions from both of these investigations further support our concerns regarding pesticide exposures in this area.

Each of the EPA°s studies evaluated four pesticides used in this area; Dimethoate, Disulfton, methyl parathion and ethyl pararthion in soil and water samples in and around surface impoundments on the reservation. The first study found each of these pesticides at the different sampling locations and in various amounts. The second study was expanded beyond those areas originally surveyed and soil and water samples were again taken. Each of the pesticides were detected in this second evaluation, however, these were only found in the soil samples and in many cases in greater amounts than in the first study (This information was conveyed to the NIOSH project officer by the EPA contractor in March 1984). One of the sampling sites evaluated by the EPA contractor was located within 50 yards of the Parker Valley Gin.

This investigation also determined that the hydrogelogy and the potential for leachate migration in this area is very conducive to pesticide migration through the soil and particularly those water soluble pesticides. The report further concluded that infiltration of the various pesticides appears to greatly exceed evaporation from free water surfaces and finally, that the potential for pesticide contaminants to move large distances over short periods of time in this type of soil (i.e., 250 to 620 feet per year) is very great.

With the above information it would appear that the results received in these studies support the conclusions made by NIOSH in its previous studies on gin workers exposed to pesticide dust laden materials in this valley. The current NIOSH investigation further supports these concerns and suggest that all the workers involved in cotton processing in this valley are being overexposed to a variety of different pesticides during cotton harvesting and ginning operations. It would further support the concern that members of cotton growing communities not involved in cotton production are also at risk to pesticide exposures.

Finally, based on the environmental and medical results found in this investigation, as well as findings from previous NIOSH studies performed in this area, organophosphates or carbamates and possibly other pesticides used in the cotton crop production may also be contributing to the ill health of workers in this cotton industry. It has further been shown from previous NIOSH Health Hazard Evaluations during the 1980-1981 cotton growing season that this appears to be related directly to the PRLM found in the harvesting and ginning operations and that these exposures are potentially year round. Due to the limited time, resources, sampling and analytical procedures, we were not able to determine the relative effects of all the different pesticides used in this area.

VIII. RECOMMENDATIONS

For the protection of the employees' health whenever possible engineering controls are the preferred method for decreasing environmental exposures to toxic substances and harmful physical conditions. In view of the findings of our environmental and medical study, as well as personal communications with individuals who work in this industry, the following recommendations are made to ameliorate potential health hazards and to provide a better work environment for the employees covered by this report.

A. General

1. Cotton field dust exposures should be reduced as much as possible for both cotton workers and non-workers.

2. Dust exposures in the cotton gin should be reduced as much as possible.

3. Both gin and field workers should be provided with respiratory protection when working under dusty conditions.

4. The problem of RBC cholinesterase depressions should be studied further in both the cotton workers and in non-cotton workers in the valley. This will need to be done by a group with a rapid response capability. It is recommended that the IHS help develop a program suitable to the unique needs of this particular situation.

B. Gins

1. Ventilation

Exhaust ventilation is the most effective means of removing the

contaminant from the work environment. The Parker Valley Gin has developed such controls and this system, when used, should help reduce the cotton dust exposures.

2. Housekeeping

Due to the numerous sources of dust in the gin environment, it is believed that a rigorous housekeeping program is essential. This should include periodic cleaning as well as a thorough cleaning at the end of each shift. A vacuum system should be the only technique used for cleaning. High pressure air nozzles should not be used due to the high dispersion of dust created by this method.

3. Personal Protection Equipment

a. Respiratory Protection

When the limits of exposure cannot be immediately met by limiting the concentrations in the work environment, via engineering and administrative controls, a program of respiratory protection should be utilized to protect those exposed persons working in the gin. This program should be an official written respiratory program.

At present there are two types of NIOSH approved respirators (disposable and non-disposable) available from different manufacturers to reduce and/or eliminate exposures to the pesticide residue laden materials which are of concern in this study.

The following is a brief description of some of the primary concerns which should be addressed in a respiratory program when using either a disposable or non-disposable respirator:

(1) There should be an established procedure and means and facilities provided to issue respiratory protective equipment, to decontaminate and disinfect the equipment (non-disposable type), and to repair or exchange damaged equipment.

(2) Employees should be given instructions/education on the proper use of respirators assigned to them, cleaning respirators, and testing for leakage.

(3) Respirators should be issued with caution. There might be individuals in the group for whom wearing a respirator (either disposable or non-disposable) carries certain specific dangers, i.e., highly increased resistance to airflow in a person with compromised pulmonary function may be associated with acute respiratory insufficiency. Employees experiencing frequent and continuous breathing difficulty while using respirators should be evaluated by a physician to determine the ability of the workers to wear a respirator.

(4) The information described above should also be given or available in Spanish when needed.

Further information on this topic is available in NIOSH Publication 76-189, "A Guide to Industrial Respiratory Protection." Finally, for those individuals who are not getting a proper respiratory face mask fit, alternative respirators should be made available. There are a number of different designs and sizes, both large and small, on the market today and these alternatives should be sought.

b. Personal Protective Clothing

Personal protective clothing should be provided to employees working in those areas where dust is presently being generated in excessive amounts. This clothing should be disposable clothing or clothes to be worn at work only. Nondisposable clothing should be laundered outside the home in order to eliminate exposures to family members.

4. Personal Hygiene

Attention to personal cleanliness and avoiding contamination of food, drinking water, and tobacco products with cotton dust should minimize absorption of noxious pesticides and/or other chemicals from the dust by either ingestion, inhalation, and/or skin absorption.

C. Field Workers

1. Recommendations for Personal Protective Equipment and Personal Hygiene are the same as for gin workers. Extra effort will be needed to allow workers adequate personal hygiene in the fields.

2. If high pressure nozzels are essential in cleaning equipment used in cotton harvesting then the use adequate personal protection (see above) should be manditory during this process. We believe that this practice was one of the major sources of dust contamination to these workers.

D. Other

In order to reduce the pesticide contaminations found in both of NIOSH°s studies it is further recommended that the Occupational Safety and Health Administrations (OSHA°s) proposed policy on basic sanitation facilities be instituted. It is also recommended that shower facilities be provided to the workers who were evaluated in these studies.

Guidelines for such sanitation concerns, shower facilities, work clothing changerooms and proper procedures for handling contaminated work clothing have been in use in the pesticide formulating industry for many years and have been shown to improve the workers health. References for these concerns can be obtained in the following NIOSH publications: (1) Pesticide Residue Hazards To Farm Workers, HEW Publication No. (NIOSH)

76-191, May, 1976 and (2) Criteria For A Recommended Standard, Occupational Exposures During the Manufacture and Formulation of Pesticides, DHEW (NIOSH) Publication No. 78-174, July, 1978.

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ADDITIONAL USEFUL REFERENCES

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NIOSH is thankful to the Colorado River Tribal Council, Tribal Health Department, and the management and employees of the CRIT Farms and Parker Valley Gin for their cooperation and assistance with this Health Hazard Evaluation. The information gathered from this study will not only assist in maintaining the health and safety of those persons working here, but also other companies who perform similar operations.

XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies of this report have been sent to:

1. CRIT Farms
2. Parker Valley Gin, HE No. 80-247.
3. Colorado River Tribal Health Department.
4. U.S. Department of Labor/OSHA - Region IX.
5. NIOSH - Region IX.
6. Arizona Department of Health.
7. State Designated Agency.
8. Phoenix Area Indian Health Service
9. PHS Indian Hospital, Parker, Arizona

For the purpose of informing the affected employees, a copy of this report shall be posted in a prominent place during the season and should accessible to the employees for a period of 30 calendar days.

TABLE 1

Pesticides Used During Cotton Growing Season 1980-81
Parker, Arizona

Pesticide	Type Pesticide	Criteria mg/M^3 OSHA	NIOSH	TLV (ACGIH)	Time Sprayed	Dose Sprayed
Insecticides						
Carbaryl (Sevin)	C	5.0	5.0	5.0	M	L
Methyl Parathion*	O.P.	--	--	0.2	M/L	L/M
Parathion*	O.P.	0.11	0.05	0.1	M/L	L/M
Malathion	O.P.	15.0	15.0	10.0	NA	NA
Methomyl-(Lannate, Nudrin)*	C	--	--	2.5	E/M/L	H
Trichlorfon (Dylox)	O.P.	--	--	--	E/M	M
Demetron (Systox)	O.P.	0.1	--	0.1	NA	NA
Dimethoate*	O.P.	--	--	--	NA	NA
Bacillus Thurigiensis	Microb.	--	--	--	M/L	H
Toxophene	C.H.	--	--	0.5	E	L
Heliothis Virus (Elcar)	Microb.	--	--	--	NA	NA
Dicofol (Kelthane)	O.P.	--	--	--	E/M/L	H
Supracide	O.P.	--	--	--	M	M/H
Phosphamidon	O.P.	--	--	--	NA	NA
Lorsban*	O.P.	--	--	--	M/L	M
Orthene	O.P.	--	--	--	M/L	L
Ambush	S.P.	--	--	--	M/L	H
Karmex (Diuron)	O.P.	--	--	--	E	L/M
Pounce	S.P.	--	--	--	M/L	H
Pydrin*	S.P.	--	--	--	M/L	H
Bolstar	O.P.	--	--	--	M/L	L/M
Chlordimeform-(Galecron-Fundal)	Form.	--	--	--	M/L	H
Azodrin*	O.P.	--	--	0.25	E/M/L	H
Aldricarb (Temik)*	C	--	--	--	E	M
Bidrin	O.P.	--	--	0.25	M/L	L
Azinphosmethyl-(Guthion)	O.P.	0.2	--	0.2	M	M
Disulfaton	O.P.	--	--	0.1	M/L	M
Herbicides (continued next page)						

TABLE 1 (continued)

Pesticides Used During Cotton Growing Season 1980-81
Parker, Arizona

Pesticide	Type Pesticide	Criteria mg/M^3 OSHA	NIOSH	TLV (ACGIH)	Time Sprayed	Dose Sprayed
Herbicides						
Protluralin-(Tolban)	Amiole	--	--	--	E/L	Pre Plant
Fluchloralin-(Baseline)	Nitroamiline	--	--	--	NA	NA
Trifluralin-(Treflan)	Nitroamiline	--	--	--	Pre Plant	H
Pendinethalis-(Prowl)	O.P.	--	--	--	Pre Plant/M	H
Diuron	Subst. Urea	--	--	--	Lay By	L
Prometryn (Caparol)	Triazine	--	--	--	Pre Plant/Lay By	H
Bensulide (Prefer)	O.P.	--	--	--	NA	NA
DCPA (Dacthal)	O.P.	--	--	--	NA	NA
Glyphosate-(Roundup)	O.P.	--	--	--	E/M/L	H
DSMA	Inorg. Arsine.	--	--	--	E/M	L
MSMA	Inorg. Arsine.	--	--	--	E/M	L
Pronamide (Kerb)	Amide	--	--	--	NA	NA
Cotoran	O.P.	--	--	--	Lay By	H
Defoliants						
Sodium Chlorate	Inorg.	--	--	--	L	H
Paraquat	Dipyridylium	0.5	--	0.5	L	M
Folex*	O.P.	--	--	--	L	H
DEF*	O.P	--	--	--	L	H

* NOTE: Chemicals found during recent studies

TLV (ACGIH) = Threshold Limit Values established by the American Conference of Governmental Industrial Hygienists.

LEGEND NO. 1

C = Carbamate
O.P. = Organophosphate
C.H. = Organochlorine
Microb. = Microbial
Inorg. = Inorganic

LEGEND NO. 2

Time Sprayed: E = Early season (May-July); M = Midseason (July-August); L = Late Season (August-October).
Dose Sprayed: L = Light spraying; M = Moderate spraying; H = Heavy spraying.
NOTE: Time and Dose sprayed are normal periods and concentrations.
NA = Non-applicable, i.e., was not used during 1980-81 cotton growing season.

TABLE II

HAZARD CHARACTERISTICS OF PESTICIDES USED IN
PARKER, ARIZONA

PESTICIDE	TOXIC DOSE**(mg/kg) ORAL	INHALATION	SKIN	EPA REENTRY	EPA FOOD	RESEARCH NIOSH	RESEARCH NCI	RESEARCH EPA	TOXICITY CATEGORY/GROUP EPA	TOXICITY CATEGORY/GROUP WHO
Insecticides										
Methyl Parathion*	9	120	67	48	No	-	SC	-	1	2
Methomyl-(Lannate, Nudrin)*	17	77	-	D-D	No	-	-	-	1	2
Trichlorfon (Dylox)*	400	-	-	D-D	No	C	-	-	3	3
Dicofol (Kelthane)*	100	-	1150	D-D	No	-	C	ONCO	3	3
Lorsban*	145	-	202	D-D	No	-	-	ONCO	2	3
Azodrin*	21	162	112	48	No	-	-	-	1	2
Pydrin*	^50	-	-	D-D	No	-	-	-	2	3
Aldricarb (Temik)*	1	-	25	24	No	-	C	ONCO	1	1
Herbicides										
Pendinethalis-(Prowl)	1250	-	-	D-D	No	-	-	-	2	4
Bensulide (Prefar)	770	-	3950	D-D	No	-	-	-	2	4
DCPA (Dacthal)	300	-	-	D-D	No	-	-	-	3	4
Glyphosate-(Roundup)	4320	-	-	D-D	No	-	-	-	3	4
Cotoran	89	-	-	D-D	No	-	C	-	1	3
Defoliants										
Folex*	910	-	615	D-D	No	-	-	-	2	3
DEF*	150	-	160	D-D	No	-	-	-	2	3

* = Chemicals found during recent studies.
** = References: (1) Agricultural Chemicals And Pesticides, DHEW (NIOSH) Publication No. 77-180, July, 1970 and (2) Registry of Toxic Effects of Chemical Substances (RTEC), 1981-1982, Vol 1-3, DHHS (NIOSH) Publication No. 83-107.

LEGEND NO. 1

D-D = Dry-Drift
SC = suspected carcinogen
C = carcinogen
ONCO = oncological

LEGEND NO. 2 - Toxicity Category/Group

EPA	WHO
1 = most hazardous	1 = most hazardous
2 = moderately hazardous	2 = moderately hazardous
3 = least hazardous	3 = least hazardous
	4 = not hazardous

TABLE III

Characterization of Population Studied by Group, Age, Sex, and Number of Red Blood Cell Cholinesterase Samples

Colorado River Indian Reservation
Parker, AZ

1981 - 1982 Season

	Number			Age		Number per Drawing			Multiple Drawing Combinations			
	Total	Male	Female	Mean	Range	First	Second	Third	All 3	1 & 2 only	1 & 3 only	2 & 3 only
Head Start School	17	4	13	32.4	21-49	17	15	14	14	1	0	0
Le Pera School	16	3	13	35.4	19-55	16	16	14	14	2	0	0
PHS Hospital	12	6	6	34.9	26-52	12	12	11	11	1	0	0
Subtotal	45	13	32	34.2	19-55	45	43	39	39	4	0	0
Police & Wildlife	8	8	0	35.1	24-55	8	5	6	4	1	2	0
Total Controls	53	21	32	34.3	19-55	53	48	45	43	5	2	0
Picker Operators	8 *	8	0	31.4	20-42	8	6	6	6	0	0	0
Trompers	9 *	9	0	27.2	16-61	8	3	2	1	1	0	1
Rood Operators	(2 *	2	0)	29.0	27-31	0	1	1 +	0 +	1	1	0
Total Field Workers	17 #	17	0	29.2	16-61	16	10	9 +	7 +	2	1	1
Inside Gin Workers	9	9	0	29.0	21-48	8	4	6	3	0	2	1
Outside Gin Workers	7	7	0	34.9	20-50	7	0	3	0	0	3	0
Total Gin Workers	16 @	16	0	31.6	20-50	15	4	9	3	0	5	1
Total Cotton Workers	33	33	0	30.3	16-61	31	14	18	10	2	6	2
Grand Total	86	54	32	32.8	16-61	84	62	63	53	7	8	2

* One picker and one tromper were operating Rood pickers when seen a second time.

\+ One individual's results from third drawing not included because of medical intervention.

\# Individuals included only once. Manager and Utility Worker seen but not included in these figures.

@ Supervisor seen but not included in figures.

TABLE IV

Pesticide Composite - Bulk Samples
Crit Farms and Parker Valley Gin
Parker Arizona

March, 1984

Description/Location	DEF	ppm/sample Lorsban	Pydrin	Nudrin
Cotton Field				
Picking Machine	30.2	11.8	ND	ND
Picking Machine	12.6	10.5	9.7	4.0
Picking Machine	5.5	0.8	1.1	ND
Rood Machine	65.4	27.6	10.2	ND
Rood Machine	49.2	13.4	14.2	4.9
Rood Machine	07.3	01.8	14.6	6.4
Cotton Gin				
Trash	14.0	8.5	7.8	ND
Rafter (new area)	22.6	1.5	9.5	4.6
Brack	12.6	10.4	6.1	ND
Rafter (old area)	19.5	1.5	6.7	ND

ppm/sample = parts per million of sample

TABLE V

Personal Wipe Samples
Crit Farms and Parker Valley Gin
Parker, Arizona

March, 1984

Job/Task Description	ug/sample DEF	Lorsban	Pydrin
First Sampling (Nov.)			
Picker Operator	6.4	ND	1.0
Picker Operator	3.9	ND	0.6
Picker Operator	1.6	ND	0.5
Tromper	3.8	ND	0.5
Tromper	4.0	ND	0.5
Bale Press	0.44	ND	0.17
Gin Stand	0.86	ND	0.15
Yardman	1.2	ND	0.15
Last Sampling (Feb.)			
Picker Operator	260	ND	ND
Picker Operator	1000	ND	ND
Rood Operator	100	31	ND
Rood Operator	63,900**	55	ND
Rood Operator	882	37	ND
Tromper	2.7	15	ND
Tromper	1.3	21	ND

ug/sample = micrograms per sample
** = confirmed by mass spectroscopy

TABLE VI

Breathing Zone Concentrations for DEF
Crit Farms
Parker, Arizona

March, 1984

Job/Task Description	Sampling Time (minutes)	mg/m3 DEF (Range)
Picker Operator	300 - 360	0.03 - 0.06
Picker Operator	300 - 360	0.03 - 0.05
Picker Operator	300 - 375	0.03 - 0.04
Road Operator	300 - 320	0.24 - 0.55
Road Operator	300 - 320	0.27 - 0.47
Tromper Operator	300 - 350	0.02 - 0.08
Tromper Operator	300 - 350	0.07 - 0.18
EVALUATION CRITERIA		NONE

mg/m^3 = Milligrams of substance per cubic meter of air

TABLE VII

Breathing Zone Concentrations for DEF
Parker Valley Gin
Parker, Arizona

March, 1984

Job/Task Description	Sampling Time (minutes)	mg/m3 DEF (Range)
Bale Press	300 - 360	0.03 - 0.04
Gin Stand	300 - 360	0.04 - 0.18
Yardman	300 - 360	0.03 - 0.07
EVALUATION CRITERIA		NONE

mg/m^3 = Milligrams of substance per cubic meter of air

TABLE VIII A
Mean Red Blood Cell Cholinesterase Levels by Control Groups

Colorado River Indian Reservation
Parker, AZ

1981 - 1982 Season

	September				October-November				February			
	Number	Mean	Std.Dev.	Range	Number	Mean	Std.Dev.	Range	Number	Mean	Std.Dev.	Range
		pH Units				pH Units				pH Units		
Head Start School	17	0.726	0.047	0.65-0.80	15	0.773	0.070	0.65-0.90	14	0.682	0.072	0.50-0.80
Le Pera School	16	0.725	0.080	0.65-0.90	16	0.709	0.090	0.60-0.90	14	0.629	0.089	0.45-0.75
PHS Hospital	12	0.800	0.128	0.65-1.10	12	0.767	0.107	0.60-0.90	11	0.650	0.100	0.45-0.75
Subtotal	45	0.746	0.090	0.65-1.10	43	0.748	0.092	0.60-0.90	39	0.654	0.088	0.45-0.75
Police & Wildlife	8	0.800	0.200	0.60-1.20	5	0.660	0.074	0.55-0.75	6	0.658	0.097	0.55-0.80
Total Controls	53	0.754	0.113	0.60-1.20	48	0.739	0.094	0.55-0.90	45	0.654	0.088	0.45-0.80

Analysis of Variance: $F_{(3,49)} = 1.899$ Not Significant; $F_{(3,44)} = 3.119$ $p = 0.042$; $F_{(3,41)} = 0.876$ Not significant

Other Statistically Significant Differences

September vs. October-November vs. February by Groups:

Le Pera School	$F_{(2,43)} = 5.197$	$p = 0.0097$
PHS Hospital	$F_{(2,32)} = 5.553$	$p = 0.0089$

L Values: October-November Specimens

	Difference in Means	95% Confidence Limits
Head Start School & PHS Hospital vs. Le Pera School, & Police & Wildlife	0.085	±0.082

TABLE VIII B
Mean Red Blood Cell Cholinesterase Levels by Worker Groups

Colorado River Indian Reservation
Parker, AZ

1981 - 1982 Season

	November				December				January			
	Number	Mean	Std.Dev.	Range	Number	Mean	Std.Dev.	Range	Number	Mean	Std.Dev.	Range
		pH Units				pH Units				pH Units		
Picker Operators	8	0.863	0.119	0.70-1.10	6	0.725	0.094	0.65-0.90	6	0.667	0.041	0.60-0.70
Trompers	8	0.800	0.107	0.60-0.90	3	0.583	0.076	0.50-0.65	2	0.575	0.035	0.55-0.60
Rood Operators	0	---	---	---	1	0.55	---	---	1	0.65	---	---
Total Field Workers	16	0.831	0.114	0.60-1.10	10	0.665	0.111	0.50-0.90	9	0.644	0.053	0.55-0.70
Inside Gin Workers	8	0.700	0.053	0.60-0.80	4	0.650	0.041	0.60-0.70	6	0.617	0.129	0.50-0.75
Outside Gin Workers	7	0.843	0.079	0.70-0.90	0	---	---	---	3	0.600	0.050	0.55-0.65
Total Gin Workers	15	0.767	0.098	0.60-0.90	4	0.650	0.041	0.60-0.70	9	0.611	0.105	0.50-0.75
Total Cotton Workers	31	0.800	0.110	0.60-1.10	14	0.661	0.094	0.50-0.90	18	0.628	0.083	0.50-0.75

Analysis of Variance: $F(3,27) = 4.735$, $p = 0.0091$ | $F(3,11) = 2.835$* Not Significant | $F(3,13) = 0.788$* Not significant

* Rood Operator not included

1980 - 1981 Season

	Early Season				Mid-Season				Late Season			
Inside Gin Workers	9	0.639	0.049	0.60-0.70	0	---	---	---	15	0.500	0.057	0.40-0.55
Outside Gin Workers	6	0.617	0.075	0.50-0.70	0	---	---	---	6	0.575	0.042	0.50-0.60
Total Gin Workers	15	0.630	0.059	0.50-0.70	0	---	---	---	21	0.521	0.062	0.40-0.60

TABLE VIII B (cont.)

Mean Red Blood Cell Cholinesterase Levels by Worker Groups
Statistically Significant Differences

1981 - 1982 Season

L Values:	November Specimens	Difference in Means	95% Confidence Limits
	Inside Gin Workers	-0.135	±0.114
vs.	Pickers, Trompers, & Outside Gin Workers		

Analysis of Variance: November vs. December vs. January by Groups:

Pickers	$F_{(2,17)} = 8.066$	p = 0.0041
Trompers	$F_{(2,10)} = 8.032$	p = 0.0087
Outside Gin	$F_{(1,8)} = 23.371$	p = 0.0018

t Tests:	d.f.	t Value	Probability
1980 - 1981 Season			
Inside Gin Workers vs. Outside Gin Workers			
Early Season	13	0.692	Not Significant
Late Season	19	2.904	p = 0.0096
Early Season vs. Late Season			
Inside Gin Workers	15	6.079	p = less than 0.001
Outside Gin Workers	11	1.197	Not Significant
1980 - 1981 Season vs. 1981-1982 Season			
Early Season			
Inside Gin Workers	15	2.466	p = 0.030
Outside Gin Workers	11	5.261	p = less than 0.001
Total Gin Workers	28	4.639	p = less than 0.001
Late Season			
Inside Gin Workers	19	2.943	p = 0.0093
Outside Gin Workers	7	0.796	Not Significant
Total Gin Workers	28	2.942	p = 0.0082

TABLE IX A

Mean % Change in Red Blood Cell Cholinesterase by Control Group

Colorado River Indian Reservation
Parker, AZ

1981 - 1982 Season

	October-November/September				February/October-November				February/September			
	Number	Mean %	Std.Dev.	Range	Number	Mean %	Std.Dev.	Range	Number	Mean %	Std.Dev.	Range
Head Start School	15	+7.0	7.9	-.1to+15.4	14	-12.2	8.1	-27.8to 0	14	-5.7	10.8	-28.6to +7.7
Le Pera School	16	-1.3	14.8	-27.8to+28.6	14	-11.8	12.9	-27.8to+15.4	14	-11.7	15.5	-38.9to +7.7
PHS Hospital	12	-3.0	14.3	-25.0to+28.6	11	-12.9	18.3	-38.9to+25.0	11	-17.2	10.9	-36.4to -6.3
Subtotal	43	+1.1	13.1	-27.8to+28.6	39	-12.3	12.9	-38.9to+25.0	39	-11.1	13.2	-38.9to +7.7
Police & Wildlife	5	-10.6	19.3	-35.0to+16.7	4	+7.0	21.4	-15.4to+27.3	6	-16.0	17.8	-41.7to +8.3
Total Controls	48	-0.1	14.1	-35.0to+28.6	43	-10.5	14.7	-38.9to+27.3	45	-11.7	11.2	-41.7to +8.3

Statistically Significant Differences

t Tests: October-November/September vs. February/October-November	d.f.	t Value	Probability
Head Start School	27	6.459	p = less than 0.001
Le Pera School	28	2.063	p = 0.049

TABLE IX B
Mean % Change in Red Blood Cell Cholinesterase by Cotton Worker Group

Colorado River Indian Reservation
Parker, AZ

1981 - 1982 Season

	December/November				January/December				January/November			
	Number	Mean %	Std.Dev.	Range	Number	Mean %	Std.Dev.	Range	Number	Mean %	Std.Dev.	Range
Picker Operators	6	-15.9	5.3	-22.2to -7.1	6	-7.1	10.4	-22.2to +7.7	6	-21.6	13.1	-36.4to 0
Trompers	2	-15.5	1.7	-16.7to-14.3	2	+1.2	12.5	-7.7to+10.0	1	-8.3	---	----
Rood Operators	1	-31.3	---	----	0	---	---	----	1	-18.8	---	----
Total Field Workers	9	-17.5	6.7	-31.3to -7.1	8	-5.0	10.7	-22.2to+10.0	8	-19.6	12.0	-36.4to 0
Inside Gin Workers	3	-10.7	12.9	-25.0to 0	4	-17.2	7.2	-23.1to -8.3	5	-10.5	20.6	-31.3to+14.3
Outside Gin Workers	0	---	---	----	0	---	---	----	3	-27.5	6.0	-33.3to-21.4
Total Gin Workers	3	-10.7	12.9	-25.0to 0	4	-17.2	7.2	-23.1to -8.3	8	-16.9	18.2	-33.3to+14.3
Total Cotton Workers	12	-15.8	8.5	-31.3to 0	12	-9.1	11.1	-23.1to+10.0	16	-18.2	14.9	-36.4to+14.3

	1980 - 1981 Season	Late Season/Early Season		
Inside Gin Workers	6	-24.6	7.2	-33.3to-15.4

Statistically Significant Differences
1981 - 1982 Season

t Tests:	d.f.	t Value	Probability
December/November vs. January/December			
Field Workers	15	2.925	p = 0.011
1980 - 1981 Season vs. 1981 - 1982 Season			
Inside Gin Workers	9	1.579	Not Significant

TABLE X
Mean Red Blood Cell Cholinesterase Levels & % Change by Control and Cotton Worker Groups

Colorado River Indian Reservation
Parker, AZ

1981 - 1982 Season

	October-November				January-February				January-February/October-November			
	Number	Mean	Std.Dev.	Range	Number	Mean	Std.Dev.	Range	Number	Mean	Std.Dev.	Range
	pH Units				pH Units				%			
Head Start School	15	0.773	0.070	0.65-0.90	14	0.682	0.072	0.50-0.80	14	-12.2	8.1	-27.8to 0
Le Pera School	16	0.709	0.090	0.60-0.90	14	0.629	0.089	0.45-0.75	14	-11.8	12.9	-27.8to+15.4
PHS Hospital	12	0.767	0.107	0.60-0.90	11	0.650	0.100	0.45-0.75	11	-12.9	18.3	-38.9to+25.0
Subtotal	43	0.748	0.092	0.60-0.90	39	0.654	0.088	0.45-0.75	39	-12.3	12.9	-38.9to+25.0
Police & Wildlife	5	0.660	0.074	0.55-0.75	6	0.658	0.097	0.55-0.80	4	+7.0	21.4	-15.4to+27.3
Total Controls	48	0.739	0.094	0.55-0.90	45	0.654	0.088	0.45-0.80	43	-10.5	14.7	-38.9to+27.3
Picker Operators	8	0.863	0.119	0.70-1.10	6	0.667	0.041	0.60-0.70	6	-21.6	13.1	-36.4to 0
Trompers	8	0.800	0.107	0.60-0.90	2	0.575	0.035	0.55-0.60	1	-8.3	---	----
Rood Operators	0	---	---	---	1	0.65	---	---	1	-18.8	---	----
Total Field Workers	16	0.831	0.114	0.60-1.10	9	0.644	0.053	0.55-0.70	8	-19.6	12.0	-36.4to 0
Inside Gin Workers	8	0.700	0.053.	0.60-0.80	6	0.617	0.129	0.50-0.75	5	-10.5	20.6	-31.3to+14.3
Outside Gin Workers	7	0.843	0.079	0.70-0.90	3	0.600	0.050	0.55-0.65	3	-27.5	6.0	-33.3to-21.4
Total Gin Workers	15	0.767	0.098	0.60-0.90	9	0.611	0.105	0.50-0.75	8	-16.9	18.2	-33.3to+14.3
Total Cotton Workers	31	0.800	0.110	0.60-1.10	18	0.628	0.083	0.50-0.75	16	-18.2	14.9	-36.4to+14.3
Grand Total	79	0.763	0.104	0.55-1.10	63	0.647	0.087	0.45-0.80	59	-12.6	15.0	-38.9to+27.3

Analysis of Variance:

$F_{(7,71)} = 4.716$
p = less than 0.001

$F_{(7,54)} = 0.879$*
Not significant
* Rood Operator not included

$F_{(6,52)} = 2.161$
Not Significant

TABLE X (cont.)

Mean Red Blood Cell Cholinesterase Levels & % Change
by Control and Cotton Worker Groups
Statistically Significant Differences

1981 - 1982 Season

L Values: October-November Specimens	Difference in Means	95% Confidence Limits
Head Start School, Le Pera School, PHS Hospital, Police & Wildlife, & Inside Gin Workers vs. Pickers, Trompers, & Outside Gin Workers	-0.114	±0.089
Head Start School, Le Pera School, PHS Hospital, & Police & Wildlife vs. Pickers, Trompers, & Outside Gin Workers	-0.108	±0.092

TABLE XI A.
Numbers of Control Subjects with Excessive Drops in Red Blood Cell Cholinesterase Level by Group

Colorado River Indian Reservation
Parker, AZ

1981 - 1982 Season

	October-November/September				February/October-November				February/September			
	Total Number	Over 15% Drop	%	Over 30% Drop	Total Number	Over 15% Drop	%	Over 30% Drop	Total Number	Over 15% Drop	%	Over 30% Drop
Head Start School	15	0	0	0	14	3	21	0	14	2	14	0
Le Pera School	16	2	12	0	14	6	43	0	14	5	36	2
PHS Hospital	12	2	17	0	11	6	55	2	11	5	45	2
Subtotal	43	4	9	0	39	15	38	2	39	12	31	4
Police & Wildlife	5	2	40	1	4	0	0	0	6	4	67	1
Total Controls	48	6	13	1	43	15	35	2	45	16	36	5

Statistically Significant Differences

October-November/September	February/October-November	February/September
Not Significant	Not Significant	Head Start School vs. Le Pera School, PHS Hospital & Police and Wildlife Fisher's Exact p = 0.044

October-November/September vs. February/October-November (1 d.f.):

Le Pera School & PHS Hospital	$X^2 = 5.613$	p = 0.039
Controls without Police & Wildlife	$X^2 = 8.199$	p = less than 0.01
Controls with Police & Wildlife	$X^2 = 5.203$	p = 0.023

TABLE XI B

Numbers of Cotton Workers with Excessive Drops in Red Blood Cell Cholinesterase Level by Group

Colorado River Indian Reservation
Parker, AZ

1981 - 1982 Season

	December/November				January/December				January/November			
	Total Number	Over 15% Drop	%	Over 30% Drop	Total Number	Over 15% Drop	%	Over 30% Drop	Total Number	Over 15% Drop	%	Over 30% Drop
Picker Operators	6	4	67	0	6	1	17	0	6	4	67	1
Trompers & Rood Operators	3	2	67	1	2	0	0	0	2	1	50	0
Total Field Workers	9	6	67	1	8	1	12	0	8	5	63	1
Inside Gin Workers	3	1	33	0	4	2	50	0	5	2	40	1
Outside Gin Workers	0	--	--	--	0	--	--	--	3	3	100	1
Total Gin Workers	3	1	33	0	4	2	50	0	8	5	63	2
Total Cotton Workers	12	7	58	1	12	3	25	0	16	10	63	3

Statistically Significant Differences

December/November vs. January/December (1 d.f.): Field Workers Fisher's Exact p = 0.036

TABLE XI C

Numbers of Control Subjects and Cotton Workers with Excessive Drops in Red Blood Cell Cholinesterase Level by Group

Colorado River Indian Reservation
Parker, AZ

1981 - 1982 Season

January-February/October-November

	Total Number	Over 15% Drop	%	Over 30% Drop
Head Start School	14	3	21	0
Le Pera School	14	6	43	0
PHS Hospital	11	6	55	2
Subtotal	39	15	38	2
Police & Wildlife	4	0	0	0
Total Controls	43	15	35	2
Picker Operators	6	4	67	1
Trompers	1	0	0	0
Rood Operators	1	1	100	0
Total Field Workers	8	5	63	1
Inside Gin Workers	*5*	*2*	*40*	*1*
Outside Gin Workers	3	3	100	1
Total Gin Workers	8	5	63	2
Total Cotton Workers	16	10	63	3
Grand Total	59	25	42	5

Statistically Significant Differences

Head Start School and Police & Wildlife
vs. Le Pera School and Inside Gin Workers
vs. PHS Hospital, Field Workers and Outside Gin Workers
$X^2 = 8.945$ (d.f.=2)
$p = 0.012$

Head Start School and Police & Wildlife
vs. Le Pera School, PHS Hospital and Cotton Workers
$X^2 = 5.577$ (d.f.=1)
$p = 0.020$

TABLE XII

% Change in Red Blood Cell Cholinesterase Level
by Initial Cholinesterase Level

Colorado River Indian Reservation
Parker, AZ

1981 - 1982 Season

Initial Cholinesterase pH Units	Controls Number	Controls Mean %	Controls S.D.	Cotton Workers Number	Cotton Workers Mean %	Cotton Workers S.D.	Total Number	Total Mean %	Total S.D.
under 0.75	27	-12.0	±18.5	10	-12.1	±16.6	37	-12.0	±17.8
0.75 - 0.84	12	-11.6	± 6.2	4	-29.0	±13.4	16	-16.0	±11.2
0.85 +	6	-44.8	±23.0	5	-44.5	± 8.7	11	-44.7	±17.1
Totals	45	-16.3	±20.0	19	-24.2	±19.7	64	-18.6	±20.1

Analysis of Variance:

$F_{(5,58)} = 7.665$ p less than 0.001

L Values:

		Difference in Means	95% Confidence Limits
Controls under 0.75 & 0.75 - 0.84, and Cotton Workers under 0.75 vs. Rest		+27.6	±17.0
Controls and Cotton Workers 0.85+ vs. Rest		-28.5	±19.5

Colorado River Indian Reservation
Parker, AZ

1981 - 1982 Season

TABLE XIII
Initial Red Cell Cholinesterase Level
by Months in Area

Group	Less than 3 Months			3 Months or More			Total		
	Number	Mean pH Units	S.D.	Number	Mean pH Units	S.D.	Number	Mean pH Units	S.D.
Head Start & Le Pera Schools	8	0.738	±0.044	25	0.722	±0.069	33	0.726	±0.064
PHS Hospital & Police-Wildlife	2	0.725	±0.106	18	0.808	±0.160	20	0.800	±0.156
Cotton Workers	21	0.793	±0.119	13	0.777	±0.107	34	0.787	±0.113
Total	31	0.774	±0.105	56	0.763	±0.118	87	0.767	±0.113

Analysis of Variance:

$F_{(5,58)} = 1.736$ $p = 0.15$

TABLE XIV
% Change in Red Cell Cholinesterase Level
by Months in Area at Time of Initial Cholinesterase

Group	Less than 3 Months			3 Months or More			Total		
	Number	Mean %	S.D.	Number	Mean %	S.D.	Number	Mean %	S.D.
Head Start & Le Pera Schools	6	-19.9	±20.2	22	-9.9	±18.1	28	-12.1	±18.6
PHS Hospital & Police-Wildlife	2	-25.6	±26.7	15	-22.9	±20.9	17	-23.2	±20.8
Cotton Workers	9	-29.9	±24.3	10	-19.0	±13.7	19	-24.2	±19.7
Total	17	-25.9	±22.1	47	-16.0	±18.9	64	-18.6	±20.1

Analysis of Variance:

$F_{(5,81)} = 1.671$ $p = 0.17$

TABLE XV

Months in Area at Time of Initial Cholinesterase
by Group

Colorado River Indian Reservation
Parker, AZ

1981 - 1982 Season

Group	1 Month or Less		Over 1 Month but Under 3 Months		3 Months or More		Total
	Observed	Expected	Observed	Expected	Observed	Expected	
Head Start School	2	4.3	3	1.8	12	10.9	17
Le Pera School	1	4.0	2	1.7	13	10.3	16
PHS Hospital	1	3.0	1	1.2	10	7.7	12
Police & Wildlife	0	2.0	0	0.8	8	5.1	8
Total Controls	4	13.4	6	5.5	43	34.1	53
Cotton Field Workers	6	4.6	1	1.9	11	11.6	18
Inside Gin Workers	6	2.3	2	0.9	1	5.8	9
Outside Gin Workers	6	1.8	0	0.7	1	4.5	7
Total Gin Workers	12	4.0	2	1.7	2	10.3	16
Total	22		9		56		87

Statistical Significance:

	Degrees of Freedom		
Controls vs. Cotton Field Workers vs. Gin Workers	4	$X^2 = 32.244$	p = less than 0.0005