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A STUDY OF THE HEALTH WORKERS INVOLVED IN THE PRODUCTION OF
PENTACHLOROPHENOL AND OTHER CHLORINATED PHENOLS

Department of Environmental Health
University of Cincinnati

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Submitted by:

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A STUDY OF THE HEALTH WORKERS INVOLVED IN THE PRODUCTION OF
PENTACHLOROPHENOL AND OTHER CHLORINATED PHENOLS

Raymond R. Suskind, M.D.

1. INTRODUCTION

During the week of October 1 - 5, 1979, a medical survey of 115 employees of the Monsanto Chemical Intermediates Co., in Sauget, Illinois was conducted by the Department of Environmental Health University of Cincinnati. The objective was to determine the health status of employees of the W.G. Krummrich plant, who had been exposed to chlorinated phenols and to identify those conditions which might be related to the work environment.

Pentachlorophenol is a common substance which has been used for many years as a preservative of wood products, a preharvest defoliant, a pesticide for termite control and a general herbicide. Acute exposure at high concentrations may cause irritation of eyes and respiratory tract. There have been reports of accidental systemic intoxication which have been fatal. In work situations, prolonged exposure may result in acneform dermatitis which may become complicated by skin infections. Ortho and parachlorinated phenols have been employed as disinfectants and bacteriostatic agents in a number of household and industrial uses. These uses have sometimes been associated with skin irritation and sporadic allergic sensitization.

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2. THE SCOPE AND CONDUCT OF THE SURVEY

The medical survey included the completion of an administered questionnaire by the employee-participant, a medical history, a thorough dermatologic examination, as well as the examination of other organ systems, if indicated by the clinical history. Skin biopsies were done as well as cultures for bacteria and fungi when indicated. Clinical laboratory tests included: blood, CA, P, BUN, Creatinine, BUN-creatinine ratio, uric acid, glucose (fasting blood sugar), total protein, albumin, globulin, total bilirubin, direct bilirubin, transaminase SGO and SGP, alkaline phosphatase, LDH, cholesterol, iron, magnesium, sodium, potassium, chloride, G-glutamyl-transpeptidase, triglycerides and lipoprotein profiles; CBC and differential, urinalysis and urinary coproporphyrin, uroporphyrins, and creatinine. Since the values for urinary coproporphyrin, uroporphyrins and creatinine were determined from a single void sample rather than the required 10 ml. aliquot of 24 hr. volume it was not possible to interpret significance of levels outside the normal range.

A thorough review of records provided by Monsanto for relevant information was carried out. These records included dispensary notes, physical examination records by plant physicians, medical insurance claims, workmen's compensation records, and personnel records of work assignments. These records were particularly useful in confirming historic information given by the participants, i.e., personal medical histories obtained in this survey were compared with physician notations which indicated previous physician recognition and medical care for specific problems, e.g., acne vulgaris, chloracne, hypertension, diabetes, etc. These records also provided additional information

not obtained through the questionnaire or during the physical examination.

The population examined included persons who had worked in Building 236 in which pentachlorophenol was produced until April 1978 and/or in Building 237 where o and p chlorophenol was made. The total number of active employees who worked in these two areas was 157. Of these, 115 persons volunteered for this examination; 115 were interviewed and 106 completed the physical examination. The interviews were conducted by two experienced occupational health interviewers with nursing training and experience.

3. CHARACTERISTICS OF THE WORK AND WORK AREAS

At the time of the survey employee-participants were working in as many as thirty-six departments. They included machinists, insulators, pipefitters, welders, mechanics, painters, truck drivers, coal passers, service department personnel, warehouse personnel, operators, unit controllers, carpenters, safety personnel, instrument mechanics, electricians, engineers, foremen, and production and maintenance supervisors.

Their commonality was having worked in either Department 236 and/or 237. O and p chlorophenol were and are still produced in Department 237.

Employees describe their work assignments in Department 236 as follows:

Bagging, packing, drum or drumming, prill or working the prill tower, working on the chlorinator, dryers, flaker, pouring molds or burning molds, working on the filter, working on the dissolver, making briquettes or working with the briquette machine and mixing or blending raw materials.

According to Mr. P.E. Heisler the Plant Safety Director:

Two products were made in the pentachlorophenol department: 134

- 1) Pentachlorophenol or "Penta" and,
- 2) Sodium Pentachlorophenate or "Santobrite"

Pentachlorophenol (Penta)

Pentachlorophenol was produced by "chlorinating phenol" on the by-product mono, di or trichlorophenols. The reaction vessel was called a chlorinator. As first produced the pentachlorophenol existed as a molten liquid and had to be cooled and solidified in order to be sold. There were three ways to produce the solid product in a form which could be used by the purchaser:

- a) The material was "flaked", by feeding molten material into a container from which it was picked up on the surface of a cold rotating drum. The drum rotated against a stationery blade which separated the thin film of material from the surface. This immediately broke up into small flakes which were conveyed mechanically to a packing area. For sale the product was "bagged" or "drummed", that is, packed in rigid cylindrical "fiber" drums or into steel drums.
- b) The flaked material was superceded by "prilled" material. In this process the molten material was sprayed into a stream of cool air where it solidified into spherical beads or "prills". The equipment used was called the prill tower. The waste air was "scrubbed" to remove "penta" before discharge to atmosphere. The prills

were cooled further in a "rotolouvre" cooler and conveyed mechanically to a hopper for packing into bags, fiber-packs or steel drums as was the flaked material. The prilled material flowed more freely and was easier to pack than the flaked material but also escaped from the conveying and packing equipment rather easily. This spilled material required regular clean-up from around the equipment. As may be expected, the prilling operation required careful control and even with the best operation the tower and air ducts became coated with material. Frequent cleaning was required and this was indeed a dusty and dirty job. Various coating techniques were used to make prills which were "dust free".

- c) Some customers had facilities in which they could dissolve a large solid block of pentachlorophenol. Accordingly the molten material was poured into large tapered molds and allowed to set. The material was then removed from the molds and packed in containers for shipment as a solid block. Removing the material required that the mold be heated to release it from the block. Because of the high melting point of the material it was necessary to use a welding torch to heat the mold -- hence the term "burning" the molds. As the mold was released a small amount of "penta" vaporized from the

surfaces which had been heated.

Sodium Pentachlorophenate (Santobrite)

This material was made by dissolving pentachlorophenol in sodium hydroxide solution to form a solution of sodium pentachlorophenate in water. The solution was made in the "dissolver" and transferred to a "settler" to remove settleable impurities. It is possible that a filter was once used for this purpose but there is no record of this.

The solution was then sprayed into a "paddle mixer" which could have been referred to as a "blender". This formed a granular product which was then dried in a rotary drier and separated into "fines" and "pellets". The fines were fed to a "briquette" machine which compressed the material into tablets. As with the pentachlorophenol, the dry product in its various forms was transferred to hoppers, etc. by various mechanical conveyors and elevators and was packed into a variety of packages according to customer needs. Clean-up of the material lost from conveyors, driers, mills, screens, etc. as well as clean-up of the equipment, was a requirement of the job. Emptying and cleaning of reaction vessels is a common source of exposure.

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4. RESULTS

The results of the survey and examinations are summarized in a series of tables (Tables 1 to 23).

All participants were informed that the results of the individual examinations would be made known to them through their personal physicians. Eighty-five requested reports and these were sent out to physicians.

Significant Clinical Observations

As indicated in Table 2 there was a fairly even distribution of workers in the age groups 21-30, 31-40, 41-50, 51-60. Sixty-six of 115 workers had a history of chloracne (Table 3). Forty-three were found to have residual chloracne and of these cases 67.6% was mild and 32.5% moderate. All of the residual cases were comedonal in type and 32.5% of those had cystic lesions as well (Table 3). Chloracne is most frequently characterized by comedones, cysts, pustules and papules, occurring on the cheeks, periorbital, temporal areas and forehead. Lesions are sometimes limited to the malar areas and hirsutism may first be observed on the malar sites as well. In some types of phenoxy herbicide chronic chloracne cases, elastic tissue changes, such as actinic elastosis, are observed to occur even at a relatively early age. In this group, 5 of 106 persons were found to have malar hirsutism and 12 were found to have actinic elastosis (Table 5). However, most of these were in persons who were both of light complexion and over 50 years old. Four of the 12 cases of actinic elastosis had chloracne.

Of the 106 persons examined, 45 had a history of acne vulgaris and 22 or 20.7% had some evidence of acne vulgaris at the time of the examination. Of the 43 cases of chloracne 20 worked in Building 236, 22 worked in both Building 236 and 237 and a questionable case was

found among the 6 persons examined, who worked in Building 237, only. This was a case of acne vulgaris who appeared to have some characteristics of chloracne.

In Table 8 it would appear that among workers exposed for more than two years there was a significantly higher number of cases of chloracne than those exposed in less than two years. It should also be noted that all of these cases left the process between 1971 and 1978. Sixteen of those had residual chloracne of which 11 were mild and 5 were moderate.

Clinical Laboratory Findings

Of the eight skin cultures taken four corroborated the clinical impression of dermatophytosis. They consisted of three persons with *T. rubrum* infections and one with *T. mentagrophytes* infection. The laboratory data is presented in Tables 15 through 22.

5. DISCUSSION

The populations surveyed consisted of persons exposed to a pentachlorophenol manufacturing process or to the pentachlorophenol process as well as the ortho and para chlorophenol process. Since population exposed only to the o and p chlorophenol process alone was very small [8] and it was not possible to compare findings in the "penta" group with that of the o and p chlorophenols group. There appears to be no significant difference in the clinical and laboratory findings when the group exposed solely to the pentachlorophenol process [Building 236] compared with the group exposed to the combined

pentachlorophenol process ortho and para chlorophenol [Building 237].

In the analysis of laboratory data, possible correlations between the history of chloracne or residual chloracne and levels of test results were examined. A small number of evaluated total serum lipids were observed. There was no correlation between the serum lipids and the presence of chloracne. While persons with elevated triglycerides were found in both the chloracne and non-chloracne groups, there appeared to be no correlation between serum triglycerides in the presence or absence of chloracne. No significant differences in levels of cholesterol, LDL, SGOT, SGPT, and GGT were found between the chloracne and non acne groups.

Several interesting statistic correlations were observed. Their significance with respect to the risk of pentachlorophenol exposure is still to be determined. The frequency of abnormal levels of VLDL was significantly increased in those persons with a history of chloracne or with residual chloracne as compared to those who never had chloracne. VLDL consists of about 60% triglyceride.

Another interesting observation concerns the levels of HDL found in relation to persons with no history of chloracne, a history of chloracne and those with residual chlorance (Table 23). There appears to be less residual chloracne in the group with HDL level of 45 or more than those in the group with levels less than 45. Levels of 45 or greater are known to be indicative of average to low risk for coronary heart disease.

There was also significantly less chloracne found in workers who do not smoke now even if they smoked previously, than those who currently smoke. In this instance there is the possibility that persons who smoke may smoke on the

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job and hands contaminated with material from the pentachlorophenol process may contact the face and forehands and result in a heavier exposure of those skin sites.

It should be noted at this time that 24 participants in the current study had also worked in Departments 262 and 268 in this plant where esters of 2,4-D and 2,4,5-T were made. The ethyl, butyl, isopropyl and isooctyl esters of 2,4-D and 2,4,5-T were made in Department 268 and 2,4-D itself made in Department 262. The exposure periods vary from less than one month in either Department to as much as 84 months in Department 268 and as long as 32 months in Department 262. The years in which these processes were in operation were: 1947 to 1970 for Department 262; 1962 to 1970 for Department 268.

When the examination records of the twenty-four persons exposed to the above processes were analyzed, there appeared to be no significant difference in the frequency or severity of chloracne in these twenty-four as compared with those who were exposed to the processes in Building 236 and 237. While the groups are relatively small it appears that this additional exposure did not enhance chloracne. At this time we do not know if there were persons who were just exposed to the processes in Building 262 and 268 but not to the pentachlorophenol process or the para and ortho chlorophenol process.

We wish to express our appreciation to Mr. P.E. Heisler and his able staff, Teddi Marshalak, all of the nurses, for their invaluable assistance during the conduct of the survey.

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TABLE 1

W. G. KRUMMRICH PLANT

CHLOROPHENOL STUDY

	<u>NUMBER</u>	<u>PERCENT</u>
Participants	115	
Interviewed	115	
Examined	106	
Males	113	98.26
Females	2	1.74

	<u>RACE</u>	
	<u>NUMBER</u>	<u>PERCENT</u>
Black	17	14.8
Hispanic	1	.9
White	97	84.3

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TABLE 2

STATUS OF EMPLOYEE-PARTICIPANT

	<u>NUMBER</u>	<u>PERCENT</u>
Active Hourly	89	77.4
Active Salary	23	20.0
By Contract	1	.9
Not Working/Medical Reason	2	1.7
	<u>115</u>	

AGE

<u>Age in Years</u>	<u>NUMBER</u>	<u>PERCENT</u>
21 - 30	24	20.8
31 - 40	22	19.1
41 - 50	31	27.0
51 - 60	31	27.0
61 - 63	7	6.1

EDUCATION

<u>Highest grade completed</u>	<u>NUMBER</u>	<u>PERCENT</u>
Through grade 8	4	3.5
High school graduate	71	61.8
College Graduate	35	30.4
Post - graduate	5	4.3

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TABLE 3

OCCURRENCE OF CHLORACNE

Examined 106

	<u>NO</u>	<u>YES</u>	<u>PERCENT POSITIVE</u>
History of Chloracne	40	66	62.3
Current findings	63	43	40.6
Severity			
mild		29	67.4
moderate		14	32.5
severe		0	
Type			
comedonal		43	100.0
cystic		14	32.5
pustular		1	2.3

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TABLE 4

DISTRIBUTION OF CHLORACNE

Examined 106

SKIN AREA

Temporal	22
Forehead	7
Malar	27
Cheeks	10
Occipital	0
Neck	2
Trunk	3
Shoulders	3
Genitalia	

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TABLE 5

PRESENCE OF HIRSUTISM, ACTINIC ELASTOSIS AND CHLORACNE

Hirsutism	<u>NO</u>	<u>YES</u>	<u>PERCENT POSITIVE</u>
malar area	101	5	4.7
Actinic Elastosis	94	12	11.3
Severity			
mild		6	50.0
moderate		4	33.3
severe		2	16.7
Area of Actinic Elastosis			
face		10	
neck		5	
Both Chloracne and Elastosis		4	9.3

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TABLE 6

OCCURRENCE OF ACNE VULGARIS

	<u>NO</u>	<u>YES</u>	<u>PERCENT</u>
History of	61	45	42.5
Current Acne Vulgaris		22	20.7
Severity			
mild		19	86.4
moderate		3	13.6

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TABLE 7

Occurrence of Chloracne
by
Department

	<u>NO CHLORACNE</u>	<u>CHLORACNE</u>
Department 236 (penta)	24	20
Department 236 and 237	34	22
Department 237 (o and p chloropheno)	5	1(?)
Total	63	43

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TABLE 8

RELATIONSHIP BETWEEN NUMBER OF MONTHS IN PENTACHLOROPHENOL PRODUCTION
AND DERMATOLOGIST HISTORY OF CHLORACNE

	<u>NO HISTORY</u>	<u>HISTORY OF CHLORACNE</u>
1 To 3 Mo.	3	1
4 To 5 Mo.	1	3
6 To 11 Mo.	10	16
1 To 2 Yr.	11	11
2 To 3 Yr.	3	9
3 To 5 Yr.	3	8
5 To 10 Yr.	2	8
10 To 20 Yr.	1	7
undetermined	1	2
#237 only	<u>5</u>	<u>1</u>
Total	40	68

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Among those workers in the survey
the # of cases of chloracne is sig-
nificantly higher in those workers
who have worked 2 or more years than
in those who worked less than 2 years.

	<u>LESS THAN 2 YR.</u>	<u>GREATER OR EQUAL TO 2 YR.</u>
No History of chloracne	25	9
History of chloracne	31	32

TABLE 9

RELATIONSHIP BETWEEN NUMBER MONTHS IN PENTACHLOROPHENOL PRODUCTION
AND RESIDUAL CHLORACNE

	<u>NO RESIDUAL</u>	<u>RESIDUAL</u>
✓ 1 To 3 Mo.	3	1
4 To 5 Mo.	3	1
6 To 11 Mo.	15	11
1 To 2 Yr.	14	8
2 To 3 Yr.	6	6
3 To 5 Yr.	6	5
5 To 10 Yr.	6	4
10 To 20 Yr.	3	5
undetermined	2	1
#237 only	<u>5</u> 63	<u>1</u> (?) 43

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TABLE 10

RELATIONSHIP BETWEEN NUMBER OF MONTHS IN PENTACHLOROPHENOL PRODUCTION
AND SEVERITY OF RESIDUAL CHLORACNE

	<u>MILD</u>	<u>MODERATE</u>
1 To 3 Mo.	0	1
4 To 5 Mo.	1	0
6 To 11 Mo.	9	2
1 To 2 Yr.	4	4
2 To 3 Yr.	4	2
3 To 5 Yr.	4	1
5 To 10 Yr.	2	2
10 To 20 Yr.	4	1
undetermined	1	0
#237 only	<u>0</u>	<u>1</u>
Total	29	14

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TABLE 11

RELATIONSHIP BETWEEN THE DATE OF LEAVING PENTACHLOROPHENOL PRODUCTION
AND HISTORY OF CHLORACNE

<u>PERIOD</u>	<u>NO HISTORY</u>	<u>HISTORY</u>
1947 To 1952	5	7
1953 To 1958	3	3
1959 To 1964	6	13
1965 To 1970	2	1
1971 To 1976	8	20
1977 To 1979	10	20
undetermined	1	1
only in #237	5	1

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TABLE 12

RELATIONSHIP BETWEEN DATE OF LEAVING PENTACHLOROPHENOL PRODUCTION
AND RESIDUAL CHLORACNE

<u>Period</u>	<u>No Residual</u>	<u>Residual</u>
1947 To 1952	9	3
1953 To 1958	4	2
1959 To 1964	9	10
1965 To 1970	2	1
1971 To 1976	17	11
1977 To 1979	15	15
undetermined	2	0
Only in #237	<u>5</u>	<u>1</u>
Total	63	43

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TABLE 14

OTHER CLINICAL FINDINGS

OCCURRENCE IN 106 PERSONS EXAMINED

	<u>NUMBER</u>	<u>PERCENT</u>
Folliculitis	10	9.4
Actinic Keratoses	3	2.8
Seborrheic Dermatitis	9	8.5
Dermatophytosis	35	33.0
Hands	1	
Feet	31	
Nails	6	
Other	12	
Atopic Dermatitis	1	.9
Poikiloderma		
Site		
Face	1	
Neck	0	
Chest	0	
Other		

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TABLE 14

	<u>NUMBER</u>	<u>PERCENT</u>
Dermatofibroma	1	.9
Lipoma	4	3.8
Pigmented Nevi	7	6.6
Rosacea/Rhinophyma	5	4.7
Lichens Simplex Chronicus	3	2.8
Alopecia (other than pattern baldness)	0	
Neurofibroma	0	
Petechiae or Ecchymoses	1	.9
Depuytren's Contraction	1	.9
Junctional Nevi	1	.9
Lymphadenopathy	2	1.9

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TABLE 14

	<u>NUMBER</u>	<u>PERCENT</u>
Livido Reticularis (c. marmorata)	2	1.9
Xerosis	4	3.8
Pilonidal Cyst	0	
Otitis Externa	2	1.9
Mild Chronic Dermatitis	1	.9
Xanthelasma	1	.9
Seborrheic Keratoses	8	7.5
Psoriasis	0	
Squamous Cell Epithelioma	0	
Basal Cell Epithelioma	0	

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TABLE 15

Lipids, Total Serum
Dermatologist History of Chloracne

	<u>NO HISTORY</u>	<u>HISTORY</u>
Normal	39	64
High	1	1
undetermined	<u> </u>	<u>1</u>
Total	40	66

WGK

Lipids, Total Serum
Chloracne

	<u>NO RESIDUAL</u>	<u>RESIDUAL</u>
Normal	61	42
High	<u>2</u>	
Total		

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Normal range 0.30 - 1.00

TABLE 16

Possible Relation Between Serum Triglycerides
Dermatologist History of Chloracne

	<u>NO HISTORY</u>	<u>HISTORY OF CHLORACNE</u>
Normal	32	45
High	8	21

Possible Relation Between Triglycerides and Residual Chloracne

	<u>NO RESIDUAL</u>	<u>RESIDUAL</u>
Normal	51	26
High	12	17

Normal range 50.00 - 200.00

Triglycerides
Severity of Chloracne
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	<u>MILD</u>	<u>MODERATE</u>
Normal	16	10
High	<u>13</u>	<u>4</u>
Total	29	14

Normal range 50.00 - 200.00

TABLE 17

Relationship Between Serum Cholesterol and
Dermatologist History of Chloracne

	<u>NO HISTORY</u>	<u>HISTORY OF CHLORACNE</u>
Normal	35	56
High	<u>5</u>	<u>10</u>
Total	40	66

WGK

Cholesterol
Residual Chloracne

	<u>NO RESIDUAL</u>	<u>RESIDUAL</u>
Normal	56	35
High	<u>7</u>	<u>8</u>
Total	63	43

Range mg/DL 125 - 300

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TABLE 18

LDL
vs
Dermatologist History of Chloracne

	<u>NO HISTORY</u>	<u>HISTORY</u>
Low	0	1
Normal	29	48
High	11	16
undetermined	<u> </u>	<u>1</u>
Total	40	66✓

LDL
vs
RESIDUAL CHLORACNE

	<u>NO RESIDUAL</u>	<u>RESIDUAL</u>
Low	0	1
Normal	47	30
High	16	11
undetermined	<u> </u>	<u>1</u>
Total		43

Range mg/DL 60 - 185

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TABLE 19

V L D L
vs
DERMATOLOGIST HISTORY OF CHLORACNE

	<u>NO HISTORY</u>	<u>HISTORY OF CHLORACNE</u>
Normal	36	47
High	4	18
undetermined		
Range mg/DL .00 - 40.0		

The incidence of high levels of VLDL is significantly greater in those having a history of chloracne than in those not having chloracne.

(two-tail Fisher Exact Test, $p=.049$)

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TABLE 20

V L D L
vs
Residual Chloracne

	<u>NO RESIDUAL CHLORACNE</u>	<u>CHLORACNE</u>
Normal	55	28
High	8	14
undetermined		1

The incidence of high levels of VLDL
is significantly higher in those
having chloracne than is those not
having chloracne.

(two-tail Fisher Exact Test, $p=.022$)

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TABLE 21

Possible Relation Between
G - Glutamyl Transpeptidase (GGT)
and
Dermatologist History of Chloracne

	<u>NO HISTORY</u>	<u>HISTORY OF CHLORACNE</u>
Normal	36	60
High	4	5
undetermined	—	<u>1</u>
Total	40	66

G - Glutamyl Transpeptidase (GGT)
vs
Residual Chloracne

	<u>NO RESIDUAL</u>	<u>RESIDUAL CHLORACNE</u>
Normal	56	40
High	7	2
undetermined	—	—
Total	63	42

Normal range units/L 1.00-40.00

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TABLE 22

	<u>Smoking</u> <u>vs</u> <u>Chloracne</u>	
	<u>NO CHLORACNE</u>	<u>CHLORACNE</u>
Smoke now	26	27
Do not smoke	37	14
never, smoked	18	6
used to smoke	19	8
Did not answer		2

Significantly less chloracne was found
in workers who do not smoke now (even
if they smoked previously) than in
workers who currently smoke.

(two-tail Fisher Exact Test, $p=.024$)

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TABLE 23

DISTRIBUTION OF HDL AMONG PERSONS WITH NO HISTORY OF CHLORACNE,
HISTORY OF CHLORACNE AND RESIDUAL CHLORACNE

	<u>NO HISTORY</u>	<u>HISTORY</u>	<u>RESIDUAL</u>	<u>NO RESIDUAL</u>
L.T. 25 mg/DL	3	8	6	5
26-35 mg/DL	7	14	10	11
36-44 mg/DL	7	14	11	10
45-59 mg/DL	9	15	7	17
60-74 mg/DL	10	12	6	16
G.T. 75 mg/DL	<u>4</u>	<u>2</u>	<u>2</u>	<u>4</u>
Total	40	65(+1)	42(+1)	63

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