

*A well-controlled 10-year epidemiological study of two population groups shows that excess amounts of fluoride in a water supply do not produce gross physical defects.*

# Medical Aspects of Excessive Fluoride In a Water Supply

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THE STUDY of a group of people living in Bartlett and Cameron, Tex., reported here is one of several related studies designed to provide information on the effects of excessive amounts of fluoride occurring naturally in a water supply.

Previous investigations (1-3) indicate a need for additional information on the effects of pro-

longed fluoride exposure. Moreover, other studies have related, in a limited number of people, physiological reactions to the presence of excess fluoride, but have not defined the prevalence or incidence of these characteristics in the exposed group (2-4).

Bartlett, Tex., was selected as a study area because the town's water supply contained 8 p.p.m. fluoride (F), one of the higher fluoride levels of public drinking water in the United States. A town with a water supply naturally containing excessive fluoride was selected on the assumption that any association between exposure and physiology might be manifest at a high fluoride concentration, particularly after prolonged ingestion. Cameron, Tex., was selected as the control study area. The Cameron water supply contains 0.4 p.p.m. F. Both towns are similar with respect to geography, racial composition, and principal occupation, which is agriculture. Each participant in the study was required to have been a resident of one of these towns for 15 consecutive years prior to 1943.

The medical history of the participants since birth was recorded at the start of the study, and their medical experience during the 10-year period 1943 to 1953 was carefully reviewed.

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**Table 1. Composition of water,<sup>1</sup> Bartlett and Cameron, Tex., 1943 and 1953**

Components	Bartlett			Cameron	
	Raw water		Defluoridated water	Raw water	
	January 1943 <sup>1</sup>	December 1953	December 1953	January 1943	December 1953
Dissolved solids.....	1, 698. 4	1, 708. 8	1, 701. 2	435. 2	363. 6
Loss on ignition.....	40. 0	34. 4	16. 0	66. 4	60. 8
Fixed residue.....	1, 658. 4	1, 674. 4	1, 685. 2	368. 8	302. 8
Silica (SiO <sub>2</sub> ).....	15. 2	16. 0	17. 6	6. 4	5. 6
Iron (Fe).....	0. 03	0. 01	0. 01	0. 02	0. 02
Aluminum (Al).....	0. 0	0. 00	0. 02	0. 07	0. 01
Calcium (Ca).....	19. 4	24. 6	21. 2	74. 3	85. 8
Magnesium (Mg).....	11. 5	11. 4	11. 4	20. 6	8. 4
Sodium and potassium (calculated as Na).....	588. 9	585. 7	582. 2	46. 6	22. 6
Carbonate (CO <sub>3</sub> ).....	0. 0	7. 2	2. 4	0. 0	1. 2
Bicarbonate (HCO <sub>3</sub> ).....	485. 6	458. 7	451. 4	258. 6	168. 0
Sulfate (SO <sub>4</sub> ).....	482. 2	471. 9	493. 6	65. 8	93. 0
Nitrate (NO <sub>3</sub> ).....	2. 2	0. 22	1. 33	4. 4	4. 2
Chloride (Cl).....	319. 0	325. 9	323. 5	63. 0	30. 4
Phosphate (PO <sub>4</sub> ).....	0. 0	0. 0	0. 0	0. 0	0. 0
Fluoride (F).....	8. 0	7. 6	1. 2	0. 4	0. 5

<sup>1</sup> The 1943 water analyses were made by Elvove (6), the fluoride determinations by means of the zirconium-alizarin reagent. The 1953 fluoride analyses were done by the method described by McClure (7). Both investigators are from the National Institutes of Health. Phosphates were determined by an adaptation of the colorimetric method of Benedict and Theis (8). Determinations other than fluoride and phosphate were made according to the Standard Method of Water Analysis of the American Public Health Association.

This permitted a comparison of the individuals in each group with themselves and of those in a high-fluoride group with those in a low-fluoride group.

The study has produced findings of two types—those that can be enumerated and analyzed by statistical techniques and those that

are classified as clinical impressions. The latter are more difficult to evaluate, but are important in the analysis of specific clinical problems.

This paper is concerned with the statistical analysis of the results of the study. Clinical impressions will be evaluated in subsequent papers, in which the medical, X-ray, and dental findings will be presented in more detail.

**Table 2. Distribution of participants by locality, age, and sex, based on 1943 age**

Age group (years)	Bartlett			Cameron		
	Male	Female	Total	Male	Female	Total
15-24.....	5	16	21	11	7	18
25-29.....					5	5
30-34.....	2	4	6	1	6	7
35-39.....	5	11	16	6	12	18
40-44.....	1	7	8	6	11	17
45-49.....	7	6	13	11	15	26
50-54.....	7	15	22	4	8	12
55-59.....	3	11	14	4	9	13
60-64.....	7	3	10	2	1	3
65-69.....	2	3	5	1	1	2
70+.....		1	1			
Total.....	39	77	116	46	75	121

**Characteristics of Study Areas**

Bartlett and Cameron are geographically located on a triangle with Temple, Tex., which is 135 miles due south of Dallas. Bartlett is 20 miles south and Cameron is 38 miles southeast of Temple. The two towns are about 25 linear miles apart but are not connected by a direct road. In 1940, the populations of Bartlett and Cameron were 1,668 and 5,040; and in 1953, 1,706 and 5,272, respectively.

Prior to 1943, there were usually 2 practicing physicians and 1 dentist in Bartlett; 10 physicians and 6 dentists in Cameron. During the 1953 survey, there were 1 practicing physician

and 1 dentist in Bartlett, and 8 physicians and 4 dentists in Cameron. Bartlett residents are also seen by physicians in nearby Temple and Taylor, and Cameron residents are served by the medical profession in Temple and Marlin.

### Bartlett

The municipal water supply of Bartlett, serving the entire town, comes from two deep wells of approximately the same depth. Well No. 1 was drilled to 2,005 feet in 1901; well No. 2, to 1,595 feet in 1936. By the latter year, both were plugged to 1,040 feet. Both wells are now pumping at the 240-foot level, each with a free-flowing capacity output of 220 gallons per minute.

Until March 11, 1952, the raw water was pumped into three storage tanks, from which it entered directly into the general distribution system (5). Repeated analyses of the Bartlett

water supply have shown a fluoride level ranging from 7.6 to 8.2 p.p.m. F since the municipal water supply has been in use. Few sizable communities in the United States use water supplies with a fluoride concentration in excess of 6 p.p.m. F.

Table 1 shows the typical composition of the raw water supplies of Bartlett and Cameron during the period of study. On March 11, 1952, an experimental defluoridation unit was installed in Bartlett, and the table also shows the composition of the defluoridated water on the day the raw water was sampled.

Since the installation of the defluoridation unit, the fluoride content of the water has varied considerably. However, it has remained somewhat above the desired level of 1.0 p.p.m. F. "Optimal defluoridation" has not been achieved without interruption because of necessary changes in the experimental unit (5). By 1953

**Table 3. Distribution of participants, by locality, age, and sex, based on 1953 age**

Age/group (years)	Examined						Not exam- ined	Deceased		
	1943			1953				Male	Female	Total
	Male	Female	Total	Male	Female	Total				
<b>Bartlett</b>										
25-29	5	12	17	5	9	14	3			
30-34		4	4		2	2	3			
35-39										
40-44	2	3	5	2	3	5				
45-49	4	11	15	4	10	14				
50-54	2	6	8	2	6	8				
55-59	6	8	14	3	8	11		3		3
60-64	10	13	23	8	13	21		1	1	2
65-69	2	11	13	1	9	10		1	2	3
70+	8	9	17	6	5	11		3	3	6
Total	39	77	116	31	65	96	6	8	6	14
<b>Cameron</b>										
25-29	11	6	17	9	6	15	2			
30-34		1	1		1	1				
35-39		5	5		4	4	1			
40-44	1	4	5	1	4	5				
45-49	6	13	19	6	13	19				
50-54	6	11	17	5	11	16		1		1
55-59	11	13	24	11	12	23	1			
60-64	4	10	14	4	10	14				
65-69	4	10	14	2	9	11		2		2
70+	3	2	5	2	3	5		1		1
Total	46	75	121	40	73	113	4	4		4

**Table 4. Distribution of removed participants, 1943 to 1953, by age and sex**

Age group (years)	Examined			Not examined <sup>1</sup>			Total
	Male	Female	Total	Male	Female	Total	
<b>Bartlett</b>							
25-29	2	7	9		3	3	12
30-34		1	1		3	3	4
35-39							
40-44	1		1				1
45-49							
50-54		1	1				1
55-59							
60-64	1	1	2				2
65-69		2	2				2
70+							
Total	4	12	16		6	6	22
<b>Cameron</b>							
25-29	8	3	11	2		2	13
30-34		1	1				1
35-39		2	2		1	1	3
40-44							
45-49	1	1	2				2
50-54		2	2				2
55-59	1	1	2		1	1	3
60-64		1	1				1
65-69							
70+							
Total	10	11	21	2	2	4	25

<sup>1</sup> Medical history in 1953, but no physical, laboratory, or X-ray examination.

the Bartlett participants in the study had ingested fluorides at high levels for an average of 36.7 years. Any significant physiological manifestations of prolonged exposure would not be expected to have regressed materially in the 18 months of partial defluoridation.

#### *Cameron*

Cameron has taken its raw water from the Little River since 1895. Sedimentation basins were installed in 1911 and floored in 1929. The water has been alum treated since 1911, chlorinated since 1919, and carbon treated since 1936. The present treatment consists of prechlorination, coagulation with alum and lime, sedimentation, and postchlorination. Occasionally, activated carbon is added for the control of taste and odor. The plant is not equipped with filters. In 1953 a pressure tank was added to the system. (See table 1 for water analyses.)

#### **Procedure**

In 1943, a medical-dental team from the Public Health Service examined 116 participants in Bartlett and 121 in Cameron. At that time, the participants' ages ranged from 15 to 68 years, in both towns. All were of the white race.

The group was selected by a survey covering approximately every household in Bartlett and every third household in Cameron. An adult member of each household was interviewed and a "household roster" card was filled out. In addition, a "residence and water history" card was made for each household member. On the basis of the data obtained, a random sample was selected from those who met the basic requirement—15 years or more of continuous residence prior to 1943.

The 1953 investigation involved the location and study of the group 10 years later and a re-examination of as many participants as possible.

**Table 5. Percentage distribution of participants by age groups, based on 1953 age**

Age group (years)	Bartlett		Cameron	
	1943	1953	1943	1953
25-29	14.7	14.6	14.0	13.3
30-34	3.4	2.1	.8	.9
35-39			4.1	3.5
40-44	4.3	5.2	4.1	4.4
45-49	12.9	14.6	15.8	16.8
50-54	6.9	8.3	14.0	14.2
55-59	12.1	11.5	19.9	20.4
60-64	19.8	21.8	11.6	12.4
65-69	11.2	10.4	11.6	9.7
70+	14.7	11.5	4.1	4.4
Total	100.0	100.0	100.0	100.0

The 1943 and 1953 investigation procedures were essentially parallel. These included a medical history, physical and dental examinations, X-rays, and blood and urine studies. Both sets of data were recorded on punchcards to facilitate comparison. In the 1943 study, the

physical and dental examinations and the laboratory work were done locally in the respective towns, but the patients were later transported to the Scott and White Clinic in Temple, Tex., for X-rays.

The 1953 procedure differed slightly in that the majority of physical and laboratory examinations, as well as X-rays, were performed at the Scott and White Clinic by Public Health Service personnel. Blood and urine analyses were done by the Scott and White Clinic laboratory technicians, and the chief of the X-ray department supervised the taking of X-ray films and made the initial interpretations. The films were later evaluated independently by Theodore F. Hilbish, chief, Department of Diagnostic X-ray, Clinical Center, National Institutes of Health, and Merrill C. Sosman, chief, department of radiology, Peter Bent Brigham Hospital, Boston.

Approximately 71 percent of the 237 participants in the 1943 survey still resided in Bart-

**Table 6. Incidence of abnormal clinical findings, 1943 to 1953**

[Participants residing in study area for the 10-year period]

Characteristic studied	Bartlett			Cameron			Significant difference (P=0.05)
	Number at risk	Number abnormal	Rate (per-cent)	Number at risk	Number abnormal	Rate (per-cent)	
Arthritic change	80	11	13.8	89	13	14.6	No.
Blood pressure:							
Systolic 151 mm/Hg and over	58	18	31.0	81	20	24.7	No.
Diastolic 100 mm/Hg and over	73	11	15.1	83	11	13.3	No.
Pulse pressure 75 mm/Hg and over	70	9	12.9	89	16	18.0	No.
Bone changes: <sup>1</sup>							
Density	74	<sup>2</sup> 7	9.5	81	<sup>3</sup> 2	2.5	No.
Coarse trabeculation	74	4	5.4	81	2	2.5	No.
Hypertrophic	74	8	10.8	81	6	7.4	No.
Spurs	74	1	1.4	81	4	4.9	No.
Osteoporosis	74	5	6.8	81	10	12.3	No.
Bone, increased density (new cases)	66	1	1.5	79			
Cataract and/or lens opacity	79	8	10.1	85	12	14.1	No.
Thyroid	74	3	4.1	82	6	7.3	No.
Cardiovascular system (except uncomplicated hypertension)	80	10	12.5	92	22	23.9	Yes.
Hearing (decreased acuity)	72	14	19.4	78	10	12.8	No.
Tumor and/or cysts	80	12	15.0	92	10	10.9	No.
Fractures	80	12	15.0	92	7	7.6	No.
Urinary tract calculi	72	14	19.4	76	12	15.8	No.
Gallstones	73	0	0.0	80	1	1.2	No.

<sup>1</sup> Bone changes determined by simultaneous reading of identical views of X-rays taken in 1943 and repeated in 1953.

<sup>2</sup> Increased density, 4; decreased density, 3.

<sup>3</sup> Increased density, 2.

PHS Examining Teams

1943

Physicians: J. W. Hawkins, M. E. Shimkin, Chester Brown

Dentist: F. A. Arnold, Jr.

Nurses: Christine Mason, Mary Harte

Technician: Stoel Davis

1953

Physician: N. C. Leone

Dentist: E. R. Zimmermann

Nurse: Patricia Geiser

Assistants: Vona Harrell, F. D. Baty, Elaine Pickett

lett and Cameron in 1953. Information on the deceased, another 8 percent, was obtained from the next of kin, and copies of the death certificates were obtained to establish cause of death. Because of the unusual success in accounting for 79 percent of the participants locally, it was deemed advisable to follow up the remaining 21 percent of the participants who had moved from the study areas. All of the 1943 participants, living and deceased, were accounted for in the 1953 study (tables 3 and 4).

A total of 47 participants had moved from the 2 towns by 1953. Of these, 37 were examined and the data were obtained by the same procedures as used for the persons who remained. Forty-three of the "removed" participants still lived in Texas. Two had moved to California, 1 to Oklahoma, and 1 to New York City.

The 10 living participants who were not examined were interviewed by personal contact, telephone, or mail, and a 10-year medical and residence history was obtained. None reported acute, chronic, serious, or debilitating illnesses.

*Physical Examination*

In 1943 and again in 1953, a medical and residence history was obtained for each person in the study. At the conclusion of the examinations, a summary of the findings in each case was prepared for the family physician.

The laboratory blood studies in 1943 and 1953 included a determination of hemoglobin, red and white blood counts, a differential white count, and a serologic test for syphilis. Urine determinations included specific gravity, qualitative albumin and sugar, and microscopic examination.

In 1953, additional procedures were included. Rectal and pelvic examinations of most of the females and prostate examinations of males were routine. Hematocrit, sedimentation rate, and blood calcium were determined, and when indicated, further studies were made, such as acid and alkaline phosphatase, blood sugar, and special hematology. Consultant service was used when needed.

**Table 6A. Incidence of abnormal clinical findings, 1943 to 1953**

[Removed participants]

Characteristic studied	Bartlett		Cameron	
	Number at risk <sup>1</sup>	Number abnormal	Number at risk <sup>1</sup>	Number abnormal
Arthritic change-----	16	0	21	2
Blood pressure:				
Systolic 151 mm/Hg and over-----	16	2	19	1
Diastolic 100 mm/Hg and over-----	16	0	21	0
Pulse pressure 75 mm/Hg and over-----	16	2	19	0
Bone changes: <sup>2</sup>				
Density-----	15	0	20	<sup>3</sup> 1
Coarse trabeculation-----	15	0	20	0
Hypertrophic-----	15	2	20	0
Spurs-----	15	0	20	0
Osteoporosis-----	15	0	20	0
Bone, increased density (new cases)-----	15	0	20	0
Cataract and/or lens opacity-----	16	2	21	1
Thyroid-----	16	0	19	4
Cardiovascular system (except uncomplicated hypertension)-----	16	4	21	2
Hearing (decreased acuity)-----	16	0	21	1
Tumor and/or cysts-----	16	3	21	5
Fractures-----	22	2	25	2
Urinary tract calculi-----	16	0	21	2
Gallstones-----	15	0	20	0

<sup>1</sup> At risk for that part of the 10-year interval in which the participant resided in the study area.

<sup>2</sup> Bone changes determined by simultaneous reading of identical views of X-rays taken in 1943 and repeated in 1953.

<sup>3</sup> Decreased density, 1.

**Table 6B. Incidence of abnormal clinical findings, 1943 to 1953**

[Resident and removed participants]

Characteristic studied	Bartlett			Cameron		
	Number at risk	Number abnormal	Rate (percent)	Number at risk	Number abnormal	Rate (percent)
Arthritic change.....	96	11	11.5	110	15	13.6
Blood pressure:						
Systolic 151 mm/Hg and over.....	74	20	27.0	100	21	21.0
Diastolic 100 mm/Hg and over.....	89	11	12.4	104	11	10.6
Pulse pressure 75 mm/Hg and over....	86	11	12.8	108	16	14.8
Bone changes: <sup>1</sup>						
Density.....	89	<sup>2</sup> 7	7.9	101	<sup>3</sup> 3	3.0
Coarse trabeculation.....	89	4	4.5	101	2	2.0
Hypertrophic.....	89	10	11.2	101	6	5.9
Spurs.....	89	1	1.1	101	4	4.0
Osteoporosis.....	89	5	5.6	101	10	9.9
Bone, increased density (new cases).....	81	1	1.2	99		
Cataract and/or lens opacity.....	95	10	10.5	106	13	12.3
Thyroid.....	90	3	3.3	101	10	9.9
Cardiovascular system (except uncomplicated hypertension).....	96	14	14.6	113	24	21.2
Hearing (decreased acuity).....	88	14	15.9	99	11	11.1
Tumor and/or cysts.....	96	15	15.6	113	15	13.3
Fractures.....	102	14	13.7	117	9	7.7
Urinary tract calculi.....	88	14	15.9	97	14	14.4
Gallstones.....	88	0	0.0	100	1	1.0

<sup>1</sup> Bone changes determined by simultaneous reading of identical views of X-rays taken in 1943 and repeated in 1953.

<sup>2</sup> Increased density, 4; decreased density, 3.

<sup>3</sup> Increased density, 2; decreased density, 1.

The removed participants were given essentially the same examination by the same Public Health Service physician, who visited them at their current residence and arranged for their examination at a local medical facility.

#### *X-Ray Examination*

The X-rays taken at the Scott and White Clinic were made on a 500-ma. radiographic unit with rotating anode tube. Emphasis was placed on bone detail. Anteroposterior views of the dorsal spine, the lumbar spine, and the pelvis with the proximal third of the femur were taken for each patient. When a question of unusual findings arose, a radiographic bone survey was made, consisting of the following views: lateral skull, cervical spine, left upper arm, forearm and hand, and right femur, lower leg and foot.

The removed participants were similarly X-rayed at the nearest available facility. Both the 1943 and 1953 X-ray films, regardless of where they were taken, were independently evaluated by three roentgenologists.

#### *Oral Examination*

All physical examinations included an oral examination by the Public Health Service physician. In addition, the majority of participants seen at Scott and White Clinic in 1953 received a complete dental examination, including X-rays. Estimations were made on the degree and prevalence of dental fluorosis, caries experience, gingivitis, and alveolar bone loss. Dental X-rays were taken on all participants seen by the dentist, including edentulous persons, and the films were evaluated independently by four dentists. The presence or absence of dental fluorosis in the removed participants was determined by the examining physician.

#### **Evaluation of Findings**

The results of the study are discussed in terms of age and sex distribution of the participants and their medical experiences during the 10-year interval. The importance of age distribution and residence have been taken into consideration in the overall evaluation.

**Table 7. Prevalence of abnormal laboratory findings, 1943 and 1953**

[Participants residing in study area for the 10-year period]

Laboratory determination	Year	Bartlett			Cameron			Significant difference (P=0.05)
		Number examined	Number abnormal	Rate (percent)	Number examined	Number abnormal	Rate (percent)	
Hemoglobin-----	1943...	116	34	29.3	121	37	30.6	No.
	1953...	79	20	25.3	83	26	31.3	
Hematocrit-----	1943...							No.
	1953...	79	5	6.3	82	7	8.5	
Red blood count-----	1943...	116	25	21.6	121	24	19.8	No.
	1953...	80	6	7.5	85	2	2.4	
White blood count-----	1943...	116	17	14.7	121	5	4.1	Yes.
	1953...	78	11	14.1	82	7	8.5	
Differential count: Neutrophiles-----	1943...	71	15	21.1	71	6	8.5	Yes.
	1953...	78	23	29.5	82	13	15.9	
Lymphocytes-----	1943...	71	2	2.8	71	1	1.4	No.
	1953...	78	35	44.9	82	36	43.9	
Eosinophiles-----	1943...	71	0	0.0	71	0	0.0	No.
	1953...	78	6	7.7	82	14	17.1	
Sedimentation rate-----	1943...							No.
	1953...	79	31	39.2	83	22	26.5	
Blood calcium-----	1943...							No.
	1953...	79	9	11.4	66	7	10.6	
Serologic test for syphilis-----	1943...	71	2	2.8	71	3	4.2	No.
	1953...	84	2	2.4	95	2	2.1	
Urine albumin-----	1943...	115	3	2.6	121	10	8.3	Yes.
	1953...	77	5	6.5	85	12	14.1	
Urine glucose-----	1943...	115	2	1.7	121	4	3.3	No.
	1953...	77	0	0.0	85	1	1.2	

*Age and Sex Distribution*

Table 2 gives the age-sex distribution of the original 1943 participants. Table 3 gives the age-sex distribution of the participants in the 1943 and 1953 surveys and the deceased during the 10-year period. In this and subsequent tables, the age groupings are on the basis of the participants' ages in 1953. Table 4 gives the age-sex composition of the group that moved from the study area in the 10-year interval, and table 5 shows the percentage distribution of all examined participants by age group.

Table 3 shows that in Bartlett and Cameron the ratio of male to female participants in both 1943 and 1953 is approximately 1 to 2. The male-female ratio for the entire populations in the towns is 0.9 to 1 in Bartlett and 1.1 to 1 in Cameron (9, 10).

The age distribution of the participants does not exactly parallel that of the populations. In 1943, 57.8 percent of the Bartlett participants were over 55 years of age (table 5), whereas persons 55 and over constituted about 50 percent of the total adult population. The comparable figures for Cameron are 47.2 percent and approximately 38 percent. This imbalance was due to the basic requirement of 15 years' continuous residence and the absence of males of military age.

The sex ratios of the participants were approximately the same in the two study areas, and the age distributions were similar though not exactly comparable, since in Bartlett the participants were predominantly older. The imbalance is particularly evident in the age group 70 and over. As a result, the difference



**Table 7A. Prevalence of abnormal laboratory findings, 1953**

[Removed participants]

Laboratory determination	Bartlett		Cameron	
	Number examined	Number abnormal	Number examined	Number abnormal
Hemoglobin.....	11	5	20	4
Hematocrit.....	10	0	20	1
Red blood count.....	11	0	18	3
White blood count.....	11	1	20	6
Differential count				
Neutrophiles.....	11	2	20	3
Lymphocytes.....	11	6	20	10
Eosinophiles.....	11	0	20	2
Sedimentation rate.....	10	5	20	2
Blood calcium.....	0	0	0	0
Serologic test for syphilis.....	5	0	7	0
Urine albumin.....	13	0	19	0
Urine glucose.....	13	0	19	0

between the age-corrected mortality rates is not significant by statistical analysis. (See table 3 for age-sex distribution of the deceased.)

#### *Removed Participants*

In table 4 the removed participants are subdivided into those who were examined (including X-ray and laboratory studies) and those who were not. The number of persons that left each town was almost equal, 22 from Bartlett and 25 from Cameron, predominantly of the younger age groups.

The average duration of continuous residence of all living participants examined was 36.7 years in Bartlett and 38.2 years in Cameron, and the corresponding averages for those who moved were 22.4 in Bartlett and 21.3 in Cameron.

#### *Results*

Table 6 shows the 10-year incidence rates for selected clinical findings of those who were at risk for the entire 10-year period. Table 6A shows the 10-year incidence figures for the same characteristics studied in the removed participants. Table 6B shows composite findings for all participants examined. Similarly, tables 7 and 7A show the prevalence data for abnormal laboratory findings, and table 7B is a composite of the data in the two tables. In the subse-

quent evaluation of data, the differences between the findings for the two towns are subjected to statistical analyses in order to test the hypothesis that Bartlett did not differ from Cameron with respect to the characteristics studied. (Each characteristic studied, laboratory determination, and dental finding was tested statistically for significant differences between towns. Approximately 40 tests were made. It was therefore expected that at least three characteristics would be judged significant as a consequence of the statistical procedure (11). It was necessary to use this statistical procedure because a main objective of the study was to determine which, if any, of the characteristics were important.)

The number of persons "at risk," as the term is used in the various tables, is the number of individuals who had a chance to acquire the "characteristic studied" during the 10-year interval. A participant was considered at risk only with respect to characteristics for which he was examined both in 1943 and 1953. The variation in the number at risk is largely due to the unavoidable omission of parts of examinations.

No attempt has been made to reconcile the differing concepts of "normal" with respect to the characteristics studied. Objective criteria, which apply equally to both towns, were chosen to designate the "abnormals." The purpose of these criteria was to form a dichotomy of the participants with respect to each characteristic, to permit statistical evaluation. The ranges, standards, and definitions used are given on page 935.

Tables 6 and 7 show that significant differences were found between the two study areas in the incidence rates for cardiovascular abnormalities and the prevalence rates for abnormal white blood counts, neutrophiles, and urine albumin.

As was expected, dental fluorosis was observed in Bartlett in all of the participants born and in continuous residence in Bartlett during the tooth formative period. In Cameron, the single individual with dental fluorosis had a history of early fluoride exposure. No new cases appeared in the participants of either area in the 10-year period.

**Table 7B. Prevalence of abnormal laboratory findings, 1943 and 1953**

[Resident and removed participants]

Laboratory determination	Year	Bartlett			Cameron		
		Number examined	Number abnormal	Rate (percent)	Number examined	Number abnormal	Rate (percent)
Hemoglobin.....	1943	116	34	29.3	121	37	30.6
	1953	90	25	27.8	103	30	29.1
Hematocrit.....	1943						
	1953	89	5	5.6	102	8	7.8
Red blood count.....	1943	116	25	21.6	121	24	19.8
	1953	91	6	6.6	103	5	4.9
White blood count.....	1943	116	17	14.7	121	5	4.1
	1953	89	12	13.5	102	13	12.7
Differential count:							
Neutrophiles.....	1943	71	15	28.1	71	6	8.5
	1953	89	25	23.0	102	16	15.7
Lymphocytes.....	1943	71	2	2.8	71	1	1.4
	1953	89	41	46.1	102	46	45.1
Eosinophiles.....	1943	71	0	0.0	71	0	0.0
	1953	89	6	6.7	102	16	15.7
Sedimentation rate.....	1943						
	1953	89	36	40.4	103	24	23.3
Blood calcium.....	1943						
	1953	79	9	11.4	66	7	10.6
Serologic test for syphilis.....	1943	71	2	2.8	71	3	4.2
	1953	89	2	2.2	102	2	2.0
Urine albumin.....	1943	115	3	2.6	121	10	8.3
	1953	90	5	5.6	104	12	11.5
Urine glucose.....	1943	115	2	1.7	121	4	3.3
	1953	90	0	0.0	104	1	0.9

Neither the statistically significant differences nor those that are not significant predominate in either group, except in the case of dental fluorosis. The other significant differences were just above the significance level. These differences were no greater than would be expected in a like study of any two areas similar to Bartlett and Cameron, with or without an excess of fluoride in either water supply.

**Conclusions**

The incidence of specific systemic abnormalities and the prevalence of abnormal laboratory findings showed no tendency toward higher or lower rates for either town, except that the number of cases of dental fluorosis was significantly higher in Bartlett than in Cameron and the difference in the rates for cardiovascular

abnormalities reached a significant level in Cameron.

The differences in laboratory findings are recognized to be clinically transient and must be evaluated in terms of clinical circumstances. They do not suggest a pattern of association to fluoride effects.

The difference between the age-corrected death rates in the two study areas is not statistically significant.

No clinically significant physiological or functional effects resulted from prolonged ingestion of water containing excessive fluoride, except for dental fluorosis.

**Summary**

A 10-year study of 116 persons in Bartlett and 121 in Cameron, Tex., was conducted to

**Glossary of ranges, standards, and definitions of abnormalities**

Determination	Defined range	Reference
<i>Laboratory Findings</i>		
Hemoglobin:		
Male.....	14-16 mg. percent.....	} (12)
Female.....	12-14 mg. percent.....	
Red blood count:		
Male.....	4.6-6.2 per cu. mm.....	} (12)
Female.....	4.2-5.4 per cu. mm.....	
White blood count.....	5,000-10,000 per cu. mm.....	(12)
Differential:		
Neutrophiles.....	50-65 percent.....	} (12)
Lymphocytes.....	25-35 percent.....	
Monocytes.....	4-10 percent.....	
Basophiles.....	0-2 percent.....	
Eosinophiles.....	.5-4 percent.....	
Abnormal cells.....	Reported as observed.....	
Hematocrit:		
Male.....	40-54 vol. percent.....	} (12)
Female.....	37-47 vol. percent.....	
Sedimentation rate (corrected):		
Male.....	0-9 mm. per hr.....	} (12)
Female.....	0-20 mm. per hr.....	
Blood calcium.....	9-11 mg. percent.....	(13)
Urine:		
Albumin.....	Reported as observed (qualitative).....	
Glucose.....		
<i>Clinical Abnormalities</i>		
Blood pressure:		
Maximum normal for study.....	150/99.....	} (14)
Systolic hypertension.....	151 mm. Hg and over.....	
Diastolic hypertension.....	100 mm. Hg and over.....	
Abnormal pulse pressure in presence or absence of hypertension.....	75 mm. Hg or greater.....	
Cardiovascular.....	Presence of arteriosclerosis alone or with decompensation, diastolic murmurs, abnormal pulse pressure, aneurysms, heart block, or other abnormal cardiac findings, including hypertension. (For the purpose of the study, hypertension alone is recorded as an abnormality of blood pressure.).....	(14)
Thyroid.....	When grossly enlarged or palpable. When nodules are present, regardless of size, recorded with tumors and/or cysts.	
Eyes.....	Cataract and/or lenticular opacity, recorded as observed. Opacity or cataract which developed in second eye since examination in 1943 is designated as 1 person, but as an increase.	
Ears.....	Air conduction or bone conduction decreased auditory acuity, but not deafness. Decreased acuity associated with excess cerumen alone not included.	
Gallbladder.....	Gallstones only when demonstrated by X-ray.	
Renal calculi.....	Renal calculi when demonstrated by X-ray, history of calculi with urine positive for red and white cells, surgical removal, or passage of calculi. (Red blood cells in urine of young females not considered abnormal without supporting CVA tenderness, X-ray, or other positive evidence.)	
Prostate.....	Nodular prostate recorded with tumors and/or cysts.	
Dental fluorosis (mottled enamel).....	Presence of very mild through severe fluorosis as determined by Dean's criteria.....	(15)
Other physical examination findings.....	Recorded as observed.	
<i>X-ray</i>		
Bone.....	For purpose of the study, X-rays of the lumbar spine, sacrum, pelvis, trochanters, and proximal third of the femurs are used for comparisons.	
Hypertrophic bone change.....	When alone or in combination with bone spurs.	
Increased bone density.....	When alone or in combination with coarse trabeculation.	
Coarse trabeculation.....	When alone and not in combination with increased bone density.	
Other bone changes:		
Fractures.....	Recorded as observed.	
Osteoporosis.....	Recorded as observed.	
Spurs.....	When not associated with hypertrophic change.	

determine if prolonged exposure to fluoride in the water supply of Bartlett had produced detectable physiological effects.

Bartlett's water contained about 8 p.p.m. F until 1952, when an experimental defluoridation unit was installed, reducing the fluoride content to approximately 1.2 p.p.m. F. Cameron was the control area with 0.4 p.p.m. F in its water supply.

The participants, aged 15 to 68 in 1943, were chosen at random from persons who had resided in the respective communities for at least 15 years. The average length of fluoride exposure in 1953 was 36.7 years.

In 1943, the investigators took medical histories and gave each participant a medical, X-ray, and dental examination. In 1953, this procedure was repeated for all the original participants, except the 18 deceased and 10 of the 47 persons who had moved away from the 2 towns.

No significant differences between the findings in the two towns were observed, except for a slightly higher rate of cardiovascular abnormalities in Cameron and a marked predominance of dental fluorosis in Bartlett.

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