3. It was observed that a daily intake of 8 cc. of cod liver oil for one week produced healing rickets in seven weeks and a completely calcified bone in nine, showing again the small amount of cod liver oil required to initiate and for some time to keep in action the calcification process.

4. In preventing rickets in premature infants, cod liver oil should be administered as soon as food is consumed.

5. Excessively rapid and great gain in weight should not be encouraged.

6. The food should contain a higher mineral and protein content than does human milk, and it is suggested that if human milk is used it be supplemented with boiled skim milk.

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THE EFFECT OF ULTRAVIOLET IRRADIATION ON THE HEALTH OF A GROUP OF INFANTS *

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The importance of sunlight for the welfare of the infant and the growing child has only recently been recognized. The favorable effect is ascribed chiefly, if not altogether, to the ultraviolet or invisible rays. As Hess [1] recently has pointed out, these radiations constitute less than 1 per cent of the total solar spectrum and it is therefore all the more remarkable that they should prove to be the factor essential to normal growth of the child.

The effect of the ultraviolet rays in rickets in infants and animals has been investigated by many workers in this country and abroad. It has been shown objectively by means of chemical analysis of the blood and the roentgen rays that infantile rickets comes about largely from a lack of the ultraviolet solar rays and can be prevented and cured by such radiations.

Recently, Eidinow [2] reported an increase of the normal bactericidal power of the blood following exposure to ultraviolet rays. When only a mild erythema was produced, the power of the blood to kill bacteria was increased 65 per cent in rabbits and about 20 per cent in man. After excessive irradiation, the bactericidal power is greatly diminished, a reaction that is noticed about two hours after the exposure.

The study that we have made was carried out in a large child-caring institution, harboring children ranging from a few weeks to 5 years of age. Our experience for many years has been that during the summer months the morbidity is low, but that during the autumn, winter and early spring, the children suffer from respiratory infections partly because of a lack of sunlight, especially of the deprivation of its ultraviolet rays, which, as is generally known, are not transmitted by window glass. In the hope of overcoming this situation, which constitutes the greatest health problem in this and other similar institutions, now that intestinal disturbances have been successfully combatted, it seemed worth while to make a serious attempt to ascertain whether these infections could be obviated by means of systematic exposures of a group of infants to ultraviolet rays from an artificial source. For this purpose, the mercury vapor lamp was used, which emits ultraviolet radiations of exceptionally high intensity. The object was primarily to determine the value of these rays in the prevention of respiratory infections and secondly on the nutrition of the children. As it happened, the scope of the study was somewhat enlarged to include the value of this therapeutic agent in pertussis, varicella and adenitis. As far as we are aware, the nutritional effect of actinic rays in infants has as yet not been systematically studied.

About the middle of November, 1925, two wards were selected for this purpose, one occupied by infants largely under 1 year of age, and the other by children from 1 to 2½ years. The children of each ward were divided into two groups, the one to be irradiated and the other not to be irradiated, but to receive the usual amount of sunlight available during these seasons of the year. Before beginning our study, a careful physical examination of every child was carried out, which included a notation of its weight, height and percentage of hemoglobin. These observations were systematically and periodically noted during the course of the six months that comprised this investigation. To facilitate interpretation, the study was subdivided into five periods, three of irradiation, totaling four months, and two subsequent periods comprising two months. The entire study covered therefore a span of six months, from November to May (tables 1 and 2).

The children in the various groups have been inmates of the home since early infancy, so that previous data relating to their health was readily available. Another decided advantage over studies conducted in an outpatient department is that we could be certain that the diet was adequate and uniform and that the general care was of the best. All the children received liberal amounts of orange juice and cod liver oil daily. Thus the possibility of a vitamin deficiency was eliminated as a factor in lowering resistance.

The technic consisted in irradiating for short periods at the outset and gradually augmenting the intensities in order to bring about increasing tolerance of the skin. The children were nude except for a mask worn to protect their eyes. The initial irradiations were of three minutes' duration, alternating on the dorsal and ventral surfaces. At all times treatment was given only on alternating days, as it was considered that this is preferable to daily exposures. Later, front and back were irradiated at the same session; the maximum irradiation, which was reached about the middle of February, was fifteen minutes' exposure to the front and an equal period to the back. Up to this time, the lamp was placed at a distance of 36 inches from the table; subsequently this distance was changed to 30 inches in order to increase the intensity.

There can be no question that the infants received a sufficient degree of irradiation when we consider that the younger children were irradiated for a total of eleven hours at a distance of 3 feet, and in addition for a period of almost five hours at a distance of 30 inches. Any failure in achievement cannot be ascribed to insufficient treatment. The same is true in regard to the older children, who were irradiated approximately with the same intensity. The only exception in the procedure was in the case of several children who developed pertussis and for this reason

* From the Home for Hebrew Infants.
1. Hess, A. F.: The Ultraviolet Rays of the Sun, J. A. M. A. **84**: 1033-1037 (April 4) 1925.
2. Eidinow: Brit. J. Radiol. **31**: 35 (Jan.) 1926.

Table 1.—*Clinical Data of Infants Treated for a Period of Months with Ultraviolet Rays*

Case No.	Prior to Irradiation				Periods of Irradiations																		Subsequent to Irradiation									
					0 to 1 Month						1 to 2½ Months						2½ to 4 Months						4 to 5 Months					5 to 6 Months				
	Age, Mo.	Wt., Lb.	Ht., In.	Hb. %	Age	Wt.,	Ht.	Hb. %	Infections	Exposure, Min.	Age	Wt.	Ht.	Hb. %	Infections	Exposure, Min.	Age	Wt.	Ht.	Hb. %	Infection	Exposure, Min.	Age	Wt.	Ht.	Hb. %	Infection	Age	Wt.	Ht.	Hb. %	Infection
Ward 1																																
1	4	11¼	24.6	90	5	13	25.2	85	—	81	6½	14¾	26.2	95	+	403	8	15¼	27.2	88	+*	178 and 284†	9	16½	27.6	85	—	10	17	28.1	89	+
2	7	17½	27.4	62	8	19¾	27.8	61	+	81	9½	20¼	27.8	53	+	403	11	21¼	30	53	+	178 and 284†	12	22½	30	51	—	13	22¾	31	53	—
3	5	14½	26	61	6	16½	28	78	—	81	7½	17¾	27	75	—	403	9	18¾	28	64	+	178 and 284†	10	20	28.2	50	+	11	20½	29	52	—
4	7	20¼	29.8	66	8	20½	30	62	—	81	9½	20¼	30.5	77	—	403	11	20¼	30.6	81	—	118	12	21¾	31.1	80	—	13	21¼	31.1	95	—
5	6	17¼	26.8	105	7	17½	....	95	—	81	8½	‡	27.2	80	+*	351	10	18¾	27.9	89	—	....	11	20½	28.8	89	+	12	21½	29.1	86	+
6	3	11¼	25.1	105	4	13½	....	91	—	81	5½	12¾	26	92	+	351	7	13	26.5	95	+*	....	8	14½	27	98	—	9	15¼	27.9	80	—
7	8½	22	28.3	55	9½	21¾	28.3	66	—	81	11	23	28.5	47	—	403	12½	23¼	29.6	50	+	178 and 284†	13½	23¼	30.5	65	+	14½	24	30.5	62	—
8	6	16¼	27	72	7	18	27.5	53	—	81	8½	19¼	28.2	60	+*	403	10	19½	29	58	+*	178 and 284†	11	20	29	76	—	12	20½	30	82	—
9	8	20¼	28.5	77	9	22	28.6	65	+	81	10½	23¾	28.6	60	+	403	12	24¾	30.1	62	+*	178 and 284†	13	25½	31.1	70	—	14	25½	31.1	76	+
10	9	17½	27.3	48	10	18½	27.5	45	+	81	11½	19	28.5	41	—	403	13	19¾	28.8	50	+*	178 and 284†										
11	6	15	26.1	75	7	15¼	26.2	70	+	81	8½	16¾	27.2	75	+	403	10	17¾	27.8	75	+	178 and 284†	11	19	28.6	71	+	12	20	29	72	—
12	7½	18¾	28	82	8½	21½	28.4	87	+	81	10	22½	29.5	75	—	403	11½	23	30.2	80	+*	178 and 284†	12½	24¾	30.5	90	—	13½	22	30.6	67	+*
Ward 8																																
1	25	24½	32.2	87	26	25¼	32.2	82	—	91	27½	25½	33.2	70	+	378	29	25¼	33.6	83	+*	204	30	26½	33.6	75	—	31	28	33.7	82	—
2	27	27¼	32.5	75	28	27½	33.5	85	+	91	29½	26½	34.2	78	+	378	31	‡	34.5	88	—	204 and 52†	32	‡	34.5	78	—	33	‡	34.6	79	—
3	17	25¾	31	87	18	25¼	32.4	87	+	91	19½	25¼	32.4	94	+	378	21	24½	32.6	71	—	204 and 292†	22	‡	33.2	81	—	23	‡	33.2	81	+
4	20	24¼	31	87	21	23½	32.4	81	—	91	22½	24¼	32.4	78	+	378	24	‡	32.8	90	—	204 and 52†	25	‡	32.8	92	+	26	25¼	33.1	82	—
5	12	20¾	29.2	80	13	20½	29.5	85	+	91	14½	21	30.2	77	+	378	16	21½	30.8	65	+	204 and 292†	17	22¼	31.2	72	+	18	‡	31.5	74	+
6	19	21¾	29.2	75	20	23	30.2	80	—	91	21½	23½	31.2	73	—	378	23	23½	31.2	75	—	204 and 292†	24	24¾	32.1	73	—	25	‡	32.2	83	—
7	21	27¾	32.5	82	22	27½	33	90	—	91	23½	28¼	33	90	—	378	25	‡	33	93	—	204 and 52†	26	‡	33.1	96	—	27	29	33.7	92	—
8	25	26¼	31.5	85	26	26	32.2	84	—	91	27½	25¼	32.2	72	—	378	29	26	32.5	78	+	204 and 292†	30	27½	32.5	89	—	31	27¾	33	89	—
9	22	24½	31	74	23	25	32	77	—	91	24½	25	32.9	88	—	378	26	25½	33.2	73	—	204 and 292†	27	26¼	33.2	82	—	28	26	33.8	89	+

* Multiple respiratory infections.
† Distance of lamp to the table was 30 inches, during the last month of irradiation; prior to this time it was 36 inches.
‡ Children isolated for pertussis were not weighed.

Table 2.—*Clinical Data of Infants Not Treated with Ultraviolet Rays*

Case No.	Prior to Irradiation				Period of Irradiation															Subsequent to Irradiation									
					0 to 1 Month					1 to 2½ Months					2½ to 4 Months					4 to 5 Months					5 to 6 Months				
	Age, Mo.	Wt., Lb.	Ht., In.	Hb., %	Age	Wt.	Ht.	Hb., %	Infection	Age	Wt.	Ht.	Hb. %	Infection	Age	Wt.	Ht.	Hb. %	Infection	Age	Wt.	Ht.	Hb. %	Infection	Age	Wt.	Ht.	Hb. %	Infection
Ward 1																													
1	9	23	30.2	75	10	24	30.2	65	—	11½	24½	31.5	67	—	13	24½	32.1	60	+*	14	24¾	32.3	74	—	15	24¾	32.8	65	+
2	10	13¼	26.4	63	11	13½	26.5	..	+	12½	15	26.6	92†	+	14	15¼	28	80	+*	15	15¾	29	91	—	16	15	29.5	68	+
3	15	15¼	26.7	60	16	17½	27.2	51	+*	17½	19¼	28	70	+	19	20	28.7	68	+*	20	22½	29.5	63	—	21	24	30.2	69	—
4	5½	12	24.4	80	6½	13¼	25.8	85	+	8	14½	26.4	83	+	9½	15	27.1	85	+	10½	16	27.8	84	—	11½	17	28.8	92	—
5	10½	22½	29.7	78	11½	24	30	70	—	13	24	31.5	49	—	14½	24	21.5	55	—	15½	24¾	32	68	—	16½	24¾	32	78	—
6	13	21	30.1	73	14	21¾	30.2	70	—	15½	22	31.2	47	—	17	22¾	31.5	45	+*	18	23¾	32.5	68	+	19	23¼	32.5	78	—
7	9	21	28.2	89	10	22	28.2	87	—	11½	22½	28.2	94	—	13	23½	28.5	84	+	14	23¾	29.2	82	+	15	23	29.2	94	—
8	10	21	29.5	80	11	19¼	30	89	+	12½	20	31	68	—	14	21½	31.5	84	+	15	21½	31.6	94	—	16	21¾	31.6	85	—
9	12½	23	30.1	68	13½	23	30.5	70	+	15	22¼	40.8	78	—	16½	21½	30.8	71	—	17½	21½	31.4	68	—	18½	‡	31.4	75	—
10	12½	19½	29.8	68	13½	20	29.8	64	+*	15	20	30	69	—	16½	20	30.3	65	+*	17½	21¼	31.6	72	—	18½	21½	31.7	82	—
11	14	21½	30.6	77	15	22¾	30.6	81	—	16½	23	31	85	—	18	22½	31.4	84	+	19	22	32.3	93	—	20	23	32.4	93	—
Ward 8																													
1	30	25	33.5	88	31	25	33.5	100	—	32½	24¾	33.7	90	—	34	25	34.6	85	+	35	‡	34.6	88	—	36	‡	34.8	88	—
2	22	22	30.2	77	23	23½	30.8	94	—	24½	24	31.4	75	—	26	24	31.8	77	+	27	25¾	31.8	72	—	28	26½	32	84	—
3	27	24½	31.5	100	28	24½	32.4	88	—	29½	25	32.6	98	—	31	24¼	33.9	95	+	32	26¼	33.9	98	—	33	26¼	34	98	—
4	20	29½	32	80	21	29¼	33	83	—	22½	30	33.7	86	—	24	29½	34.5	88	+	25	31¼	34.5	88	—	26	34	34.5	96	—
5	16	21½	30	79	17	20½	30	100	—	18½	20¼	30.5	93	—	20	21	31.5	90	—	21	21	31.9	91	—	22	21¾	32	89	—
6	22	25¾	32.8	83	23	26	32.8	95	—	24½	26	33.2	93	—	26	....	34	75	+	27	‡	34	85	—	28	27½	34.1	92	—
7	26	23½	32.3	91	27	22¾	32.5	98	—	28½	23½	33.1	80	—	30	....	33.9	85	+	31	‡	33.9	95	—	32	‡	33.9	90	—
8	26	28½	35.2	85	27	28½	35.2	90	—	28½	29¼	35.9	93	—	30	....	35.9	90	—	31	‡	35.9	85	—	32	28½	37.2	75	+*

* Multiple respiratory infections.
† Child was transfused several days prior to estimation of hemoglobin.
‡ Children isolated for pertussis were not weighed.

had to be placed under quarantine to prevent the spread of infection.

In considering the dosage of ultraviolet irradiation, it should be mentioned that at present all conceptions on this subject are entirely empiric and based on no accurate or scientific knowledge. No one can state, even with approximate accuracy, the correct dose of irradiation, either for the prevention or cure of rickets or for a general nutritional effect. It is our belief that at the present time ultraviolet irradiation is given in excess rather than in too small degree, and that it will be found that exposures of lesser intensity accomplish the same result and perhaps are of decided advantage.

The study of our data, especially in regard to the weight and the general nutrition of the children, gives support to this point of view. For example, during the first month of irradiation, when the total exposure had been only eighty-one minutes, the children, both small and large, increased in weight to a greater extent than the corresponding group which had not been irradiated (table 3). It would seem that there is an initial stimulation from the irradiation which reaches its maximum at about this time. During the subsequent months the gains were less, in both of the irradiated groups. Whereas infection no doubt played a rôle in these months, it did not confuse the comparative picture during the first month of the study.

TABLE 3.—*Effect of Irradiation on Growth in Weight (Average)*

Number of Children		Previous to Irradiation		Period of Irradiation: 0 to 1 Month		1 to 2½ Months		2½ to 4 Months		Subsequent to Irradiation: 4 to 5 Months		5 to 6 Months	
		Age, Mo.	Weight, Lb.	Weight, Lb.	Gain, Oz.	Weight, Lb.	Gain, Oz.	Weight, Lb.	Gain, Oz.	Weight, Lb.	Gain, Oz.	Weight, Lb.	Gain, Oz.
	Ward 1												
12	Irradiated	6½	16¾	18¼	22	19	15	19¾	9	20¾	16	21	4
11	Nonirradiated	11	19½	20	12	20½	8	21	6	21½	10	21¾	3
	Ward 8												
9	Irradiated	21	24¾	25	2	25	1	24½	—8	25½	16	27¼	28
8	Nonirradiated	23½	25	25	0	25½	4	24¾	—10	26	22	27½	22

In regard to growth as indicated by increase in height, it is difficult to express a definite opinion. The variations among individuals, as the result of hereditary and other factors, are so great that large numbers of observations are necessary in order to make the conclusions of value. It can be stated, however, that in the small series of children which we followed (table 6) no superiority in this respect was brought about by several months of irradiation.

TABLE 4.—*Incidence of Respiratory Infection*

Number of Children		Period of Irradiation: 0 to 1 Month	1 to 2½ Months	2½ to 4 Months	Subsequent to Irradiation: 4 to 5 Months	5 to 6 Months
	Ward 1					
12	Irradiated	5	9	16	4	5
11	Nonirradiated	8	3	14	2	2
	Ward 8					
9	Irradiated	3	5	4	2	3
8	Nonirradiated	0	0	6	0	3

TABLE 5.—*Effect of Irradiation on Hemoglobin (Average Percentage)*

Number of Children		Previous to Irradiation	Period of Irradiation: 0 to 1 Month	1 to 2½ Months	2½ to 4 Months	Subsequent to Irradiation: 4 to 5 Months	5 to 6 Months
	Ward 1						
12	Irradiated	75	71	69	68	75	74
11	Nonirradiated	67+	66+	67+	66+	78	80
	Ward 8						
9	Irradiated	81	83	80	78+	82	83+
8	Nonirradiated	85+	92	88+	85	88	89

As stated, one of the many benefits that we hoped to derive from this ultraviolet therapy was a diminution of the frequent infections to which all children are prone throughout the winter months. A glance at the accompanying tables shows the failure of our efforts. Despite irradiation, the number of infections increased after November, as is customary at this season of the year. In fact, it will be seen in table 4 that the irradiated children in the ward comprising the younger infants developed a greater number of infections during the second period than the children who were not irradiated; the same is true for the older children in regard to the first and second periods. Had the result been the reverse, we might well have ascribed the benefit to the action of irradiation. The infections involved almost entirely the respiratory tract. It is evident that we cannot hope to eradicate this menace by means of ultraviolet ray therapy.

TABLE 6.—*Effect of Irradiation on Growth in Height (Average)*

Number of Children		Previous to Irradiation		Period of Irradiation: 0 to 1 Month		1 to 2½ Months		2½ to 4 Months		Subsequent to Irradiation: 4 to 5 Months		5 to 6 Months	
		Age, Mo.	Height, Inches	Height, Inches	Growth, Inches	Height, Inches	Growth, Inches	Height, Inches	Growth, Inches	Height, Inches	Growth, Inches	Height, Inches	Growth, Inches
	Ward 1												
12	Irradiated	6½	27.1	27.5	0.4	27.9	0.4	28.8	0.9	29.3	0.5	29.8	0.5
11	Nonirradiated	11	28.7	29	0.3	29.7	0.7	30.1	0.4	30.8	0.7	31.1	0.3
	Ward 8												
9	Irradiated	21	31.1	31.9	0.8	32.4	0.5	32.7	0.3	32.9	0.2	33.2	0.3
8	Nonirradiated	23½	32.2	32.5	0.3	33	0.5	33.8	0.8	33.8	0	34.1	0.3

The estimations of hemoglobin that are recorded in table 5 indicate that the fluctuations are more marked and that the average percentage is lower in young than in older infants. In the former group the hemoglobin remained stationary among those who were not irradiated, but even decreased in those who were exposed to the rays of the mercury vapor lamp. In the older children we note a similar result, the percentages of hemoglobin being less favorably affected in those of the irradiated group rather than in the nonirradiated. With the advent of spring and warmer weather and the absence of infection, which always accompanies this season of the year, the hemoglobin of all the children, younger and older, showed a definite increase, which is to be ascribed probably more to a lack of infection than to a change in metabolism.

As stated, owing to the outbreak of pertussis after the irradiation had been started, an opportunity was afforded for the study of its prophylactic and curative value. Gettinger [3] recently reported his experience with the mercury vapor lamp in twelve children suffering from pertussis. His results were uniformly more favorable with irradiation than with any other form of therapy. Marked improvement was noted after the first few exposures, in regard both to vomiting and to the intensity of the paroxysms. The incidence of pertussis in both of our wards during the period of irradiation, as indicated in table 7, shows that the irradiation had little or no effect. Four children in one ward and three in another developed pertussis in spite of having been irradiated for several months prior to the onset of pertussis. Had irradiation any prophylactic value, it should have been manifested after three months of exposure. No curative effect was observed in regard either to the severity or to the duration of the disease.

TABLE 7.—*Incidence of Pertussis*

Number of Children		Period of Irradiation		
		0 to 1 Month	1 to 2½ Months	2½ to 4 Months
	Ward 1			
12	Irradiated	2	1	1
11	Nonirradiated	4	1	2
	Ward 8			
9	Irradiated	0	0	3
8	Nonirradiated	0	0	3

A coincidental outbreak of varicella occurred during the period of irradiation. Twelve of the irradiated and fourteen of the nonirradiated children developed varicella. The eruption of the former group was more intense than that of the latter.

It was of interest to note the effect of the rays on the skin. Instead of the reddish tan observed after exposure to the sun, the skin became muddy brown, a tint that persisted for about a month after irradiation. The turgor of the muscles was greatly improved; comparing the tonicity of the muscles of the poorest of the irradiated group with that of our best nourished infants, the superiority of the former in this respect was unquestionable. To judge from the texture of the skin and the firmness of the muscles, one might readily have mistaken them for breast fed infants.

During our preliminary examination, the liver, spleen or both were found to be enlarged in several of the infants. It was of interest to ascertain whether ultraviolet irradiation influenced the size of these organs, especially in view of the fact that the roentgen rays have been found to diminish the size of glandular and lymphoid organs, such as the tonsil and the spleen. Subsequent examinations showed that these organs either remained uninfluenced or were variable in size, being palpable at one time and not felt at another. Several infants who evinced no enlargement of these organs prior to irradiation were found to have a palpable spleen or liver at one or more of the subsequent examinations. This variability probably depended on the presence or absence of infection quite irrespective of irradiation.

3. Gettinger, J. H.: Actinotherapy in Pediatrics, Arch. Pediat. **18**: 251 (April) 1926.

CONCLUSION

Irradiation of infants with the mercury vapor lamp was found to be associated with an initial increase in weight. This did not continue during the subsequent months. Irradiation did not lessen the number of infections during the winter. During the spring, however, there was a definite decrease in infection. Ultraviolet rays did not protect against or mitigate pertussis. The hemoglobin was not increased by irradiation, but its percentage rose with the advent of spring and the diminution of infections. Irradiation improved the texture of the skin and the turgor of the muscles. The pigmentation brought about by the mercury vapor lamp differed somewhat in hue from that which followed heliotherapy.

1749 Grand Concourse.

THE LOCALIZATION IN ANIMALS OF BACTERIA ISOLATED FROM FOCI OF INFECTION *

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The rôle of bacteria, as found in various foci of infection, is extremely important. Although bacteria rarely enter the blood stream under normal conditions, they do harbor and thrive in various crypts, pockets or secluded spots in which there is imperfect drainage and which are therefore called foci. Occasionally, when conditions are suitable, the bacteria acquire enough virulence to invade other regions and then cause disease. Most observers who consider adequately all the facts agree that the bacteria as found in the various foci at times influence other parts of the same body in which they live. This view was voiced by Rush,[1] in 1801, who said, "I have been made happy by discovering that I have only added to the observations of other physicians, in pointing out a connection between the extracting of decayed and diseased teeth and the cure of general disease."

Billings [2] has given us the concrete conception of focal infection and has emphasized its importance in arthritis, endocarditis and nephritis. Rosenow,[3] in a long series of experiments, has emphasized the importance of the elective localizing power of bacteria as a cause of various diseases, and has produced lesions repeatedly in animals which correspond to the various lesions of man. Rosenow and Meisser [4] have produced

* From the Division of Experimental Bacteriology, the Mayo Foundation.

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