THE EFFECT OF IRRADIATION WITH ULTRA-VIOLET LIGHT ON THE FREQUENCY OF ATTACKS OF UPPER RESPIRATORY DISEASE (COMMON COLDS).*

By

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Introduction.

Published reports are at variance concerning the prophylactic value of ultra-violet light in acute upper respiratory disease. On the positive side, Maughan and Smiley (1928) claim beneficial results. These workers administered, during winter months, a quantity of ultra-violet radiation considered equivalent to that to which the ordinary city dweller is exposed in summer. Five groups of persons were employed, for the most part college students. Group I consisted of 23 adult males who considered themselves very susceptible to colds, having usually four or more per year. This group was irradiated from November 3, 1926, to January 28, 1927. The control (group II) consisted of 58 adults, of similar age and considered to be of similar susceptibility, who were observed over the same period, but not irradiated. Group III was composed of 11 adults also considered to be "cold susceptibles." These persons were irradiated from November 3, 1926, to March 19, 1927. The control for group III consisted in the number of colds which the subjects recalled that they had suffered during the previous winter. Group IV was also composed of 11 susceptible adults, irradiated from December 1, 1926, to March 26, 1927. The control in this case was similar to that for group III. Finally, group V consisted of 13 susceptible children, irradiated from December 1, 1926, to March 19, 1927. The control in this instance was the number of colds remembered by the mothers as occurring during the previous winter. Light doses were used. The authors summarize their report as fol-

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lows: "A ten-minute irradiation of the naked body with the ordinary mercury vapor lamp at a distance of 30 inches once a week throughout the dark period of the year resulted, in four groups of persons (58 persons), in a reduction in the frequency of colds of from 27.9 to 40.3 per cent."

In a second report the same authors (1929), dealing exclusively with "cold-susceptible" college students, state that in the period from November 2, 1927, to January 25, 1928, a group of 23, irradiated as in the previous experiment, had an average of only 1.56 colds per person, as compared to 2.80 per individual for a control group of 26 students, not irradiated and considered comparable in susceptibility. The experiment was repeated between January 25 and March 29, 1928, 21 "cold-susceptibles" constituting the irradiated, and 24 the control group. A similar positive result was again obtained.

On the other hand, Barenberg and Lewis (1928) report negative results, using much heavier and more frequent dosage. Nine infants were exposed naked to the rays of a carbon arc, for a period of 30 minutes and at a distance of 24 inches, on alternate days from December 15 to March 15. A summary made at the end of this period showed that these children had had rather more colds than a control group of 10 infants who were not irradiated.

In a carefully controlled study in which those to be irradiated were chosen by lot, Colebrook (1929) also was unable to demonstrate any measurable effect on the health of school children exposed to a carbon arc lamp with a high output of ultra-violet rays. In all, 287 school children, of ages five to seven years inclusive, were kept under medical supervision from the end of August, 1927 to the end of March,1928. Of these, 101 were irradiated by light from a naked carbon arc (unscreened group); 94 were exposed to a similar lamp from which radiation of wave length shorter than 3200 A. U. was cut off by window glass (screened group); and 92 children received no irradiation (control group). The dosage used was moderate, the standard aimed at being exposures "of such an intensity that an erythema reaction would be just avoided on the skin of a child of average sensibility, and, by very slowly increasing the intensity of irradiation, to maintain that level throughout." A comparison of the results showed slight advantage to the screened and control groups in respect to the number of colds per child. The average "duration per cold" was the same in the three groups.

Methods adopted in the present study.

The contradictory nature of these reports led to the present study, which was carried out in Baltimore during the academic year 1929–1930, as a part of the program of the John J. Abel Fund for Research on the Common Cold. The facilities for carrying out such an experiment are considered to have been unusually advantageous, especially the availability of an organization, set up during 1928, for securing notification and obtaining detailed records of all types of respiratory disease occurring in a large group of adult volunteers.

Particular attention was paid to four features considered to be essential: Firstly, that each group, irradiated and non-irradiated respectively, should consist of a large enough number of persons to yield results of statistical significance; secondly, that the two groups should be comparable in all respects, so far as is known, save in the factor of exposure to ultra-violet light; thirdly, that the radiations from the lamps should be carefully measured; and finally, that the effort to secure reports of attacks of respiratory disease should be equally vigorous and thorough in the two groups.

The cooperation of 363 adult volunteers was secured. Of these, 244 were students in the School of Medicine, and 119 students in the School of Hygiene or members of the faculty or of the technical staff. Of the group, 279 or 76. 9 per cent were males; 228 or 63 per cent were between 20 and 25 years of age; 66 or 18 per cent between 25 and 30, and 64, or 17.6 per cent over 30 years. Five were under 20 years of age.

Observation was commenced on September 29, 1929, and terminated on May 31, 1930, 35 weeks later. The irradiation clinic was actually in operation from October 2, 1929, to May 3, 1930, a period of approximately 31 weeks. It was conveniently located in the School of Hygiene and Public Health, where three rooms were made available. The largest of these was equipped with three mercury-vapor lamps (Hanovia Alpine Sun Mercury Arcs, Luxor Model, 110 D. C.) and three cots, and was used for males. A smaller room, equipped with a similar lamp and cot, was used for females. Entrance to these treatment rooms was possible only through the third, which served as an office. At least one skilled attendant, and usually two, were on duty during clinic hours.

Selection of those to be irradiated.—Those to be offered irradiation were selected at random as follows: A list of 373 volunteers, expected to be in residence, was given to Professor Lowell J. Reed with the request that he select approximately one half for irradiation. From

this irradiation group, he was requested also to select about two thirds for one treatment weekly (A). The remaining third was to be offered two treatments weekly (B). The other half of the volunteers constituted the control group C.*

At the commencement of the period of observation it was found that 10 persons included in the draw had to be withdrawn from the experiment, for reasons unconnected with their susceptibility to colds. Of these, seven, for various reasons, did not take up residence in the University during the academic year 1929–30. The remaining three individuals did not wish to enter the experiment on account of the inconvenience involved. Omitting these persons, there remained in group A, 116, and in group B, 63 persons, a total of 179 to be irradiated. In group C, the control group, there remained 184 persons.

Classification according to number of treatments actually received.—Certain of those in group B found it possible to attend only once weekly and thus transferred themselves into group A. Also, while the attendance † was remarkably good, many in both groups missed one or more of their scheduled treatments, chiefly because of absence during one or all of the short vacation periods. On account of these facts, it has been considered a simpler procedure to combine groups A and B and classify the irradiated persons as a whole according to the number of treatments received, rather than to hold to the original groupings (table 1).

TABLE 1.

Individuals selected for irradiation classified according to the number of treatments actually received.

	Number of treatments.								
	None	1–4	5–9	10–19	20–29	30–39	40–49	50 and over	Total
No. of individuals.....	5	4	1	15	76	39	11	28	179

* The method used by Professor Reed was to represent each volunteer by a die. Thus 122 white dice represented group A; 66 red dice group B and 185 black dice group C. The dice were thoroughly mixed in a sampling machine known to be practically free from systematic error. They were then withdrawn from the bottom of the machine one at a time. The name of each volunteer was written on a card and the cards were arranged alphabetically. The first die drawn being black, indicated that the first individual on the list belonged to the control group; the next happened to be red and indicated that the second name belonged to group B, etc.

† The number of treatments given weekly usually ranged from 185 to 195. The maximum given was 205 and the lowest 136 (week preceding Easter).

It is seen in table 1 that 10 individuals, constituting 5.6 per cent of those chosen for irradiation, received either no treatments, or fewer than ten. These individuals may all be regarded as receiving no irradiation and are classed separately throughout this study. Of the remaining 169, 154, or 91.1 per cent, received 20 or more treatments during the period.

Comparative susceptibility of irradiated and control groups.—Save for the possible effect of the exclusions noted, the irradiation group proper, consisting of 169 individuals, may reasonably be assumed from the manner of selection to have possessed the same proportions of susceptible and of resistant individuals, within the limits of chance variations, as the control group. Obviously, no absolute proof of this assumption can be given, but certain facts directly support it. From statements made at the time of enrollment, for example, it is found that 71, or 42.0 per cent, of these 169 persons, and 77, or 42.1 per cent, of the control group, gave a history of having usually four or more colds per annum. Also 62, or 36.7 per cent, of the former and 69, or 37.7 per cent, of the latter stated at that time that they usually had two colds or fewer per year.

TABLE 2.

Relative susceptibility of irradiation and control groups as evidenced by previous records of 162 volunteers.

Number of attacks October, 1928 to June, 1929	Number of re-enrolled individuals suffering designated number of "colds" (from actual records of attacks during previous academic year)		
	Irradiation group		Control group
	More than 10 treatments (79)	Fewer than 10 treatments (4)	(79)
0	6	1	1
1	9	1	11
2	19	1	19
3	16	1	19
4	14	0	13
5	12	0	11
6 and over	3	0	5

Fortunately, also, the susceptibility of a considerable number of the volunteers is very accurately known from our records. Of the 363 persons enrolled, 162 had reported their colds continuously during the period October 1, 1928 to June 1, 1929. Of these 83 were chosen to be irradiated and 79 received 10 treatments or more. The remainder, also numbering 79, fell into the control group.

If these 162 individuals had been divided fairly, with respect to susceptibility, it is a fair assumption that this was true also of the division of those newly enrolled. The distribution of these "old volunteers," of the irradiation and control groups respectively, according to the number of attacks reported during the previous academic year, is therefore of pertinent interest and is given in table 2. It is seen to be almost identical for the two groups. The average number of attacks per person was, for the 79 of the irradiation group proper, 2.9 per person; and for the 79 of the control group, 3.1 per person.

The fairness of Professor Reed's drawing and the fact that it is not materially affected by the omissions noted, is also strikingly illustrated by a comparison of the relative frequency of certain characteristics in the two groups (table 3).

The characteristics chosen are of a varied nature and were selected chiefly because requisite data happened to be available with respect to all of them for a high proportion of the volunteers. It is seen that the resemblance of the two groups with respect to the thirteen characteristics chosen is remarkable in practically every instance. Only in the classification of the individuals with respect to adenoids does there appear to be anything like a real difference between the groups; and, in this instance, if the problem be regarded as one in simple sampling, a difference as great or greater might be expected about twice in a hundred trials.*

Technique of irradiation.—The intensity of each lamp was measured every other week by the zinc sulphide method. This consists in exposing a paste of zinc sulphide in saturated lead acetate solution, pressed under a quartz plate, to the mercury arc, and finding the time necessary to darken the paste from a reflection factor of 70 to one of 50 per cent. This is the time necessary to give one ZnS unit of ultra-violet radiation. Only wave lengths shorter than 313 mμ produce this darkening so the intensity of erythema-producing rays only is measured. In the region 290–313 mμ, one ZnS unit is equal to 720,000 ergs per sq. cm. but the exact value of the unit in ergs cannot be given when the total radiation down to 200 mμ is used.

* If moderately large or large masses of adenoids be assumed to predispose to colds in adults, the irradiation group would be expected to have fewer attacks than the control on account of this peculiarity in constitution. As a matter of fact, our records indicate that the presence of an excessive amount of adenoid tissue in adults is not of significance as regards frequency of attack. Amonig continuous volunteers, for the 35 weeks' period, the average number of cases was 2.5 for persons with moderately large or large adenoids, and 2.7 for persons with small or no adenoids.

A new burner gave approximately one ZnS unit in one minute at 24 inches. All deteriorated with use. Bi-weekly testing, however, with the necessary replacement and adjustment of distance and time of exposure, was sufficient to keep very accurate control of the amount of

TABLE 3.

Frequency (per cent) of various characteristics, (a) irradiation and (b) control groups.

	(a)	(b)		(a)	(b)
Total number of individuals...	169	184	Total number of individuals .	169	184
1. Group			7. History of prior tonsillectomy		
Med. school.....	68.0	68.5	Yes.....	55.0	56.5
Sch. of Hyg. and staff.....	32.0	31.5	No.....	45.0	43.5
2. Birthplace			8. Breathing space		
Maryland.....	16.0	16.8	Both sides good..	65.8[c]	74.1[c]
U. S. exclusive of Md.....	76.3	75.0	One or both sides not good.....	34.2	25.9
Outside of U. S.....	7.7	8.2			
3. Age in years			9. Clouding of one or both antra (x-rays)		
0–19.....	2.4	0.5			
20–24.....	62.1	65.8	Yes.....	13.7[d]	20.3[e]
25–29.....	17.8	17.9	No.....	86.3	79.7
30 and over.....	17.8	15.8	10. Adenoids		
4. Sex			Small or none....	80.0[c]	68.3[f]
Male.....	78.1	77.7	Moderate or large	20.0	31.7
Female.....	21.9	22.3	11. Cold baths daily		
5. Marital status			Yes.....	22.5	26.9[a]
Single.....	80.5	81.9[a]	No.....	77.5	73.1
Married or widowed	19.5	18.1	12. History of measles		
6. Eye color (Martin's scale)			Yes.....	91.7[b]	87.8[g]
Nos. 1– 4.....	16.7[b]	19.8[a]	No.....	8.3	12.2
" 5– 8.....	32.1	31.3	13. History of influenza		
" 9–12.....	25.0	20.3	Yes.....	52.7	50.0
" 13–16.....	26.2	28.6	No.....	47.3	50.0

[a] Unknown for 2 individuals.
[b] " " 1 "
[c] " " 14 "
[d] " " 8 "
[e] " " 12 "
[f] " " 20 "
[g] " " 3 "

ultra-violet radiation to which each person was exposed. A table such as the following (table 4), was attached to each lamp and corrected once each fortnight as required.

TABLE 4.

Method of control of operation of lamps: Illustrative data from lamp III.

Distance	1 unit	1½ unit	3 units	5 units	6 units
18.5 inches.....	50 sec.	—	2.5 min.	4 min. 10 sec.	5 min.
20.0 "	1 min.	1.5 min.	3 "	5 "	6 "
25.0 "	1.5 "	2.25 "			

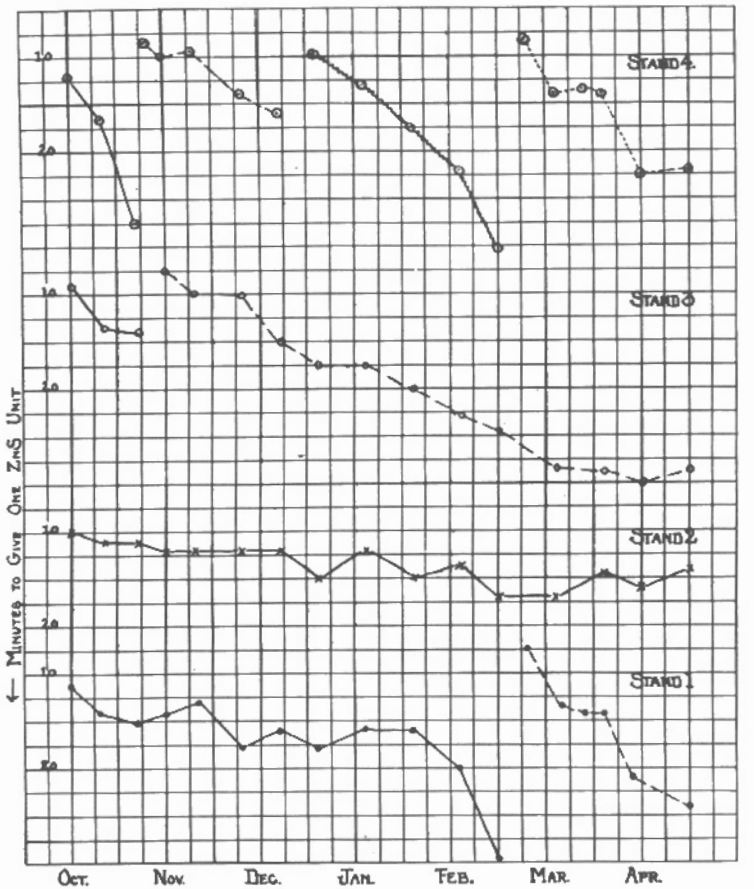

FIG. 1. Rate deterioration of quartz burners.

Of the nine burners used in the experiment, three had to be replaced on account of deterioration. (Fig. 1: Burner 1, Stand I; and Burners 1 and 3, Stand IV.) A fourth (Burner 2, Stand IV) was accidentally

destroyed; and a fifth (Burner 1, Stand III) was replaced because one known to be more efficient was on hand. It will be noted in the figure that the burners deteriorated very rapidly on Stand IV, possibly because of some defect in another part of the apparatus. This stand was used in the female treatment room and had not the rapid decrease in intensity been detected, the entire group of women would have received practically no irradiation.

Only light to moderate dosage was employed, the standard aimed at being for practical purposes that of Colebrook (1929), namely, to keep at the level of the minimal erythema dose. On the initial treatment, one ZnS dose gave a slight erythema to approximately one half of the subjects (44 per cent of the males and 51 per cent of the females). Certain sensitive individuals continued to react to small doses and could not be given more than three or four units, even late in the experiment. As a rule, however, tolerance gradually increased. A few individuals, on the other hand, were quite resistant and never had any erythema, even with the maximum dose used, five to six units.

The method of procedure was as follows: Each volunteer was stripped to the waist and irradiation was commenced on the back, only one unit being given at the outset. If, at the next treatment, the subject reported an erythema, the dose was repeated. Otherwise, the dosage was increased by one half unit each period until five to six units were given. Thus the amount of irradiation was regulated as closely as possible to suit individual sensitivity. When the five to six level was reached, the chest and abdomen were exposed instead of the back, at first only to one unit, but gradually increasing as before. After reaching five to six units on the front of the body, the cycle was repeated.

Method of securing reports of attacks.—For the purpose of securing as high a degree of completeness of reporting as possible, the volunteers were divided into small groups, for each of which a paid student assistant was responsible. For the medical students these groups numbered from 17 to 22 each, while in the School of Hygiene 104 persons were divided between three assistants. A negative or positive statement with regard to respiratory disease was requested at least three times weekly. If a cold was reported a detailed symptomatological record was secured and the case was followed to recovery. There were of necessity certain exceptions to the regularity of reporting. At the Thanksgiving recess the majority of the volunteers were absent for four days; at Christmas for 12 days, and at Easter for four days. At the conclusion of each of these periods, efforts were made to secure reports of cases during absence. During the Christmas vacation, each

volunteer also was provided with a special case card on which to note any respiratory illness. From the number of reports received it is felt that few cases were overlooked during these brief holiday periods.

Analysis of incidence in irradiated and control groups.

During the entire period of 35 weeks, there were reported, among all 363 volunteers, 930 attacks of acute upper respiratory disease, exclusive of cases of follicular tonsillitis, peritonsillar abscess, acute specific fevers and of illnesses of one day or less. Of this total, 460 were among those irradiated and receiving more than 10 treatments; 19 in the group receiving fewer than 10 treatments and 451 in the control group.

In making a computation of the gross attack rate for the period it is necessary to take cognizance of the fact that a few volunteers were not under continuous observation. The total of such persons was 23, of whom six belonged to the irradiation group proper, three to those receiving fewer than 10 treatments and 14 to the control group. Since the distribution of weeks of attendance for non-continuous volunteers, belonging to irradiation and control groups respectively, corresponds at least roughly,* comparison may be made with a sufficient degree of accuracy by expressing the risk of each group as the ratio of reported cases to student-weeks of exposure. Thus calculated, the rates are given in table 5, and show no apparent benefit to those irradiated. On the contrary, the rate for the control group is somewhat lower.

TABLE 5.

Gross attack rates per 1000 student-weeks† of exposure, for irradiated and control groups, September 29, 1929 to May 31, 1930.

Group	No. of indiv.	Stud.-weeks of exposure	No. of attacks	Attack rate per 1000 stud.-weeks of exposure
Irradiation:				
Receiving 10 or more treatments.....	169	5853	460	78.6
" less than 10 "	10	307	19	61.9
Control.....	184	6276	451	71.9
Total.....	363	12436	930	74.8

* A volunteer reporting continuously is counted as having 35 student-weeks of exposure. Absence for more than three days of any week constitutes loss of a student-week of exposure.

† This fact may be checked from data given in table 6.

TABLE 6.

Average strength, number of attacks and per cent attacked, for irradiation and control groups, by weeks, September 29, 1929 to May 31, 1930.

Week ending	Strength			Number of attacks			Per cent attacked	
	Irrad. >10	Irrad. <10	Control	Irrad. >10	Irrad. <10	Control	Irrad. >10	Control
Total	—	—	—	460	19	451	—	—
1 Oct. 5	167	9	183	31	2	30	18.6	16.4
2 12	167	9	183	19	1	35	11.4	19.1
3 19	167	9	183	22	0	13	13.2	7.1
4 26	167	9	183	15	2	9	8.8	4.9
5 Nov. 2	167	8	182	9	0	13	5.4	7.1
6 Nov. 9	167	8	182	12	1	9	7.2	4.9
7 16	167	8	182	9	1	9	5.4	4.9
8 23	167	8	182	16	1	13	9.6	7.1
9 30	167	8	182	14	0	18	8.4	9.9
10 Dec. 7	167	9	183	21	0	21	12.6	11.5
11 Dec. 14	168	9	183	18	1	14	10.7	7.6
12 21	168	9	183	10	0	10	6.0	5.5
13 28	168	9	183	13	0	11	7.7	6.0
14 Jan. 4	169	9	183	22	0	19	13.0	10.4
15 11	169	9	182	11	1	16	6.5	8.8
16 Jan. 18	169	9	182	12	1	18	7.1	9.9
17 25	169	9	182	12	0	16	7.1	8.8
18 Feb. 1	169	9	182	17	1	12	10.1	6.6
19 8	169	9	182	12	0	15	7.1	8.2
20 15	169	9	180	14	0	15	8.3	8.3
21 Feb. 22	169	9	180	13	0	10	7.7	5.6
22 Mar. 1	169	9	180	6	0	13	3.6	7.2
23 8	167	9	178	14	0	12	8.4	6.7
24 15	167	9	178	10	0	10	6.0	5.6
25 22	167	9	178	18	2	17	10.8	9.6
26 Mar. 29	166	9	178	9	1	6	5.4	3.4
27 Apr. 5	166	9	176	10	0	9	6.0	5.1
28 12	166	9	176	15	0	9	9.0	5.1
29 19	166	9	176	7	0	9	4.2	5.1
30 26	166	9	173	13	1	10	7.8	5.7
31 May 3	166	9	172	11	1	11	6.6	6.4
32 10	166	9	171	1	0	7	0.6	4.1
33 17	165	8	171	7	0	7	4.2	4.1
34 24	165	8	171	13	2	2	7.9	1.2
35 31	165	8	171	4	0	3	2.4	1.8

At no time during the period, in fact, did the attack rates show any appreciable advantage to those irradiated. This is strikingly depicted in fig. 2, in which are shown, week by week, the attack rates for both groups. The basic data from which these rates are calculated are given in table 6.

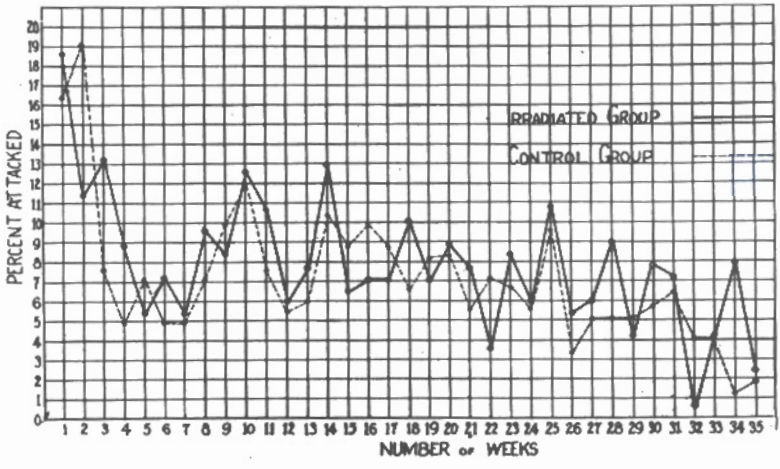

FIG. 2. Incidence of upper respiratory attacks, irradiated and control groups, by weeks, September 29, 1929, to May 31, 1930.

It is of interest also that the proportion of those suffering any designated number of attacks did not differ materially as between the two groups. Continuous volunteers are thus classified in table 7 and it is apparent that there is no significant difference in this respect between those irradiated and the others.

Incidence among cold susceptibles of each group.—As already noted, 71, or 42.0 per cent, of the 169 persons receiving 10 or more treatments, and 77, or 42.1 per cent, of those not irradiated, gave a history, on enrollment, of having usually four or more colds per annum. And, as is also noted above, a record of respiratory attacks, believed to be quite accurate, is available for certain of the volunteers for the period October 1, 1928, to June 1, 1929. From the data given in table 2, it is seen that 29 of these individuals, allotted to the irradiation group, and 29 other persons who fell into the control group, had four or more recorded attacks during this period.

Since the favorable reports of Maughan and Smiley (1928 and 1929) were based on irradiation of persons giving a history of having usually four or more colds per annum ("cold susceptibles"), we have made a

tabulation along similar lines for irradiated and control groups, the members of each being classified from their statements into those having *fewer than* and *more than* four colds per annum respectively. For those individuals for whom there is an actual record for the previous

TABLE 7.

Distribution of continuous volunteers, of irradiation and control groups respectively, having designated number of attacks, September 29, 1929 to May 31, 1930.

No. of attacks	Irradiation		Control
	Receiving 10 or more treatments	Receiving less than 10 treatments	
0	12	2	18
1	24	1	27
2	34	0	46
3	44	2	41
4	33	1	22
5	8	0	8
6	5	1	2
7	0	0	4
8	2	0	2
9	1	0	0
Total continuous volunteers	163	7	170
Total number of attacks	451	17	426
Total non-continuous volunteers	6	3	14
Total number of attacks	9	2	25

academic year, a separate tabulation is made. These statistics are presented in table 8, and it is apparent from inspection that, in this experiment, those especially susceptible to colds did not receive any benefit from irradiation. The control group has, in each case, a somewhat lower rate than those irradiated, the difference, however, being of questionable significance from a statistical point of view.

Incidence in relation to amount of irradiation.—The members of the irradiation group may be classified either according to the number of attendances or according to the number of ZnS units to which they were exposed during the period. As might be expected, these classifications are not distinct from one another. This may be judged from the fact that of the 80 individuals receiving 50–99 ZnS units, 63 at-

TABLE 8.

Attack rates per 1000 student-weeks of exposure for "cold susceptible" individuals only, of irradiated and control groups.

Group	"Cold susceptibility" from enrollment histories[a]				"Cold susceptibility" from records of 1928–1929[b]			
	No. of indiv.	Stud.-weeks of exposure	Total no. of attacks Oct. '29–June '30	Rate per 1000 stud.-weeks exposed	No. of indiv.	Stud.-weeks of exposure	Total no. of attacks Oct. '29–June '30	Rate per 1000 stud.-weeks exposed
Irrad. > 10	71	2452	227	92.6	29	1015	100	98.5
Control	77	2646	212	80.1	29	1002	94	93.8

[a] These 148 individuals each stated that they had usually four or more colds per annum.

[b] These 58 individuals each had four or more recorded attacks between September 30, 1928 and June 1, 1929.

tended on from 10–29 occasions. Similarly, of the 73 individuals receiving 100 or more ZnS units, 60 had 30 or more attendances to their credit (table 9).

TABLE 9.

Incidence of colds during the 35 weeks period, for individuals classified according to the number of treatments received and the number of ZnS units to which they were exposed.

(a) Classification according to no. of treatments.

No. of treatments	No. of individuals	Student-weeks exposed	No. of attacks	Attack-rate per 1000 student-weeks
0– 9	10	307	19	61.9
10–29	91	3169	239	75.4
30–62	78	2684	221	82.3
Total	179	6160	479	77.8

(b) Classification according to no. of ZnS units.

No. of units	No. of individuals	Student-weeks exposed	No. of attacks	Attack-rate per 1000 student-weeks
0– 49	26	854	53	62.1
50– 99	80	2797	212	75.8
100–249	73	2509	214	85.3
Total	179	6160	479	77.8

(c) Control group.

Amount of radiation	No. of individuals	Student-weeks exposed	No. of attacks	Attack-rate per 1000 student-weeks
None	184	6276	451	71.9

Inspection of table 9 shows that those attending more frequently and exposed to a greater amount of radiation suffered slightly higher rates than the other members of the group. The excess, however, is not great, and may be due to chance. It is not contended that the risk of attack increased with greater exposure.

It is of interest also that sensitivity to ultra-violet light does not seem to be related to susceptibility to colds. For 32 persons who frequently reported an erythema following treatment, and who were continuously enrolled, the average number of colds for the period was 2.7; while for 41 persons who rarely or never reported an erythema, the average was 2.9.

Severity of attack in irradiated and control groups.—Although no benefit to those irradiated is indicated so far as total attack rates are a measure, yet it is important also to study the relative severity of the cases occurring in the two groups, since any difference in this respect would likewise indicate a difference in host-resistance. Five standards of severity have been selected: (*a*) the relative frequency of cases absent from duty on two days and also in bed on one or more days; (*b*) the relative frequency of cases with fever on the first or second day of illness or on both (primary fever); (*c*) the relative frequency of cases afebrile on the first or second day but developing fever later (secondary fever); and as an indication of extent of local involvement, (*d*) the relative frequency of cases with a productive cough. Finally (*e*) a comparison is made of the duration of illness in the two groups.

Data concerning the first four of these criteria are presented in table 10. No material differences are demonstrable with respect to the comparative frequency of cases ill enough to be off duty on two or more days whether or not they were in bed. This is true also of the frequency of cases with primary fever and of those with cough and expectoration.

With regard to cases with secondary fever, there is an apparent difference in favor of the irradiated group. Even with respect to this type of case, however, the difference between the groups is of questionable significance from a statistical point of view. Among 911 total cases there occurred 66 with secondary fever, a frequency of 7.2 per cent. In the irradiated group 25 of 460 are in this class and in the control group 41 of 451; the percentage frequencies being 5.4 and 9.1 respectively. If the problem be regarded as one in simple sampling in which samples of 460 and 451 are drawn from a universe in which the proportions having fever and not having fever are .0724 and .9276 respectively, the ratio of the observed difference to its standard error

is 2.13, and the probability of getting a difference as great or greater than that observed is about three in a hundred trials.

TABLE 10.

Attack rates per 1000 student-weeks of exposure, for cases classified according to certain standards of severity, for irradiation and control groups, respectively.

Index of severity	No. of attacks		Attack rate per 1000 stud.-weeks of exposure	
	Irradiation group	Control group	Irradiation group (5853 stud.-weeks)	Control group (6276 stud.-weeks)
Off duty on 2 or more days and in bed	39	39	6.6	6.2
Off duty on 2 or more days	42	45	7.2	7.2
Primary fever				
Total [1]	62	69	10.6	11.0
Objective [2]	33	34	5.6	5.4
Secondary fever				
Total [1]	25	41	4.3	6.5
Objective [2]	16	27	2.7	4.3
Cough and sputum	157	161	26.8	25.7

[1] Includes cases stating that they had fever, whether or not a thermometer was used.

[2] Includes only cases in which the mouth temperature is known to have been 99.1° or higher.

Or, the frequency of the cases with secondary fever may be regarded as an event independent of the occurrence of other types of colds. Among the 333 continuous volunteers of both groups (excluding those receiving fewer than ten treatments) there were reported 59 cases of this type. Of these, 23 occurred among 163 irradiated individuals and 36 among 170 persons of the control group. If again, the problem be considered to be one in random sampling, a difference as great or greater than that observed would be expected about nine times in a hundred trials.

Finally, there is no material difference in duration of illness as between the two groups. As above noted, attacks having a duration of one day or less have been excluded from both groups. There were 37 such cases, 22 being in the irradiated group (169) and 15 among the controls. Of 459 cases of known duration included in the series and occurring in irradiated persons, 56.2 per cent had a duration of 10 days and over and 21.1 per cent of 20 days and over. The comparable

figures for the control group are 57.5 and 23.2 per cent. Cases of both groups are distributed according to duration in table 11.

TABLE 11.

Distribution of cases, of irradiation and control groups, according to duration.

Periods	Irradiation	Control
1 day and under	Omitted	Omitted
2– 4 days	77	85
5– 9 "	124	106
10–14 "	75	87
15–19 "	86	67
20–24 "	39	43
25–29 "	19	16
30 +	39	45
Total *	459	449

* There are 3 cases, 1 among the irradiated and 2 among the controls, in which the date of termination is unknown.

Summary.

1. A group of adult volunteers, numbering 363, was kept under observation from September 29th 1929, to May 31st, 1930, a period of 35 weeks, and a vigorous effort was made to secure reports of all cases of upper respiratory disease (common colds).

2. From this number, approximately one half were selected at random for irradiation, which was given over the first 31 weeks of the period. Mercury-vapor lamps were used and the intensity of erythema-producing rays was measured bi-weekly. The dosage was light to moderate, the individuals being stripped to the waist and exposed, either on chest or back on each occasion, to that dose which, from previous experience with the subject, seemed likely to produce only a minimal erythema.

3. Total incidence for the period was slightly higher for the irradiated (receiving more than 10 treatments) than for the controls. Also cases of a more severe type, as evidenced by absence from duty and confinement to bed, by occurrence of fever, by productive cough or by long duration, were just as frequent in the irradiated as in the control group.

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