

THE EPIDEMIOLOGY OF RINGWORM

OF THE SCALP

DUE TO MICROSPORON AUDOUINI

with reference to

AN OUTBREAK OF THE DISEASE

in

INVERNESS.

by

JOHN ERIC TILLOTSON, M.B., Ch.B.

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In carrying out the investigations required for this thesis I was given facilities to work in the Public Health Department and every encouragement by Dr. A.M. Fraser, Chief Medical Officer of Health for the Burgh and County of Inverness; Dr. H.J.R. Kirkpatrick, Pathologist to the Royal Northern Infirmary, gave much help in investigations relating to the causal organism, and Dr. G. Gottlieb, Radiologist, Royal Northern Infirmary, placed at my disposal the records of his department relating to treatment of ringworm of the scalp by X-rays; Dr. E.A. Johnston, Deputy Medical Officer of Health for the Burgh and County of Inverness, Dr. W.D. Wilson and Dr. Struan Robertson, Assistant Medical Officers of Health for the County of Inverness, made their case records available to me for study.

This assistance is gratefully acknowledged.

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I N T R O D U C T I O N .

Parkinson, (1944), defines epidemiology as, "the science of the mass phenomena of infectious diseases," or as, "the natural history of infectious diseases," and it is the purpose of this thesis to study the epidemiology of ringworm of the scalp in children, as exemplified by the outbreak of the disease which occurred in the Burgh of Inverness, Scotland, in the years 1943 to 1946.

It has been noted by Percival, (1932), that less is known regarding the infectivity of this disease and its occurrence in epidemic and endemic form, compared to knowledge of its clinical features, and perusal of standard works on Diseases of the Skin show a tendency to little change in opinion, with reference to epidemiological features of ringworm of the scalp, from the following description given by Bateman, in 1813, who stated:-

"The disease seems to originate spontaneously in children of feeble and flabby habit, as in a state approaching marasmus, who are ill fed, uncleanly, and not sufficiently exercised; but it is principally propagated by contagion; i.e., by the actual conveyance of the matter from the diseased to the healthy, by the frequent contact of the heads of children, but more generally by the use of the same towels, combs, caps, and hats. Whence the multiplication of boarding-schools appears to have given rise to an increased prevalence of this disease, among the more cleanly classes of the community, at the present time. For such is the anxiety of parents to regain the lost years of education, that they too often send their children to these schools, when capable of communicating the infection, although supposed to be cured; against which no vigilance on the part of the superintendents can afford a sufficient security."

In/

In the investigation of the epidemiology of a disease which is fairly generalised, it must be rare for one observer to have the opportunity of studying each particular case in detail, and in order to secure all the data available, the records of others must therefore be added, if possible, to the material available for study. Also, in history taking, it is not the custom for detailed notes, applicable to the epidemiology of a disease, to be recorded by all medical practitioners seeing and treating cases of infectious disease. Furthermore, sporadic cases of ringworm of the scalp, which, according to the statistics of the Chief Medical Officer to the Board of Education, (1927), is of common occurrence in Great Britain, and is not described as giving rise to lasting disability, can hardly be expected to be the subject of extensive notes. It is when such a disease shows a sudden unexpected increase that interest is aroused and by this time many cases have been seen and passed as commonplace, so that incomplete records exist and the student is left with the task of "jobbing backwards" in so far as this is possible, for much of his material. Even this retrospective investigation can only be considered to be on a sound basis when it is confined to ascertaining the objective records of experienced observers. Owing to the variability of human memory it would appear that the value of youthful recollections of an illness and its circumstances is questionable.

Such/

Such factors have affected the investigation of the outbreak of ringworm of the scalp amongst the children of Inverness, and as only a proportion of the cases occurring were seen personally, it has been thought advisable to obtain as many details as possible from other sources in order to assess the epidemiological aspects of the outbreak as accurately as possible. The information obtained has varied in its completeness, but it is thought to be sufficient to repay study of the epidemiology of the disease, although, necessarily, it is not as complete as one would wish for the discussion of some aspects.

The general circumstances of the outbreak were as follows: In the decade before 1943, from the figures available, and on the authority of the Medical Officer of Health, there were only sporadic cases of ringworm of the scalp in the Burgh and County of Inverness. In 1943 this situation altered and an increasing amount of absence from school in the Burgh of Inverness, due to ringworm of the scalp, was noticed. Initially, cases of the disease were treated by the family medical attendant, but it was found that treatment, and the criteria adopted for cure, were not of a generally satisfactory standard, a state of affairs previously noted elsewhere by Walker, (1911). Therefore, arrangements were made for children, passed as fit for return to school, to be examined in the Public Health Department. In addition a clinic was opened/

opened for the diagnosis and treatment of fresh cases, and suspected cases found at school medical inspection by the school nurses were referred to this clinic. By this means the majority of the cases which arose were seen in this clinic, others being seen or treated independently at the Royal Northern Infirmary, Inverness.

Comparing the total of cases which came under observation in the Public Health Department, and in the Royal Northern Infirmary, with the records of absence in the schools, it appears that the figure obtained of the total number of cases which occurred is reasonably accurate.

It was found that the outbreak remained limited to the Burgh of Inverness and its immediate outskirts. (See map).

For the purpose of this thesis, cases have been accepted as ringworm of the scalp which showed the presence of the causal organism on examination, or were sufficiently typical on clinical appearances to justify epilation of the scalp by means of X-rays.

Such cases totalled 384 between the 1st. of January, 1943, and the 31st. of December, 1946, and of these cases 65 were seen personally, these latter furnishing the basis for the investigation of certain details, e.g., cultural findings, family conditions, habits, to which reference is made in the text.

THE CAUSAL ORGANISM.

Ringworm of the scalp has been defined as a contagious disease affecting the hairs of the scalp, due to the invasion of a fungus. (Savill, 1945).

The explanation of the term "ringworm" is given by Dodge, (1936), as a derivation from the Greek and Roman ideas of the disease, the Greek "herpes" giving the "ring" as in the old name of herpes circinatus for the disease, whereas the Romans linked the disease with those caused by lice and applied the name "tinea" which meant any small insect larva or worm-like creature. The latter word still persists, of course, in the alternative name for the disease or tinea capitis.

Ringworm of the scalp may be caused by two distinct types of fungus, the "small-spored" or Microspora, and the "large-spored" or Trichophyta, the distinction being based on the microscopic appearances of affected hairs. (McKenna, 1937). The differentiation, elicited by examining an affected hair in potassium hydroxide solution, is described by the same author and may be summarised as follows:-

Microspora:- On the surface of the affected hair elements commonly called spores are scattered irregularly. The spores are round or oval and are discrete.

Trichophyta:- The elements seen in the affected hair, also known as spores, are relatively larger, and are found lying in chains. They may be found wholly within the hair or/

or both outwith and within the hair.

Of the 384 cases noted in the outbreak of the disease in Inverness, the causal fungus was found to be a microsporon in 191 cases. In no case, of those from whom hairs were examined, was the fungus found to be a trichophyton.

Although the microspora have been extensively classified into types by Sabouraud, (Savill, 1945), the type depending on the different appearances on culture of the organism, Swartz, (1943), has limited these various types for practical purposes to the following:-

Microsporon Audouini - human species;
 Microsporon Canis (lanosum) - animal species;
 Microsporon Gypseum (fulvum) - animal species.

An attempt was made to find the type of microsporon most likely to be the principal infecting agent in the outbreak in Inverness; unfortunately by this time the outbreak was in its latter stages, but hairs found to show the fungus in microscopic examination in 30 cases were cultured on Sabouraud's medium, as described by Swartz, (1943). In 19 cases the appearances on culture were those of microsporon audouini and in the remaining 11 cases no growth occurred on culture.

Although this series of examinations was very small it seems reasonable to assume, in view of the fact that the clinical appearances of the lesions in the outbreak were generally similar, that microsporon audouini was the predominant causal organism.

Duncan/

Duncan, (1945), points out that this is the most widely distributed fungus causing the disease, and that, in so far as England is concerned, it is the predominant species in the Midlands and the North. Calcott Fox, (1897), noted that nearly all the scalp ringworm in London was of microsporon origin and the Chief Medical Officer to the Board of Education, (1927), in a review of the disease, presumably of microsporon type, gives figures showing it to be widespread in England and Wales.

Paul, (1916), when describing the occurrence of ringworm of the scalp of microsporon type in Sydney, notes the disease as being principally confined to Great Britain and Western Europe. Fruhwald, (1924), in noting the occurrence of the disease in Germany, states that the first epidemic of microsporon type was that in Hamburg, described in 1898, that later there were reports of this type of ringworm in various parts of Germany, Austria, Switzerland, Italy, and Russia.

In the United States the occurrence of ringworm of the scalp due to microsporon audouini has been noted by Swartz, (1943), and outbreaks have been described in the Eastern States of this country by Schwartz et al. (1946), and Lewis et al. (1944).

It is apparent, therefore, that microsporon audouini is an organism widespread in its occurrence as a cause of ringworm of the scalp, and that the outbreak of the disease noted in Inverness conformed, in its predominant causal organism, to the type usually found in Great Britain.

CLINICAL APPEARANCES.

The appearances of the lesions found in ringworm of the scalp due to *microsporon audouini* have been described by various authors in standard text-books, and the following features seem to be those generally found.

The lesions of the scalp takes the form initially of a papule surrounding a hair, (Holt & McIntosh, 1940), and this increases in size until the usual lesions seen are circular or oval patches from a half to two inches in diameter; (McKenna, 1937). Dodge, (1936), states that the maximum diameter of an infected area is 4 - 6 cm., but that the infection may be carried to another part of the scalp by inoculation, so that up to five or six lesions may be formed.

The appearances of the skin in the lesions are said to vary from slight scaliness, which is most common, to erythema and even to marked inflammation with suppuration. The affected hairs are stated to be brittle in texture and to lack lustre in appearance. They are often broken off in varying lengths near the skin and show a greyish sheath close to the skin.

The lesions show two particular characteristics useful for the purpose of diagnosis. The first of these is that hair or skin affected with ringworm of *microsporon* type, fluoresces when exposed in a darkened room to rays between 4,000 and 3,000 Angstrom Units emitted from a mercury vapour lamp, /

lamp, a glass screen, invented by Professor R.W. Wood of John Hopkins University, being used to intercept the rays. (Chief Medical Officer, Board of Education, 1927).

The glass screen contains nickel oxide, (Parkinson, 1944), and the use of the lamp in diagnosis is generally described as the use of Wood's Glass. The second characteristic is a whitening, likened to hoar frost, of affected hairs following the application of Chloroform; (Savill, 1945).

The lesions found in the outbreak of the disease in Inverness corresponded to those described. Individual lesions noted, varied in diameter from approximately a quarter of an inch to two inches. In very few cases was the occurrence of inflammation noted, and where the actual number of patches was noted, in no case did this exceed four. As stated previously, the notes available did not permit of an accurate assessment of the clinical lesions found in the recorded 384 cases, but in 239 cases, the findings could be classified as follows:-

	No. of Cases.		No. of Cases
1. Single lesion of scalp noted at first examination	164	Marked inflammation present.....	5
2. Several lesions of scalp noted at first examination	75	Marked inflammation present	1

The low incidence of marked inflammation in the lesions is/

is noteworthy and tends to support the conclusion that *microsporon audouini* was principally concerned in the outbreak, for, as Andrews, (1946), states, marked inflammation often characterises infections due to *microsporon canis*.

The appearances of the lesions following the application of chloroform and under examination with Wood's Glass were noted in a few cases and the findings were consistent with those detailed on page 9.

It has been stated, (Chief Medical Officer, Board of Education, 1927); (McKenna, 1937), that *microsporon audouini* rarely causes lesions of the glabrous skin. Although not common, a number of such lesions were noted in Inverness. They can be divided into two groups, the first of these consisting of those cases in which there was a concomitant scalp lesion, and the second, those in which no scalp lesion was noted. The second group, totalling 8 cases, is unlikely to give an accurate estimate of the number of such cases which occurred, as such lesions of the skin were found to heal readily following the local application of drugs, so that many must have been unrecorded.

In none of such cases was a *microsporon* of animal origin isolated and the findings in respect of the group with scalp lesions are given in Table I.

TABLE I /

TABLE I.

Lesions of the glabrous skin noted in 384 cases
of ringworm of the scalp.

Site of skin lesion.	Males.	Fem- ales.	Cases showing		Cases showing		Total
			microspora		M. Audouini		
			in hairs.		on culture.		
			M.	F.	M.	F.	
Face	2	1	-	1	-	-	3
Neck	12	2	5	1	No growth on culture		14
Body	3	2	2	1	-	1	5
Limbs	1	-	1	-	-	-	1
Several Areas ...	4	2	1	2	-	-	6
TOTAL...	22	7	9	5	-	1	29

These findings confirm that microsporon audouini is capable of causing lesions of the glabrous skin but the cultural findings have not been sufficiently extensive in this outbreak to permit the conclusion that up to 5 per cent of cases of ringworm of the scalp due to microsporon audouini may show concomitant skin lesions.

A point which does not appear to receive much attention in text-books dealing with ringworm of the scalp, is the relative frequency with which the lesions are found on different parts of the scalp. This has received attention from Cates, (1911), who found, in 400 cases, the following distribution:-

Vertex 66.25%
Back and Sides..... 29.25%
Whole head..... 4.50%

Recently/

Recently Schwartz et al. (1946), dealing with an outbreak in Maryland, found that the majority of the lesions were found on what they term the "clipper" area, presumably the nape of the neck and inferior parietal regions.

In the outbreak investigated, the records available enabled one to determine the site of the lesion in 323 of the 384 cases and the findings, in relation to the distribution of the disease, were as follows:-

	Male Cases.	Female Cases.	Total Cases.	Percentage.
Vertex	24	12	36	11.1
Occipital Area...	152	19	171	52.9
Right Parietal...	23	5	28	8.7
Left Parietal....	27	10	37	11.5
Several areas affected.....	39	12	51	15.5

Such findings differ considerably from those of Cates, (1911), and do not appear to correspond to those found in Maryland, as at least half of the occipital lesions appeared to be situated in the region of the occipital protuberance, outwith the "clipper" area, as understood in this country.

One must bear in mind however, that there is a type of hair cut, known in the United States of America, as the "crew cut" in which the hair appears to be clipped to the region of the high occiput. It cannot be determined, from the paper quoted, whether such a hair style was in vogue in the area concerned in the outbreak of ringworm of the scalp in Maryland. Were such the case, the distribution of the lesions would be more comparable to the findings in/

in Inverness. It is of interest that, describing cases in a similar epidemic in 1943-44 in New York City, Montgomery, (Lewis et al., 1944), noted that the vast majority of the infections first appeared over the occiput.

SUSCEPTIBILITY and RESISTANCE.

A convenient classification for the discussion of the factors affecting this aspect of the epidemiology of ringworm of the scalp may be based on the description of factors given by Stallybrass, (1931), as affecting susceptibility and resistance in infectious disease. These factors can be divided into:-

1. Primary factors, consisting of (a) non-specific or general resistance and (b) specific or acquired resistance.
2. Secondary factors, the factors of age, sex, and race.
3. External factors, such as nutrition, fatigue, climatic variations, and secondary infections.

PRIMARY FACTORS.

(a) Non-specific resistance. It has been stated that the intact epithelium offers an almost unsurmountable resistance to most micro-organisms, but that a few are able to multiply in the horny layers of the skin; (Stallybrass, 1931). Examples of the latter are given by this author as the several species of trichophyton and microsporon. Therefore, there is no reason to suppose, in view of the ability of microspora to multiply on the intact skin, that, in the presence of other favourable factors affecting susceptibility, there is any great non-specific resistance to infection by microspora.

(b) Acquired or Specific Resistance. It has been stated (The Control of Communicable Diseases, 1945), that in the case of ringworm of the scalp, reinfection is common, and that there is no immunity after cure. Dodge, (1936), however, although/

although drawing attention to the spread of the disease by auto-inoculation, states that there comes a time when the lesion stops spreading and that the fungus then becomes rarely capable of further inoculation, (whether to the affected scalp or to another susceptible scalp is not stated) and this is attributed to exhaustion of the vitality of the fungus.

The possibility of re-infection of hairs newly grown after treatment, or of spread to other parts of the scalp after apparently effective local treatment, is described by various authors; (Chief Medical Officer, Board of Education, 1927); (McKenna, 1937); (Savill, 1945); but these authors, do not state the possibility of acquired resistance, apart from that related to the onset of puberty.

To determine, in the most satisfactory possible manner, the degree of acquired resistance present, following an attack of ringworm of the scalp, one would have to ascertain the susceptibility of a group of children to re-inoculation with *microsporon audouini* after they had definitely recovered from an attack of the disease due to this organism. Such an investigation is hardly practicable, but the findings in the outbreak at Inverness can be studied, in the evidence available, to determine the probability of some degree of acquired resistance to the disease occurring after infection. For this purpose it appears necessary to make a distinction between cases/

cases which showed fresh areas of infection, and those which developed signs of a fresh infection some considerable time after treatment.* The disease naturally pursues a chronic and insidious course suggesting that acquired resistance, if any, is slow to develop and therefore, when the disease recurs during or shortly after treatment designed to shorten its natural course, this recurrence may well be due to failure to eliminate the infection. Such failure is likely for the following reasons:-

- (a) There may be, apart from the obvious lesion, areas of infection in the scalp which is not observed and treated;
- (b) When a localised area is treated, there is the possibility of spread to fresh areas of the scalp before the fungus is eliminated from the treated area;
- (c) Reinfection from external sources may occur during this time and before resistance is developed.

Spread or recurrence of the disease was noted in 33 cases out of 308 cases which occurred in the Burgh of Inverness between January, 1943 and December, 1945, and which were apparently thoroughly treated by means of X-ray epilation of the scalp and fungicides.

The interval in time between the commencement of treatment in these cases and the observation of a recurrence varied between 12 and 395 days, and the detailed times of the observation of recurrences after commencement of treatment by X-rays are noted in Table II, which also shows the relationship of the areas treated by X-ray epilation to recurrence of the disease.

Table II /

TABLE II.

Recurrence of ringworm after epilation of scalp by X-rays
in cases treated between January, 1943 and December, 1945.

Areas of Scalp epilated.	Total Cases.	Recurr- ences.	Note of recurrence after initial treatment, in months.							
			1.	2.	3.	4.	5.	6.	12.	Over 12.
Whole Scalp	76	-	-	-	-	-	-	-	-	-
One area.. (a)	157	26	8	8	5	3	1	-	1	-
Two areas (b) ...	75	7	-	3	2	-	-	1	-	1
Further area (c); after (a) & (b) ...	20	3	1	2	-	-	-	-	-	-
Remainder of scalp after epilation as in (a), (b), & (c)...	13	-	-	-	-	-	-	-	-	-

In addition to X-ray epilation of the scalp the great majority of the cases included in Table II were treated by the daily application of unguentum acid benzoic Co. (B.P.C.) to the epilated area and instructions were given to shampoo the scalp twice weekly with spirit soap.

The findings in respect to recurrences following treatment are interesting. There were no recurrences following treatment of the whole scalp by X-rays, suggesting at least that the original infection was successfully eliminated/

eliminated in so far as could be judged by clinical appearances.

The recurrences which were noted following the epilation of one or two cases may well have been simply a spread of the original infection, or a part of the original infection, unobserved initially, for the reason that two-thirds were noted within two months of the commencement of treatment and all except two within six months of treatment. The disease is said to be capable of persisting for years when untreated, (Savill, 1945), so that the two recurrences noted in untreated areas about one year after local treatment of the scalp, may also have been due to unobserved spread of the original infection.

It is very unlikely that the 76 cases in which the whole scalp was epilated, were not exposed to re-infection. No particular selection was made of cases for epilation of the whole scalp. In some the disease was extensive, but in many the parents were persuaded of the advantage of this form of treatment for a small lesion, from the point of view of rapid recovery, and lessened risk of spread of the disease. The cases were not selected from any particular area of the town, or stratum of society. The ages varied from three to thirteen years, and all, in so far as one could ascertain, resumed their usual habits in areas where the disease was still prevalent.

It/

It is not likely that exhaustion of the vitality of the infecting fungus throughout the area of prevalence was a likely cause of the absence of recurrences in this group, as cases were treated by epilation of the whole scalp throughout the three year period, and not principally towards the end of this time, when there might have been a possibility of some diminution of the vitality of the infecting organism in the areas of prevalence.

Therefore, one is left with the impression that the absence of the clinical appearances of re-infection in this group of 76 cases was most likely due to the acquisition of some degree of resistance to *Microsporon audouinii*; whether the exposure of the scalp to X-rays and the application of fungicides played a part in promoting this resistance, was undetermined. Furthermore, the findings show that so called "recurrences" were likely to be unobserved areas or spread of the original infection. For many diseases, naturally acquired resistance to infectious disease is almost of an absolute quality immediately after the infection has terminated, but often tends to diminish steadily with the lapse of time, (Stallybrass, 1931), and it is also stated by the same author that there are great differences between individuals in the rate at which the acquired resistance is lost. Were the "recurrences" noted in this series of cases due to relative absence of acquired resistance, one would expect/

expect to find a gradual increase in the recurrence rate as time elapsed after initial treatment. The findings are the reverse of this, and further enhance the opinion that acquired resistance occurs after infection with *microsporon audouini*. The average duration of this resistance cannot be satisfactorily assessed from the material available, as the findings suggest that there were no cases of undoubted recurrence after initial cure.

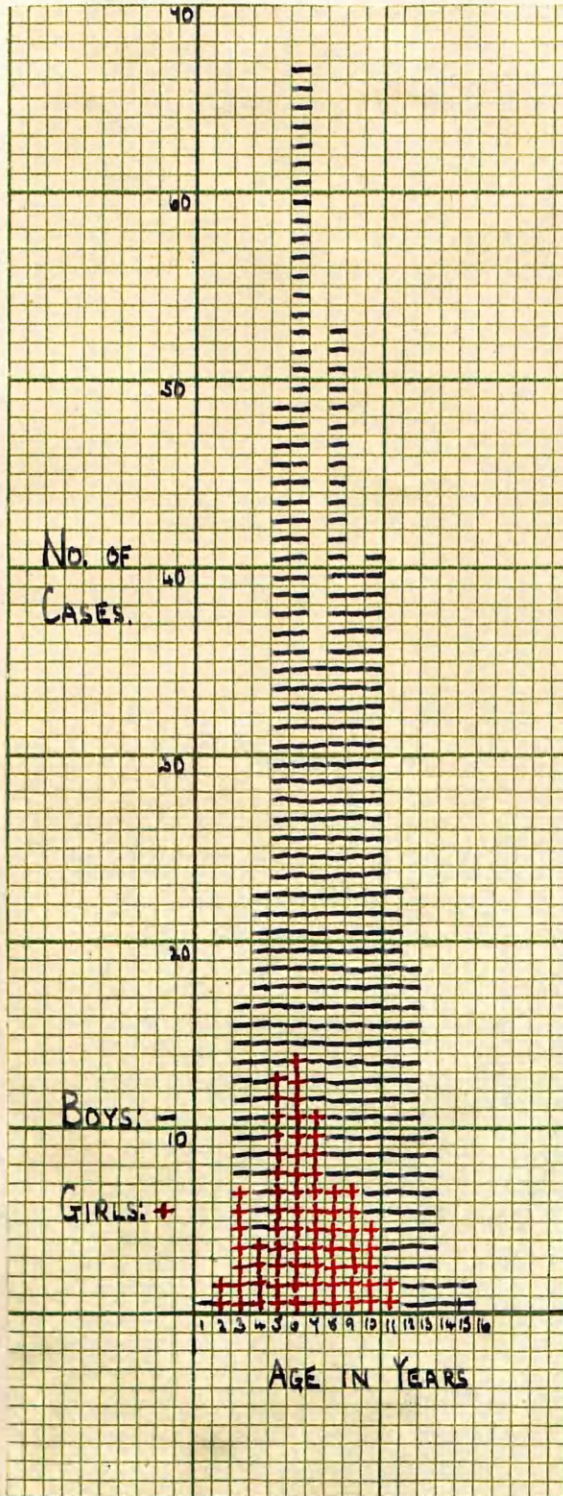
SECONDARY FACTORS.

Age. Ringworm of the scalp due to *microsporon* infection is generally stated to be unusual after the age of puberty, although cases in adults have been reported; (Dodge, 1936); (Savill, 1945). In a recent epidemic of 312 cases of ringworm of the scalp, Lewis, Hopper & Reiss, (1946), noted only one case of infection due to *microsporon audouini* in an adult. In an outbreak of 100 cases due to *microsporon audouini* in Frankfurt, Klein and Aliferis, (1922), noted typical skin lesions in two adults in close contact with the children affected. This finding was confirmed in the outbreak of the disease in Inverness, where no cases in adults were noted, and the age distribution is given in Table III.

Table III /

TABLE III.

Age incidence of 384 cases of ringworm of the scalp in Inverness.



The findings in Table III show that the age incidence, both in males and females, takes the general form of a curve with the greatest incidence in the age groups of five to eight years. A similar finding, in 400 cases, was noted by Cates, (1911), who also found the largest proportion of cases to be at six years of age, (27%), and seven years of age, (16.25%); and Scott, (1911), in 700 cases, found the disease to be most common in the 6th, 7th. and 8th years.

Cranston Low, (1908), describing 98 cases, found that the average age of cases when first seen was 5 years, while Lewis, Hopper, and Reiss, (1944), found the peak of incidence in 312 cases to be 8 years.

Therefore, the findings in Inverness seem on the whole, to be comparable to those noted in fairly large series of cases elsewhere.

Various suggestions have been made to explain these findings. In respect to the disappearance of the disease after puberty, Vamos, (1932), quoted by Dodge, (1936), found the optimum hydrogen ion concentration for the growth of *microsporon audouini* to be 6.5 to 7.2, and this has been used to explain the occurrence of the disease in the period prior to puberty, in which the hairy areas have a hydrogen ion concentration of 6.2 to 6.5, whereas after puberty the hydrogen ion concentration increases to 4.5 to 5.6. Kingery et al (1939), found evidence to show that *microsporon audouini* grew/

grew more readily in a watery extract of hair from young persons than in a similar extract from old persons.

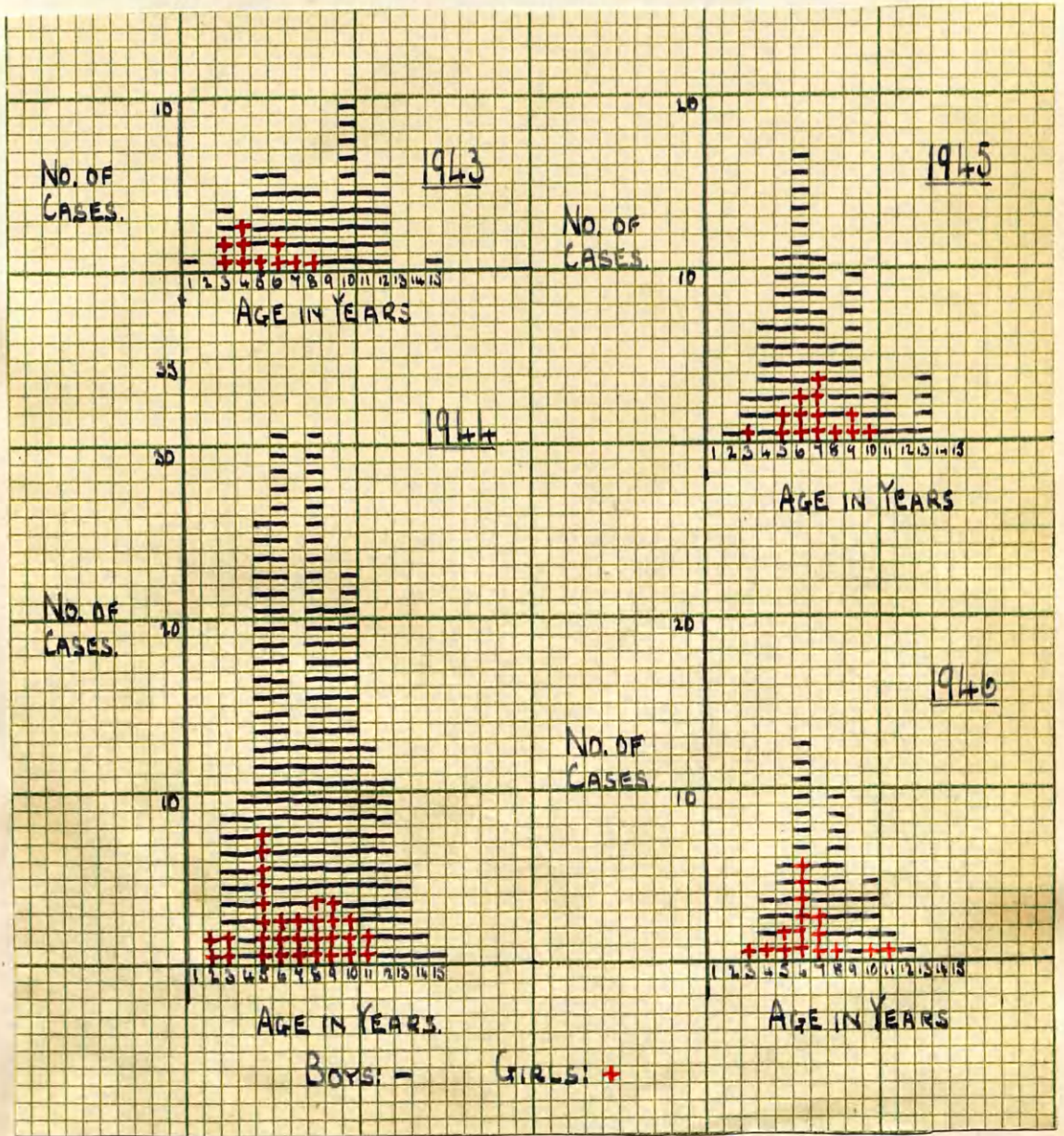
Endocrine therapy with gonadal substances has been attempted, (Neuber, 1930); (Poth and Kaliski, 1942); on the basis of this absence of the disease after puberty, but this has not given results suggesting conclusively that the presence in the body of increased amounts of such substances eliminates the disease.

No information throwing further light on this aspect of ringworm of the scalp was obtained during the outbreak in Inverness.

The greater incidence of the disease in the age groups of 5 to 8 years has been explained by Cranston Low, (1908), and Cates, (1911), as being due to increased facility of infection in the early school years. Although the graph of age incidence (Table III) might, at first sight, suggest an increased susceptibility per se in the age group of 5 to 8 years, the charting of the age incidence for each year of the outbreak, (Table IV), shows a shift from the greatest incidence in the age group of 9 to 12 years in 1943, to 5 to 8 years in 1945, the latter incidence being maintained in 1946. This would suggest that in a susceptible population, there is no marked variation in inherent susceptibility below the age of 13 years, but as the epidemic spreads and the population becomes seasoned to *microsporon audouini*, conditions associated with the onset of school attendance provide favourable opportunities for acquiring the disease.

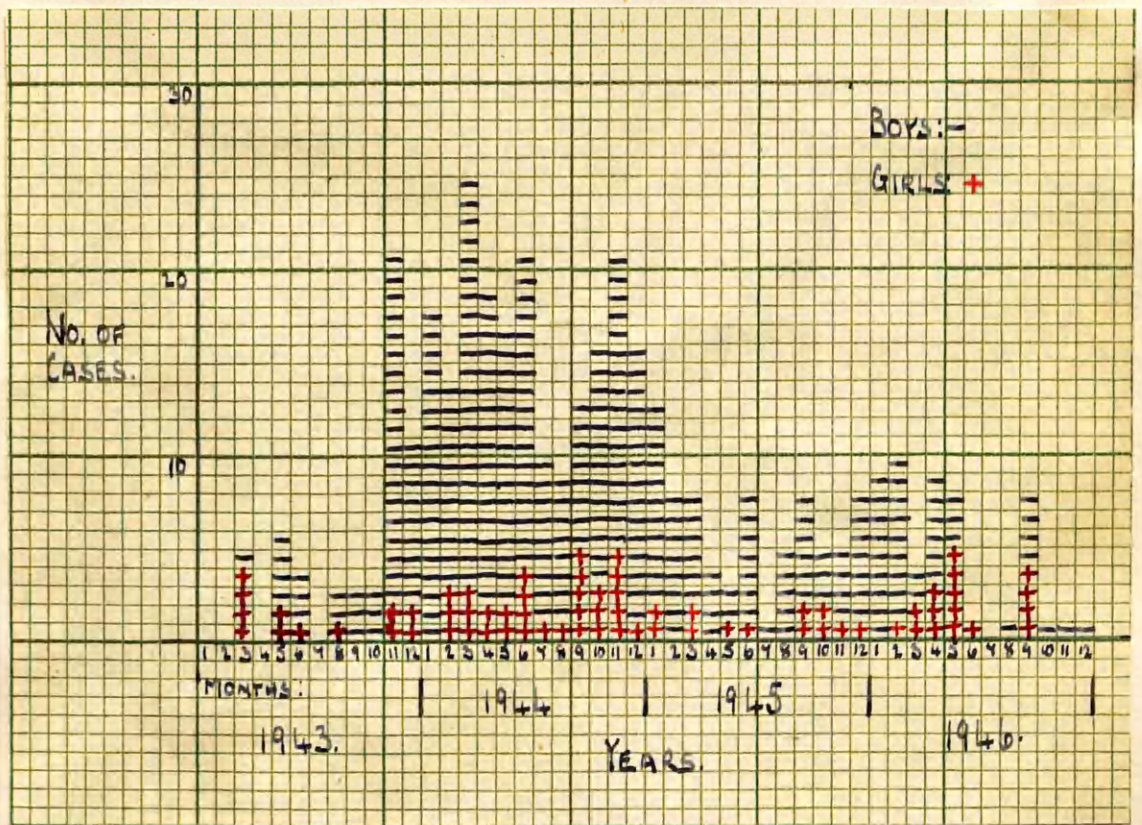
TABLE IV.

Age incidence of 384 cases of ringworm of the scalp in Inverness, charted according to the separate years of the observation of fresh cases.



Sex. Ringworm of the scalp due to microspora has been stated to be much more common in boys than in girls; Dodge, 1936, and this finding was confirmed by Schwartz et al. (1946), who found six times as many boys as girls infected in a recent epidemic. On the other hand, findings given by Cranston Low, (1908), and Cates, (1911), show little difference in incidence between the sexes, although Scott, (1911), found a slight preponderance of cases in boys. In Inverness over four times as many boys as girls were affected and in Table V. the incidence is shown throughout the outbreak of the disease.

TABLE V.



It can be seen from Table V. that throughout the four year period, the incidence of the disease in girls remained fairly constant, whereas the incidence in boys showed a much greater increase during the time of greater severity of the outbreak in 1944. In other words, in Inverness, ringworm of the scalp pursued an epidemic course in boys and an endemic course in girls. By adopting this view the conflicting findings noted above may be compatible.

From a study of the literature it appears that when Cranston Low, (1908), and Cates, (1911), published their papers, ringworm of the scalp was endemic in this country; and in Inverness in 1946 when the epidemic phase of the disease had subsided, (Table V), the incidence of the disease in boys and girls was approximately equal, in conformity with the findings of these two authors.

Schwartz et al. (1946), state that they were dealing with an epidemic of ringworm of the scalp, and, although it cannot be determined from the paper published, the case incidence in sexes may well have conformed to the pattern found in Inverness.

From these findings it appears reasonable to assume that there is no marked difference between the sexes in susceptibility to ringworm of the scalp due to *microsporon audouini*, but when the disease assumes epidemic form, the case incidence is much greater in boys, suggesting that conditions are more favourable to spread of infection in this sex.

Race. Lewis, Hopper, and Reiss, (1946), reviewing an epidemic of ringworm of the scalp in New York, concluded that susceptibility to infection with *microsporon audouini* might be overcome at a somewhat earlier age in Negro children, but in other respects race appeared, in this epidemic, to have little influence upon susceptibility. In Inverness the significance of the racial factor, if present, could not be determined. The population at risk, and affected, appeared to be predominantly of Celtic origin, but with a considerable Sassenach element. The number of persons of Jewish race in the Burgh appears to be very small and no cases were noted in children of this race.

EXTERNAL FACTORS.

Such factors as nutrition, fatigue, climatic variation and secondary infection, are noted by Stallybrass, (1931), as having an effect on the susceptibility to various infectious diseases. No direct effect of such factors could be ascertained as affecting susceptibility to ringworm of the scalp in the outbreak in Inverness.

McNealy and Lichtenstein, (1929), quoted by Dodge, (1936), draw attention to the frequent flare up of chronic ringworm conditions following trauma, but no evidence of marked trauma as a factor affecting susceptibility was obtained in this outbreak. The possibility of the inoculation of *microsporon audouini* by mild trauma is discussed in the chapter dealing with/

with modes of transmission of the disease.

CARRIERS.

Harries and Mitman, (1944), define the carrier state as being of two types. Firstly, where the body finds it difficult to eliminate invading organisms, which, although incapable of producing an overt infection, continue to live and multiply within limits; and secondly, the convalescent patient, who occasionally fails to eliminate the organisms, although, clinically, he has recovered from the disease.

The subject of carriers in relation to ringworm of the scalp due to *microsporon audouini* appears to have received little attention in medical literature. The carrier condition is difficult to define in this disease. For example, the practitioner basing his diagnosis on the well defined signs of the disease, in the stage of a patch of broken hairs, scaliness, and slight inflammation, would pass a case of ringworm of the scalp showing only the small papule described as the initial lesion. Again, cases were seen in Inverness which only showed scaliness of the scalp, and, but for the vigilance of the school nurse and the examination of hairs from the scaly area, these would not have been diagnosed as suffering from ringworm of the scalp. Finally, Schwartz et al. (1946), during an outbreak of the disease examined all school children in Hagerstown, Maryland, and adjacent rural communities with Wood's Glass and found many cases of the/

the disease showing no clinical manifestations; and Miller et al. (1946), noted similar findings in New York. A Wood's Glass was not available in Inverness until the end of 1946, so that this finding could not be confirmed, but it was noticed that unsuspected areas of the scalp of some cases were found to be infected when using this method of examination. No evidence was obtained to show that *microsporon audouini* might be present in the scalp and failed to show fluorescence with the use of Wood's Glass. One wonders how the carrier condition in diphtheria, for example, would be assessed if one had to rely on examination of the nasopharynx by a method comparable to the use of Wood's Glass, and bacteriological investigations similar in scope to those available for *microsporon audouini*. It is of interest that Davidson et al (1934), and Benedek, (1944), appear to consider cases showing fluorescence with Wood's Glass, and no clinical signs of disease otherwise, as carriers. The same arguments apply to children convalescing from ringworm of the scalp.

The conclusion would seem to be that with clinical methods involving the use of Wood's Glass, the presence of cases carrying *microsporon audouini* and not showing fluorescence has not been determined; whereas, if Wood's Glass is not used in examination, there are likely to be a number of children who are carriers, although, perhaps a purist would prefer to call them missed cases, during
an/

an outbreak of ringworm of the scalp due to *microsporon audouini*. Adopting this standard it seems very likely that in the outbreak of ringworm of the scalp in Inverness there were a number of children who were carriers of the disease.

MODES of TRANSMISSION.

For the purpose of discussing the mode of transmission of microsporon ringworm of the scalp, the definitions and terms adopted by Chapin, (1912), are convenient. According to this author, possible modes of infection are as follows:-

1. Contact infection. This implies the comparatively direct transmission of quite fresh infectious material from one person to another;
2. Infection by fomites. By this is meant infection from an object which has retained the infection for some time, and several days at least;
3. Infection by air. This mode implies that the infectious material is conveyed by air to the susceptible person.

It has been stated by Chapin, (1912), that contact infection is the most obvious mode of transmission of the infectious diseases, and that, if it can explain epidemiological phenomena,

"There is no occasion for assuming the growth of pathogenic germs outside of the body, or of infection by fomites or infection by air, or any similar theory, and no such theory should be adopted as a working hypothesis unless pretty strong evidence can be brought to its support."

In so far as bacterial infections are concerned the possibility of spread by dust has recently received increased notice, and it is stated that the evidence incriminating dust has been steadily accumulating. (Lancet, 1946).

In the case of ringworm of the scalp there appears to be considerable variation of opinion regarding the most likely/

likely mode of spread. Some authors detail various possibilities while others advance a favourite conclusion. The following modes of transmission have been listed:-

- the frequent contact of the heads of children, or by the use of the same towels, combs, caps and hats; (Bateman, 1813); (Calcott Fox, 1892); (Savill, 1945);
- intimate contact of head to head, such as sleeping in the same bed; (Chief Medical Officer, Board of Education, 1927);
- close contact; (Fruhwald, 1924);
- barber shops, cinemas, backs of subway seats; (Lewis et al. 1944);
- barber shops; (Schwartz, et al. 1946);
- transmission by air; (Cates, 1911).

Many outbreaks of ringworm of the scalp have remained localised, such as those described by Stallybrass, (1931), quoting an outbreak in Nottingham, (Medical Officer, 1929, XXXV, 48); (Fruhwald, 1924); (Glaser, 1908); and this finding has advanced the view that close contact is necessary for spread of the disease. The site of the lesion has been taken by Schwartz et al, (1946), to favour spread by means of barbers' shops and by Cates, (1911), to favour spread by air, while the finding of infected hairs by means of Wood's Glass has incriminated cinema seats and barbers' clippers, (Lewis et al. (1944); (Schwartz, et al, 1946).

These findings suggest that the majority of observers consider that the disease is spread by contact, as defined above./

In the outbreak of ringworm of the scalp which occurred in Inverness, an attempt was made to ascertain the mode of infection in 64 cases, and certain conclusions can be drawn from the general findings in the outbreak, to be discussed under the following headings:-

1. FAMILY CONTACT.

Of the 384 cases noted in the outbreak, infection in more than one child of a family was noted in 63 instances, the actual distribution being given in Table VI.

TABLE VI.

Incidence of family infection in 384 cases of ringworm of the scalp.		
No. of children in family affected.	No. of families.	Total Cases.
2	48	96
3	11	33
4	4	16
5	-	-
<u>Total</u>	<u>63</u>	<u>145</u>

Assuming that there was only one initial case in these families and that the remaining cases in the families were affected by family contact, there were 302 primary cases of ringworm of the scalp in Inverness available to spread infection by family contact. Of the families in the Burgh it/

it is estimated, (from the fourteenth decennial census of Scotland), that 80% contained two or more susceptible children. Applying this average to the 302 primary cases one is left with a total of 241 primary cases occurring in families with other susceptible members. As 63 of such families provided two or more cases of the disease, one can calculate the approximate average number of cases in which there was spread of the disease to other susceptible members of the family as 26%.

The 59 cases noted as investigated to determine likely modes of transmission of the disease came from 50 families and the incidence of infection in these families is given in Table VII, susceptible children being considered to be those under 16 years of age.

TABLE VII.

Incidence of Infection of Ringworm of the Scalp in 50 affected families.

No. in family.	No. of families.	Total susceptible children.		Children affected.		% of total affected.
		Boys.	Girls.	Boys.	Girls.	
1	4	3	1	3	1	100%
2	17	26	8	16	5	62%
3	14	21	21	13	7	48%
4	4	8	8	3	1	25%
5	5	18	7	8	-	32%
6	6	20	16	9	3	33%
Totals...	50	96	61	52	17	44%

In Table VII. these findings have been expressed differently as the attack rate in 46 families with more than one child under 16 years of age, in which cases of ringworm of the scalp were noted.

TABLE VIII.

Attack Rate in 46 families with more than one child under 16 years of age.

<u>Percentage of family under 16 years of age affected.</u>	<u>No. of families.</u>
0 - 20%	7
21 - 40%	14
41 - 60%	15
61 - 80%	5
81 -100%	5

From these findings it appears, that, in Inverness, there was not a great tendency for ringworm of the scalp due to *microsporon audouini* to be transmitted to all the susceptible members of a family, once the disease had appeared in the household, the findings giving the impression that, on the average, less than 50% of the susceptible children in affected families were liable to show signs of the disease.

This would suggest that ringworm of the scalp showing obvious clinical signs does not tend to spread with great ease by family contact.

2. CONTACT OUTWITH THE FAMILY.

In 59 cases of ringworm of the scalp an attempt was made to find a human source of the disease with which there may have been contact prior to diagnosis of the disease. The findings are given in Table IX and for the purpose of this Table, the presence of ringworm of the scalp in children in neighbouring homes has been given preference as a source of infection, to contact in school.

TABLE IX.

Probable source of infection in 59 cases
of Ringworm of the Scalp.

Nature of source of infection.	Boys.	Girls.	Total
Family	6	3	9
Playmates	12	6	18
Neighbouring children.....	22	5	27
School	3	2	5
None traced	-	-	-

It appears from these findings that all the cases investigated were likely to have come into contact with a case of ringworm of the scalp prior to development of the disease, but in over 50% the source of infection, in the neighbourhood or in school, could not be localised to a particular/

particular case. The presence of infection in neighbouring homes has been given preference to the presence of infection in school, as the distribution of the cases in the areas from which children attended the various schools, did not show a general uniformity over the various areas, but tended rather to remain localised to certain streets or small districts. (See map).

3. CONTACT WITH ANIMALS.

It has been stated previously that the evidence available suggested that the outbreak of ringworm of the scalp in Inverness was predominantly due to microsporon audouini. Inquiry was made in the 59 cases to the likelihood of exposure to ringworm in animals. In the 50 households concerned, cats or dogs, or both, were maintained in 25, but in no case were any changes noticed to suggest that the animals suffered from ringworm.

In one household where three children were affected, the father of the children had been working with cattle said to have ringworm. In these cases the fungus on microscopic examination was a microsporon and there was no growth on an attempt at culture.

This tends to confirm that the outbreak was principally due to microsporon audouini, and that ringworm in animals had little, if anything, to do with the spread of the disease in Inverness.

4. HABITS LIKELY TO LEAD TO CONTACT WITH A SOURCE OF INFECTION.

In 59 cases of ringworm of the scalp an inquiry was made into the habits of the affected children, and the findings are classified in Table X, with a note of the site of the various lesions. It is apparent, that of the habits classified, the following, leading to possible contact with infection, were common to the majority of the affected children, namely, the communal use of toilet articles, games involving bodily contact, cinema attendance, and school attendance. A majority attended barbers' shops for cutting of the hair, and this appeared to be of more significance in the boys affected, a finding similar to that noted by Schwartz et al. (1946), and used by these authors to support their view, that attendance at hairdressers played a major part in the transmission of the disease. It was found that various hairdressers in Inverness were attended, but no particular investigation was made of their establishments.

Two of the habits mentioned above require further comment. The games played by the affected children and classified as involving bodily contact, consisted of "hide and seek," football, "cowboys and Indians," and "tig." Wrestling appeared to occur amongst the boys in the course of their games, and one boy of six years of age described his usual game as that of "chasing." Although he/

he was rather vague in explaining what occurred at the end of the chase, this game has been classified as involving bodily contact. Cinema attendance involved the various cinemas in the Burgh, and, except in two cases, the children involved all occupied the cheapest seats. The frequency of attendance varied, the greatest being that of a boy who visited the cinema four times weekly, but for the majority of the children the habit appeared to consist of regular attendance every Saturday afternoon.

TABLE X /

TABLE X.

Classification of Habits prior to diagnosis, and Site of Lesions in 59 cases of Ringworm of the Scalp.

<u>HABITS.</u>	<u>BOYS.</u>	<u>GIRLS.</u>	<u>TOTAL.</u>
<u>Use of Toilet Articles:-</u>			
1. Communal	36	15	51
2. Personal	7	1	8
<u>Hairdressing:-</u>			
1. Barber attended.....	31	2	33
2. Hair cut at home.....	12	9	21
3. Hair not cut	-	5	5
<u>Games played:-</u>			
1. Involving much contact..	42	13	55
2. Involving little contact.	1	3	4
<u>Cinema attendance:-</u>			
1. Regular (up to 2 weekly intervals).....	36	9	45
2. Occasional	5	3	8
3. None	2	4	6
<u>Travel in communal vehicles:-</u>			
1. Regular	15	10	25
2. Occasional	28	6	34
<u>Visits to other homes:-</u>			
1. Regular	8	3	11
2. Occasional	35	13	48
<u>School:-</u>			
1. Attending School	41	15	56
2. Pre-school	2	1	3
<u>Headgear:-</u>			
1. Worn regularly	11	4	15
2. Rarely worn	32	12	44
<u>Site or Lesions:-</u>			
1. Occiput	32	8	40
2. Right Parietal	2	-	2
3. Left Parietal	3	4	7
4. Vertex	2	1	3
5. Several sites	4	3	7

DISCUSSION OF THE MODES OF TRANSMISSION.

From the findings in the Burgh of Inverness, and from the opinions of the authors quoted, it appears that ringworm of the scalp due to *microsporon audouini* is principally transmitted by human contact. The possibility of infection occurring by air as stated by Cates, (1911), could not be confirmed, and, by applying the reasons given for his opinion to the findings in Inverness, the possibility appeared most unlikely. This author gives, as the principal factors in favour of infection by air, the occurrence of the majority of the lesions upon the vertex, and the favourable circumstances supposedly present for "spores" of *microsporon audouini* to be present in the dust or air of school classrooms. In Inverness, as noted previously, the majority of the lesions of the disease were found upon the occiput and the marked variation in incidence in the various schools in which the disease occurred, to which reference is made on page 51, does not make it appear likely that the air of the schoolroom was a factor in the spread of the disease. No evidence was found in the investigation of this outbreak of the disease to suggest that ringworm of the scalp is transmitted by air, and the variability experienced in growing the fungus from infected hairs, in a medium presumably favourable for growth, tends to justify the opinion that infection by air or dust plays little part in transmitting ringworm of the scalp due to *microsporon audouini*.

The possibility of transmission of ringworm of the scalp by attendance at the cinema or hairdresser is considered to be more aptly classified, using the definitions of Chapin, (1912), as infection by indirect contact, coming under the heading of contact infection. The frequency of cinema attendance noted, and the fact that the instruments used by hairdressers are in fairly constant use, tend to make one think that the possible transference of infection from the backs of cinema seats, or barbers' clippers, is not sufficiently delayed for these materials to be classed as fomites, in the sense that such contaminated materials are those which harbour the infection for a long period of time before it is transferred to a susceptible person. (Chapin, 1912).

The opinion has been stated that ringworm of the scalp due to *microsporon audouini* is transmitted by contact, direct or indirect, with children harbouring the infection, and various habits and circumstances, giving rise to this contact have been detailed. There remains to be discussed the relative likelihood of these various circumstances and habits as the predominant mode of transmission of the disease. In the outbreak of ringworm of the scalp in Inverness, the findings suggested that the disease was not spread too readily in the family, where as Chapin, (1912), notes, opportunities for contact infection are particularly favourable. No particular habit leading to contact infection/

infection was found to be predominant in the lives of infected children. Although the occiput was by far the most common site of the disease, infection could alight there either by contact with the backs of seats, as in the cinema or home, or by contact with contaminated arms and hands in play, or in a proportion of the cases, by contact with contaminated clippers at the barbers.

A matter which does not appear to have received adequate attention in medical literature is the relationship of mild trauma to the transmission of ringworm of the scalp. By mild trauma is meant that which is likely to arise from rubbing the scalp, and the hypothesis is advanced that, for clinical ringworm of the scalp to arise, it is necessary for *microsporon audouini* to be inoculated into the susceptible scalp by some such mild trauma. A comparison might be made to the procedure of vaccination or that of testing a person's susceptibility to tuberculin by means of the Vollmer patch test.

Many habits of children and other customs are likely to produce mild trauma to the scalp, such as brushing and combing the hair, drying the scalp with a towel, the use of barbers' clippers, rubbing heads on the backs of seats, and bodily contact in play. In the cases of the disease seen personally, it was noted that there was a tendency, in children affected in a family subsequent to the initial case, for the lesion to appear close to the hair margin, where there/

there was likely to have been friction with a towel after washing the face and neck. In Table XI the findings regarding the site of the lesion in the secondary cases arising in 40 families with two or more children affected, during the outbreak in Inverness are given. In the remaining 23 of such families, the records were insufficient to determine which were secondary cases or the site of the lesion.

TABLE XI.

Site of lesion in secondary cases of ringworm
of the scalp in 40 families.

No. of families	40
No. of Secondary Cases	58

Site of lesion.

1. "Towel" area (close to hair margin) ..	31
2. "Comb" area (vertex)	8
3. "Other" areas (in all cases this area was the occiput)	19

The findings noted in Table XI bear out the impression that the majority of cases presumably infected by family contact develop the lesions of the disease in an area subject to friction by a towel. The possibility of the site of the lesion in the remaining cases being determined, in the absence of washing, by friction of the scalp with a comb, or less likely a brush, cannot be excluded.

By/

By accepting the hypothesis that ringworm of the scalp due to *microsporon audouini* only occurs when the causal organism is transmitted to the susceptible scalp with accompanying or subsequent mild trauma, many of the findings noted in Inverness can be satisfactorily explained. Thus the apparently low incidence of the disease in susceptible children where family contact offers favourable means of transmission; the preponderance of lesions situated on the occiput; liable to friction from infected seats, hands, or possibly barbers' clippers; the higher incidence of the disease in boys where more boisterous behaviour and short hair offer greater opportunity for friction of the skin of the scalp to occur; and the increased incidence in the age group of 5 - 8 years, when children extend the range of activities into possible contact with infection, and before height and habits diminish the likelihood of friction of the scalp arising from the backs of seats, and in play, are all compatible with this hypothesis regarding the transmission of the disease and most of the findings by other observers noted at the beginning of the chapter appear to be similarly compatible.

If, therefore, ringworm of the scalp due to *microsporon audouini* is transmitted by contact infection with accompanying or subsequent mild trauma, the routes of transmission may vary considerably in different circumstances. Thus, when a group of susceptible children are cloistered, as/

as in an institution, toilet articles, contact in play, and possibly the backs of chairs, may provide the more favourable routes of transmission, whereas, when children are moving freely throughout a town, infection spread through attendance at the cinema or barbers', may acquire greater significance in the transmission of the disease.

Transmission in School.

As one of the major disabilities of ringworm of the scalp, at least in Great Britain, is the loss of education suffered from the practice of excluding affected children from school, the influence of school attendance upon the transmission of the disease will be discussed separately. Since the time of Bateman, (1813), at least, medical opinion in Great Britain appears, on the whole, to have considered that school attendance provided one of the principal means of transmission of ringworm of the scalp due to *microsporon audouini*. Thus, Calcott Fox, (1892), states that, "however painstaking and cleanly a mother may be in tending her children, she can never be secure against the infection whilst they are attending school;" Cranston Low, (1908), states that, "in many cases the disease is contracted by an older child at school and the infection brought to younger members of the family at home;" Cates, (1911), advances several reasons for his opinion that school attendance provides the most favourable factor in the transmission/

transmission of the disease; and McKenna, (1937), in dealing with the transmission of the disease, cites contact "as when a child in school, poring over the same task as its infected neighbour, accidentally rubs its head against the sufferer's scalp." On the other hand, Robertson, (1911), notes that in the control of the disease, exclusion of affected children from school had been tried for many years and found wanting, while Dr. Brewer, Swindon, stated (Chief Medical Officer, Board of Education, 1927), that "Ringworm rarely, if ever, spreads in school." In the United States of America possible transmission of the disease in schools does not seem to have been given the same importance as in Great Britain for Robertson, (1911), stated that it was not the custom, in the city of New York, to exclude affected children from school. In recent outbreaks of the disease, however, opinions seem to have varied for Lewis et al, (1944), advocate that no child be permitted to return to school until entirely free of infection, whereas, Schwartz et al. (1946), permitted school attendance, subject to protection of the infected scalp, throughout an epidemic of the disease.

The findings in Inverness have been analysed in an attempt to determine the likelihood of transmission of ringworm of the scalp in school during this outbreak. The case incidence for the schools in the Burgh and one school adjacent to the Burgh (see map) are given in Tables XII and XIII.

TABLE XII.

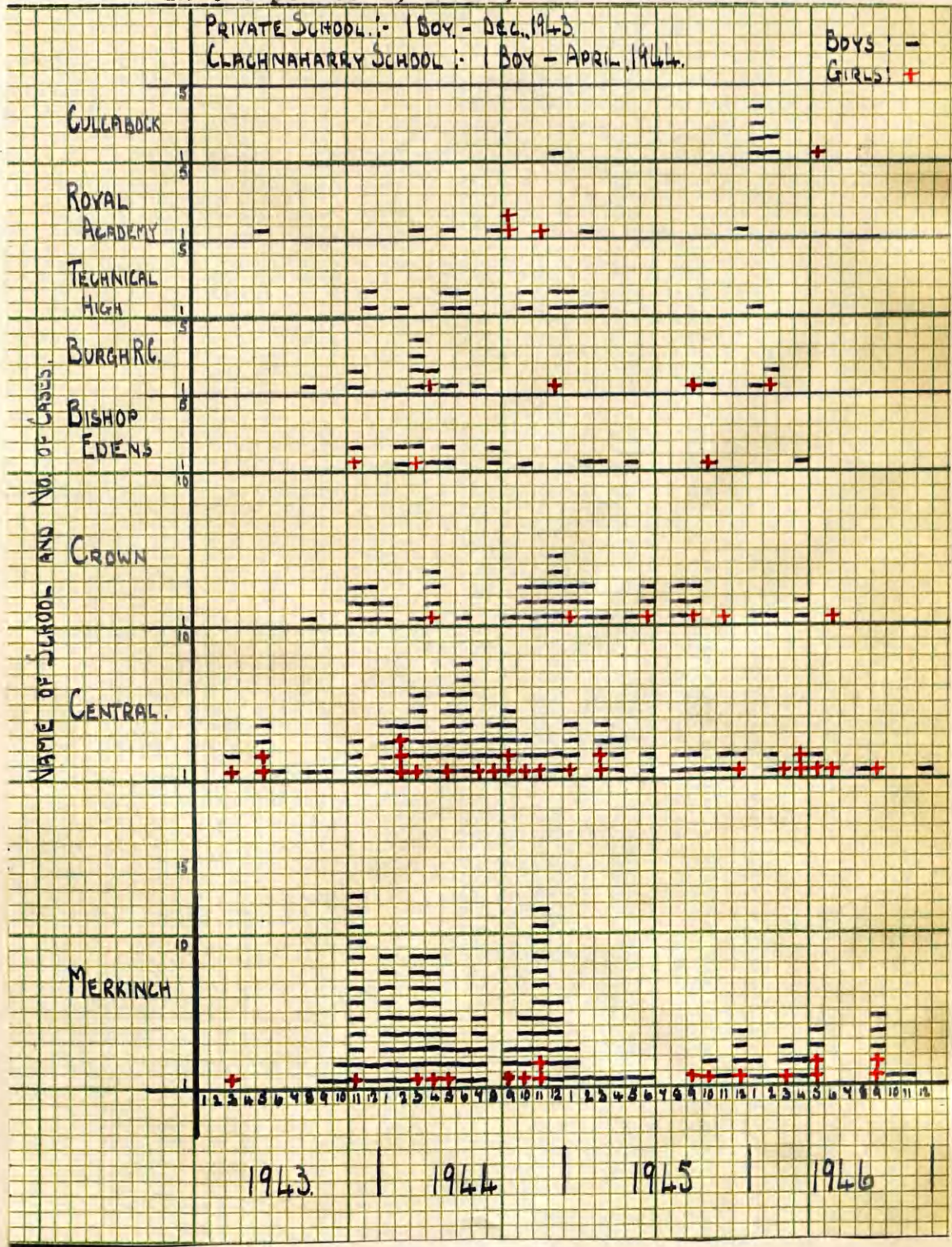
Case incidence of ringworm of the scalp
in the Schools of Inverness.

A. Name of School. (to nearest 10).	Pupils under 12			No. of cases under 12 years.			Percentage Incidence.		
	Boys.	Girls.	Total.	Boys.	Girls.	Total.	Boys.	Girls.	Total.
Merkinch.....	410	420	830	108	17	125	26.3	4.0	15.0
Crown	220	250	470	44	6	50	20.0	2.4	10.6
Central.....	330	370	700	72	24	96	21.8	6.5	13.7
Bishop Eden's..	50	50	100	14	3	17	28.0	6.0	17.0
Burgh R.C.	60	60	120	9	4	13	15.0	6.6	10.8
Clachnaharry... 20	10	30		1	-	1	5.0	-	3.3
Convent of Notre Dame....	20	30	50	-	-	-	-	-	-
Highland Orphanage.....	10	20	30	-	-	-	-	-	-
Royal Academy..	130	90	220	2	3	5	1.5	3.3	2.3
Private School.	20	20	40	1	-	1	5.0	-	2.5
Culcabock.....	40	40	80	8	1	8	17.5	2.5	10.0
Total.....	1,310	1,360	2,670	258	58	316	19.7	4.2	11.3

B. Name of School.	Pupils aged 12-16 years.			No. of cases aged 12-16 yrs.			Percentage Incidence		
	Boys.	Girls.	Total.	Boys.	Girls.	Total.	Boys.	Girls.	Total.
Technical High School..	400	350	750	16	-	16	4.0	-	2.1
Royal Academy.....	240	270	510	4	-	4	1.7	-	0.8
Burgh R.C.	15	20	35	4	-	4	26.6	-	14.3
Highland Orphanage.....	5	10	15	-	-	-	-	-	-
Total.....	660	650	1310	24	-	24	3.6	-	1.8

TABLE XIII.

Time of observation of cases in Inverness Schools
in the period 1943 - 1946.



The character of the schools noted in Table XII varied in some particulars. The children in the Convent of Notre Dame and the Highland Orphanage led an institutional life and there appeared to be little opportunity for them to mix with children from other schools. The pupils of the Royal Academy and the small private school were drawn from all parts of the town but predominantly from families of better economic circumstances. The pupils of the Burgh Roman Catholic School and the Bishop Eden's School were drawn from fairly wide areas of the town, whereas, of the pupils in the remaining schools, practically all came from the surrounding districts of these schools. With the exception of the private school, the schools noted were visited by the school medical officer and comparable satisfactory sanitary conditions were found. The private school, during the time of the outbreak of ringworm of the scalp, was conducted in one large room in a bowling pavilion, and it was noted that the conditions in this school appeared particularly to favour the spread of respiratory infection.

The following conclusions can be drawn from these circumstances and the findings detailed in Tables XII & XIII:-

1. The absence of cases of ringworm of the scalp in the Convent of Notre Dame and the Highland Orphanage probably arose from the absence of any exposure to infection owing to/
to/

to absence of contact with affected children outwith the school.

2. A markedly lower incidence of the disease in the susceptible age below 12 years, was noted in Clachnaharry School, the Royal Academy, and the private school, compared to the remaining schools in which cases occurred.
3. The distribution of the cases throughout the schools in which the disease was present was generally scattered throughout the four year period, there being an absence of marked grouping of the cases in the various schools such as one would expect from transmission of the disease in school.

The relatively small incidence of ringworm of the scalp in three schools is noteworthy. There appeared to be equal opportunities for contact in all schools and presumably the children pored over their tasks in a corresponding manner in all of them, so that, if contact in school provided favourable means of transmission of the disease, one would expect to find a more uniform incidence in all schools in which the disease was noted. Furthermore, of the cases which did occur in the schools noted to have a low incidence of infection, in the age group under 12 years, 6 or 36% resided in areas where there were a number of cases in children living in the immediate neighbourhood, and of the total number of children affected in these three schools, only one lived in an area where the neighbouring children did not appear to be affected.

It/

It has been noted previously, (Table X), that a majority of children suffering from ringworm of the scalp did not wear caps. There appeared to be a relatively greater proportion of children wearing headgear at the Royal Academy and the private school, suggesting, from the low incidence of the disease in these schools, that caps did not appear to be a likely means of the transmission of infection and it may have been that headgear tended to protect the susceptible scalp.

As already noted, Cranston Low, (1908), has stated that in many cases in pre-school children the disease is contracted from an elder member of the family affected in school. The findings in Inverness showed that this was by no means universal. Of 44 pre-school children found to be suffering from ringworm of the scalp, the disease was noted in other members of the family attending school in 20 instances, and of these 20 cases the disease was first observed in the pre-school child on two occasions. There remained, therefore, a group of 24 affected pre-school children, 55% of the total, in which no family contact with a school child suffering from ringworm of the scalp was traced.

Again, the finding in Inverness to which reference has been made before, that the charting of cases according to their house address, to be seen in the map attached, showed a tendency for cases of ringworm of the scalp to be localised/

localised to adjacent homes rather than to be spread diffusely, suggests that infection in school was not the most important mode of transmission of the disease in this outbreak.

On the other hand, in 59 cases investigated, the most likely source of infection in 4 cases was noted to be school attendance, and of these 4 cases, three occurred in one family, giving a percentage of 3.7 in which the disease was likely to have been contracted in school.

Consideration of these findings suggests that, in Inverness, school attendance played a minor part in the transmission of ringworm of the scalp, and, if one were to adopt the theory that the causal organism requires to be inoculated by mild trauma, in order to cause obvious infection, the disease is more likely to be transmitted by contact during play outwith the hours devoted to education.

INCUBATION PERIOD.

The incubation period of an infectious disease is defined, (Harries & Mitman, 1944), as the time which elapses between the entry of the causal organism and the onset of the disease. All infectious diseases have incubation periods, the duration varying in the different diseases, (Harries & Mitman, 1944), but that of ringworm of the scalp is said to be unknown. (Control of Communicable Diseases, 1945). This is hardly surprising, for the subjective symptoms of the disease are not usually noticeable in the early stages, and in children, the disease is likely to be found following inspection of the scalp by adults, this being a most variable factor in determining the onset of the disease.

Even so, the findings in the outbreak of the disease in Inverness, are considered to be worthy of examination with a view to determining the likely incubation period of ringworm of the scalp. Unfortunately no cases were seen in which the time of entry of the causal organism could be definitely determined and the case observed until the onset of the disease. Therefore, one has to base the time of entry of the organism on the date of definite contact with the disease, where this can be determined, and the time of onset of the disease has to be based on the time of the discovery of the case.

In 59 cases an attempt was made to determine the source of/
of/

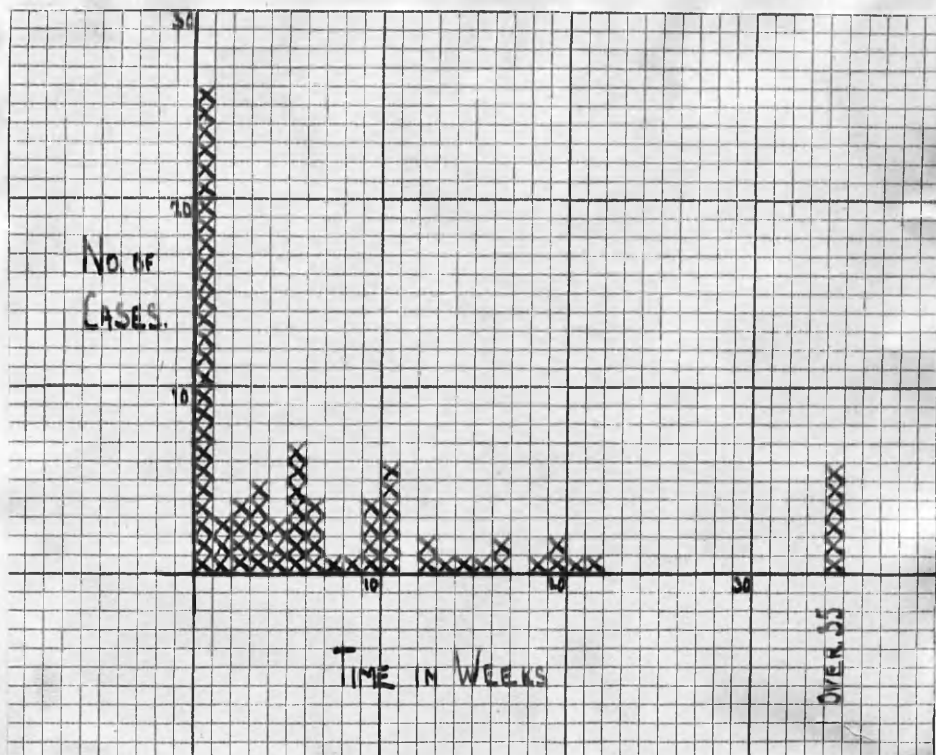
of the infection but, apart from family contact, only 11 children could name a case of the disease with which they had been in contact. Others could only state that there had been cases of ringworm in the neighbourhood and the majority of the 11 children who named a contact did not give sufficiently definite information to trace the most likely contact with certainty.

Therefore, it appeared that a study of the family contacts, only, would provide the most satisfactory data in an attempt to assess the incubation period of ringworm of the scalp. By this means one would be assessing the development of the disease after contact in fairly standardised conditions. In Table XIV the times of the occurrence of secondary cases in the 63 families which had two or more cases of the disease observed during the outbreak, have been charted according to the time of observation after the initial case. Where more than one case of the disease was noted in a family, subsequent to the first case, the interval in time charted has been from case to succeeding case, unless two cases were observed subsequent to family contact on approximately the same date, i.e., with an interval of less than one week; when both were considered to have been infected from the preceding case.

Table XIV /

TABLE XIV.

Time of noted occurrence of ringworm of the scalp
in 82 secondary and subsequent cases in 63
families after observation of the first case.



It will be observed that the majority of the secondary and subsequent cases of ringworm of the scalp were noted within 8 weeks of presumptive exposure to infection by family contact, and that 26 of such cases were noted within one week after the initial case. The question then arises whether, in these 26 cases, the members of the family were all infected at the same time from an outside source, or whether/

whether one member of the family was first infected and thereupon passed on the infection to the others, only the actual discovery of the disease being co-incidental.

It appeared likely that infection occurred in both of these ways in 26 cases, and in addition, the scantiness of the medical records available in many cases did not dispel the impression that many of them were actually first observed on different dates. For example, in some instances the only record available of the cases in a family was their attendance and treatment by X-rays, and it was quite likely that the disease had been noted at different time prior to treatment by X-rays.

The size of the lesion noted gives a clue in some of these cases to there having been in actuality a different time of onset in cases noted simultaneously. In three instances one child had the lesion noted as a "large patch" whilst his brother, for such it was on each occasion, had a smaller lesion noted. Two instances in which three members of the family were noted as suffering from ringworm of the scalp on the same date are of interest in this respect.

The lesions were:-

The lesions were:-

<u>Case 1.</u>	<u>Case 2.</u>	<u>Case 3.</u>
(a) Male, aged 5 yrs. "Patch of one and a half inches diameter."	Male aged 9 yrs. "Spot"	Male aged 10 yrs. "Spot."
(b) Male, aged 6 yrs. "Extensive patch."	Male, aged 10 yrs. "Patch."	Male, aged 4 yrs. "Patch."

This suggests that cases 2 and 3 were infected from case 1, simultaneously.

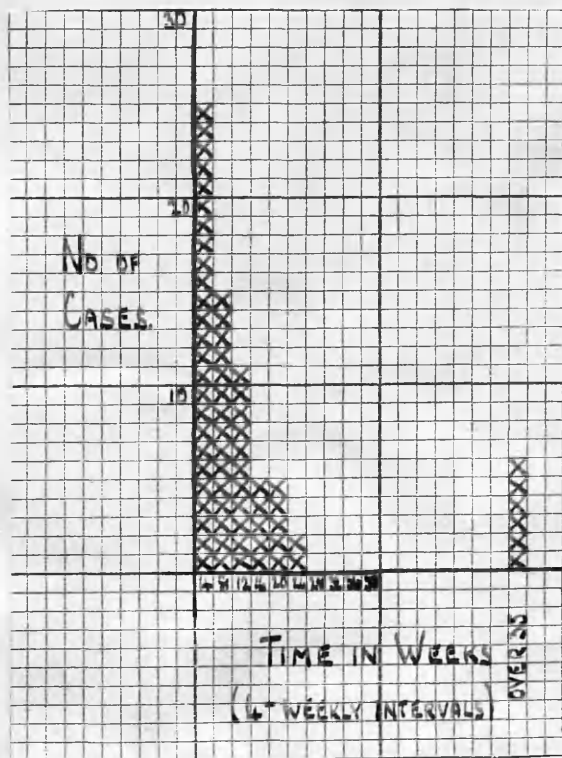
If in these 26 cases one considers the probabilities, between simultaneous infection and consecutive infection, with inadequate observation and recording, to be about equal, there would be 13 cases available for assessment as probable family contacts, these contacts having developed the disease within a few weeks of exposure to infection. This would maintain the increased incidence of secondary and subsequent cases noted within a few weeks of family contact with ringworm of the scalp, and as it seems unlikely that a gap of more than four weeks would separate the true onset of cases noted simultaneously, it appears justifiable to retain 13 of the 26 cases noted simultaneously for charting as second and subsequent cases occurring within 4 weeks of family contact with ringworm of the scalp. The findings, corrected thus, and charted on a four weekly basis, are given in Table XV, which/

which suggests that the great majority of cases of ringworm of the scalp which were recorded after likely exposure to infection in the family, in an outbreak in Inverness, were diagnosed within 12 weeks of exposure to infection.

Therefore, from these findings, one can generalise that the incubation period of ringworm of the scalp due to *microsporon audouini* is probably from one to twelve weeks on the average, but it appears impossible to define it more accurately in the absence of a marked time of onset of the disease.

TABLE XV.

Time of onset of 82 cases of ringworm of the scalp, with a history of family contact, after the observation of the initial case, 13 cases being excluded for correction of total of such contacts.



In this series of cases the observations available did not permit one to assess the size of the lesion in relation to the date noted for the onset of the disease. Therefore, in these cases the time of onset was subject to numerous circumstances such as the vigilance of parents, school nurse or doctor, the occurrence of holidays or hair-cuts, leading to early diagnosis or the failure to diagnose until the lesion was so extensive that it could not be hidden.

Furthermore, if, as has been suggested, it is necessary for the causal organism to be inoculated by mild trauma, there is liable to be considerable variation of the time of true exposure to infection from that noted in this series of cases.

The variability present, due to these factors, in assessing the likely incubation period of the disease is well illustrated by the findings in the following six families, three of which showed more than two cases and three of which were observed personally.

1. /

1. Observation of cases in three families.

Initial Case.	Case 2.	Case 3.	Two subsequent cases noted simultaneously.	Time observed after initial case in days.	Case 4.	Time after initial case.
a) Female, aged 6.	Male, aged 8.	Female, aged 6.		46	-	-
b) Male, aged 8.	Male, aged 6.	Male, aged 4.		28	Female, aged 11.	138
c) male, aged 9.	Male, aged 10	Male, aged 11		82	Female, aged 7.	109

2. Cases observed personally in three families, where the contacts were kept under observation.

Initial Case.	Case 2.	Case 3.	Time observed after initial case in days.	Time observed after initial case.	(a) initial case.	(b) Case 2.
a) Male, aged 10.	Male, aged 8		70	-	-	-
b) Male, aged 9	Male, aged 8	Male, aged 5	133	140		7
c) Female, aged 8	Female aged 10		38	-	-	-

From/

From what has been described it appears that the findings in Inverness did not permit, with any degree of accuracy, the assessment of the incubation period of ringworm of the scalp due to *microsporon audouini*. The evidence available suggests that it is likely to be not greater than eight weeks, but for further elucidation it would appear necessary to define the onset of the disease more accurately, such as making it the time when fluorescence is first apparent when using Wood's Glass, and to determine more exactly the mechanism of the inoculation of disease.

INCIDENCE.

Stallybrass, (1931), points out that infectious diseases which, whilst continuously present in a district, exhibit marked seasonal or other periodicities, or which prevail for a time and then disappear entirely, display in more or less characteristic form a variation in time known as the epidemic wave. An epidemic wave shows the incidence of cases to rise, more or less rapidly, to a maximum, and then to fall, with a roughly proportionate rapidity, either to nil or to the normal endemic level at which one person affects one other person on the average.

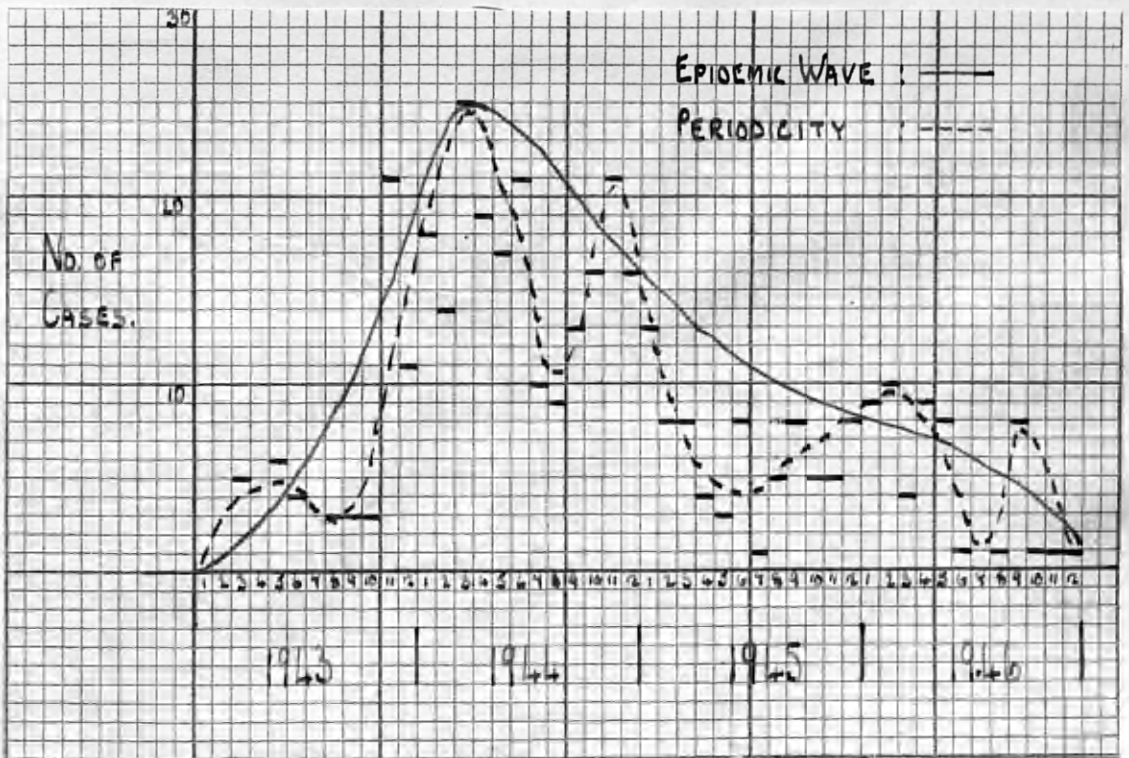
The monthly incidence of cases of ringworm of the scalp noted in Inverness has been charted for the years 1943 to 1946, this incidence being used in the chart as that likely to give the most accurate impression of incidence. In this outbreak examination of the records showed that an attempt to give the incidence on a weekly basis would give most uncertain findings. Many patients were unaware of the date of the exact onset of the disease, in view of the insidious nature of the symptoms, and at best could only state that they had noticed changes a week or two previously. Other cases were only discovered on systematic examination by the school nurse.

It is apparent from the chart (Table XVI) that the graph/

graph of incidence takes the form of a curve so that in this outbreak ringworm of the scalp shows the phenomenon of the epidemic wave consisting of an ascending and a descending limb, the latter being the longer. This type of curve is stated by Stallybrass, (1931), to be the most frequent, and the others which he describes, in order of frequency, are the symmetrical or roughly symmetrical, and the curve with a longer ascending than descending limb.

TABLE XVI.

Chart of the incidence or observation of cases of ringworm of the scalp in Inverness from 1943 - 1946.



Ross and Hudson, (1917), give the following series of curves:-

1. The steadily rising curve of an infection that gradually permeates the whole population.
2. The symmetrical bell-shaped curve.
3. The unsymmetrical bell-curve of an infection that begins with an epidemic and settles down to a steady endemic level.
4. The periodic curve with regular rise and fall due to seasonal disturbance.
5. The more irregular curve where there is recrudescence before the end of an epidemic, or where outbreaks differing in violence occur at unequal intervals.

Although the broad sweep of the curve over the four year period gives an epidemic wave (marked with a continuous line in Table XVI), in conformity with the most prevalent type of curve as described by Stallybrass, (1931), it appears that the incidence of the cases of ringworm of the scalp over the same period may also be broken into five epidemic waves. (Marked by the dotted line in Table XVI). This interpretation of the incidence would give a curve of type 4 in the series described by Ross and Hudson, (1917). For the purpose of discussion, therefore, ringworm of the scalp in Inverness during the years 1943 to 1946, appeared to show a general epidemic wave and periodic curves or periodicity.

THE EPIDEMIC WAVE.

It has been stated, (Stallybrass, 1931), that there are three factors which influence the epidemic picture of an infectious disease, the factors of transmission, susceptibility, and of parasitic variation. The same author, on the available evidence, states certain general conclusions regarding these factors, which may be applicable to ringworm of the scalp due to *microsporon audouini*. The factor of transmission is said to be one of the greatest importance, but its variability is not uniform in all classes of infectious disease and variation in the transmission factor also shows its influence in relationship to the seasonal periodicity of disease. The following circumstances have been shown to be effective in the transmission of ringworm of the scalp due to *microsporon audouini*; family contact; contact in play; cinema attendance; attendance at the barber; and school attendance. Generally, these factors did not vary throughout the four year period of the outbreak as a whole, therefore, the available evidence in this outbreak suggests that the transmission factor remained fairly constant for the general epidemic wave.

Stallybrass, (1931), next concludes, in relation to the factor of susceptibility, that there is a body of evidence which points to variations in the susceptibility of/

of the population as being the principal limiting condition of outbreaks of infectious disease, given that the factor of transmission is suitable to the propagation of the disease. As an example of this factor he states that not even a specifically polluted water supply will precipitate an epidemic in a population immune to the specific disease.

Finally, the factor of parasitic variation must be considered. Gill, (1928), in what he termed the "Quantum theory," regarded variations in the transmitting agent and in the susceptibility or insusceptibility of the population at risk as being, practically, the sole cause of the rise and fall of epidemics; Stalybrass, (1931), however, is unable to accept this conclusion and states that both laboratory experiments and the experience of mankind point to large and crucial variations in the pathogenicity of many types of organism, although he admits that no observable variations in pathogenicity have been noted in the course of experimental epizootics.

No particular observations have been made in the Inverness outbreak of ringworm of the scalp which can help one to assess this factor. It was observed that the nature and extent of the clinical lesion did not, in general, vary throughout the outbreak, but such a solitary and generalised observation is hardly sufficient reason to dismiss the possibility of some variation in the pathogenicity/

pathogenicity of *microsporon audouini*, although it seems sufficient evidence to discount gross change in the pathogenicity of the organism during the outbreak.

From the evidence available in Inverness, one may conclude that ringworm of the scalp due to *microsporon audouini*, is capable of conforming, in its epidemic picture, to that shown by other infectious diseases; the disease being capable of showing an epidemic wave, the configuration of which appears, in view of the apparent absence of variation noted in the factors of transmission and pathogenicity of the causal organism, to be determined by a decrease in susceptibility of the population at risk.

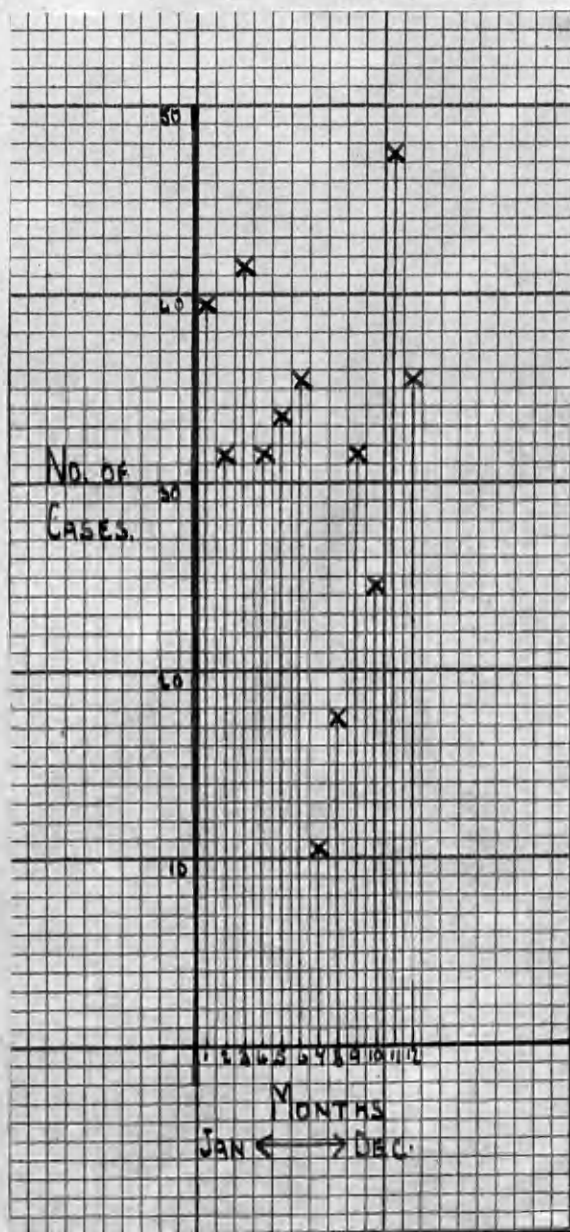
PERIODICITY.

It has been stated, (Stallybrass, 1931), that examination of the graph representing the prevalence of an epidemic disease over a number of years often reveals two periodicities in its course, seasonal or annual fluctuations, and fluctuations of a non-annual cycle, the latter being usually multi-annual, but that if either of these periodicities is very well marked it may mask the other. A search did not reveal sufficient records to enable one to assess with any accuracy the incidence of ringworm of the scalp in Inverness over a number of years prior to 1943, so that, from the figures in Inverness it is only possible to draw conclusions regarding the seasonal periodicity of ringworm of the scalp in the years 1943 to 1946.

An attempt is made to assess this periodicity by adding the figures of cases noted in Inverness in the corresponding months of the four year period. (Table XVII).

TABLE XVII.

Case Incidence of Ringworm of the Scalp in Inverness from 1943 to 1946, according to the months of the year.



From the curve it is seen that there is marked diminution in the number of cases observed during the months of July and August with an increasing incidence in September and October, to a peak incidence in November, falling thereafter to a slightly irregular incidence, on the whole greater than that noted in the months of September and October.

It is difficult to say whether this conforms to a true diminution in the incidence of ringworm of the scalp, as July and August are holiday months for the schools. In these months a number of children leave the Burgh on holiday and should any of these have developed the disease, the fact would not be noted in the records available for this survey. In addition, as was noted previously, many cases were only discovered following examination by the school nurse, and such examinations were not carried out during the time of the school holidays. Even so, were these the sole factors concerned in the diminution in incidence during July and August, one would expect the cases missed in this time to give a greater apparent incidence in the number of cases during the months of September and October than that noted in Table XVII, as by this time school attendance has been resumed and methods of detecting cases conform to the remainder of the year.

Such/

Such is not the case and the findings in Inverness suggest that in this outbreak of ringworm of the scalp there was some degree of seasonal prevalence.

Stallybrass, (1931), states that every disease, with few exceptions, has its own time and season, and he adopts the following classification for the North and South Temperate Zones:-

1. A summer group, which includes the alimentary infections, and the metaxenous diseases carried by flying insects.
2. A winter group of respiratory infections and also a number of ectoderms such as smallpox.
3. An autumnal group of less defined character, reaching their maximum prevalence in October or November, this group being largely spread by contagion.

The same author states that these annual cycles of prevalence are clearly related to the annual climatic variations, of which atmospheric temperature is the most important in temperate latitudes. Other factors, possibly productive of variations in prevalence, are given as relative or absolute humidity, rainfall, wind, and sunshine. These factors are stated to be capable of acting directly or indirectly and it is said, (Stallybrass, 1931), that they may influence the three primary factors concerned in the spread/

spread of disease, namely, the seed, the sower, or the soil. To the sum effect of these three primary factors, the virus of variable virulence and infectivity, the efficient means of transmission, and the susceptibility or resistance of individuals who compose the community at risk, Stallybrass, (1931), has given the title "dispersibility," and he states that prevalence is largely the effect of increased dispersibility, the lag between maximum dispersibility and maximum prevalence being usually three to four months.

Apart from annual climatic variation, the annual school holidays are due consideration separately in respect to the seasonal periodicity of ringworm of the scalp caused by *microsporon audouini*.

CLIMATIC FACTORS.

Although it seems possible, by the analogy of seed and soil in nature, that *microsporon audouini* and the scalp of childhood show variations in pathogenicity and susceptibility respectively in response to climatic conditions, I can find no reference to any definite findings concerning this. As has been shown, human behaviour and contact are responsible for the transmission of ringworm of the scalp and it seems possible, in respect to the occurrence of the disease in Inverness, to assess the variations/

variations in the behaviour of children due to climatic factors. The graph of incidence, (Tables XVI and XVII), shows a diminished incidence during the months of July to October, and bearing in mind the statement of Stallybrass, (1931), regarding the lag in time between dispersibility and prevalence, it may be best to consider the months of May to August as those likely to present climatic factors modifying the prevalence or ringworm of the scalp. The climate of these months in Inverness is generally termed summer weather and is characterised by a higher mean atmospheric pressure, more sunshine, with less wind and rain. The variations in habits and behaviour of children, as seen in Inverness in the different seasons may be tabulated, (Table XVIII), in so far as they concern factors affecting the transmission of ringworm of the scalp due to microsporon audouini.

TABLE XVIII.

Variations in the habits of children noted in
Inverness according to the season or the year.

<u>WINTER.</u>	<u>SUMMER.</u>
1. Headgear worn more frequently.	1. Headgear unusual.
2. Cinema attendance more frequent.	2. Less cinema attendance.
3. More prolonged contact at home.	3. More play in the open air.
4. More travelling and congestion in public vehicles.	4. Climate favours walking to school.

It is apparent therefore, from Table XVIII, that summer favours less close contact between children, and such diminution of contact during the summer months may be sufficient to account for the decreased prevalence of ringworm of the scalp noted from July to October.

SCHOOL ATTENDANCE.

Summer also coincides with the long vacation from school, and this vacation, although probably lessening contact between groups of children attending a school, gives these same children the opportunity of wandering further afield, possibly into contact with infection elsewhere. In Inverness, the factor of lessened contact during the school vacation may have been the more important one in affecting the seasonal prevalence of ringworm of the scalp as the outbreak of the disease occurred during war years with lessened facilities for travelling and holidays outwith the Burgh.

Percival, (1932), in an analysis of the figures of the monthly prevalence of ringworm of the scalp in Edinburgh in the years 1912-30, showed that there was a diminution in prevalence in the months of July and August followed by a marked increase in prevalence in the month of September. In commenting on this he favoured the hypothesis that a long vacation from school favours case spread owing to lack of medical inspection and controlling measures. In analysing/

analysing the incidence of cases in Inverness consecutively (dotted line in Table XVI), there is seen to be a distinct rise in the case incidence for September in each year, but this rise is not comparable in extent to that noted by Percival, and is dwarfed by the incidence of succeeding months. Therefore, this hypothesis of Percival, (1932), applied directly to case incidence in a corresponding manner to his method. (Table XVII) does not appear to explain the periodicity of ringworm of the scalp in Inverness, and the periodicity in this town appears, on that basis, to be related to less favourable factors affecting the prevalence of the disease being present in the summer months.

It has been noted however, that maximum prevalence is said to be largely the effect of maximum dispersibility, the time lag between the two being usually three to four months. Assuming that this is the case for ringworm of the scalp due to *microsporon audouini*, the findings in Inverness would suggest that the late summer and early autumn months were particularly favourable to the spread of the disease, and that the high incidence in the winter months is related to this.

Although it has been considered that the summer months are less favourable for the transmission of ringworm of the scalp and therefore, tend to lessen the dispersibility/

dispersibility of the disease, I think the findings regarding seasonal periodicity can be explained satisfactorily provided the time lag between maximum dispersibility and maximum prevalence in the case of ringworm of the scalp due to *microsporon audouini* is in the region of three months. In these circumstances, the sequence of events could be interpreted as follows, allowing also for the effect of control measures during school terms and lack of them during the long vacation. With the onset of warmer and summer weather towards the end of April, factors are less favourable to the transmission of the disease and at the same time measures of control have been in full force for some time, so that after a lag of about three months the seasonal prevalence of the disease is at its minimum. In July and August there is some lessening of control, owing to absence of school inspection, and a number of cases of ringworm of the scalp may be at large. With the onset of colder weather and the resumption of school in September, factors are more favourable to transmission of the disease, its dispersibility is increased and maximum prevalence occurs in the winter months.

The question then arises whether the findings regarding the prevalence of ringworm of the scalp in Inverness and Edinburgh are comparable. In the former, over/

over a four year period, there was a curve of monthly prevalence from the minimum in July to the maximum in November. In Edinburgh, over an eighteen year period, prevalence is shown to be fairly constant over the year except for a lessening during school vacations, an obvious increase following them, most marked in September, and a slight increase in prevalence during October and December. The total number of cases noted by Percival, (1932), as occurring in Edinburgh each year, suggests that for the most part the disease was endemic during the time of his observations, so that the seasonal prevalence he described was probably related to ringworm of the scalp in its endemic phase. In Inverness, as is seen in Table XVI, the disease tended to be epidemic in the earlier years, settling towards an endemic level about the end of 1945. It is noteworthy that in 1945 the incidence of cases observed in September tended to be closer to the succeeding maximum incidence and that in September, 1946, the findings conformed to the type noted by Percival, (1932). In this latter month 4 of the eight cases observed were discovered on inspection by the school nurse.

The difference in seasonal incidence noted between Inverness and Edinburgh may have been partly related to variations in habits of the respective school children, of which no record has been made in the case of Edinburgh. Two such differences might have been present, the first being/

being the likelihood of a greater density of houses to the area in Edinburgh possibly leading to more constant close contact, and the second being the relative absence of cinema attendance as a recreation during the years in which the cases in Edinburgh were observed.

The findings noted in Inverness and Edinburgh may permit of the following general conclusions regarding the seasonal periodicity of ringworm of the scalp due to *microsporon audouini*.

1. The disease shows a seasonal periodicity characterised by a greater prevalence during the winter months, appearing to be of the autumnal group of infectious disease as defined by Stallybrass, (1931).
2. The principal factors concerned in this seasonal prevalence appear to be (a) the modifying effect of relative lack of control measures during the long summer school vacation, and (b) a diminution in the transmission factors in the summer months due to childrens' habits tending to less close contact.
3. The interplay of these two factors is likely to determine the curve of prevalence during the winter months. Shouldⁿ factor (a) predominate, as when ringworm of the scalp is endemic, a great immediate/

immediate increase in incidence should be noted on the resumption of school, and in the event of factor (b) being predominant, as is likely to happen when the disease is epidemic, a gradual increasing incidence related to increasing dispersibility might be expected.

SOCIAL FACTORS AFFECTING THE INCIDENCE OF
RINGWORM OF THE SCALP.

The scope of social factors in their effect upon the incidence of infectious disease is comprehensively expressed by Stallybrass, (1931), as follows:-

"for there are few human activities which are not associated directly or indirectly with the spread of infective disease. Man's comings and goings, his habitations and places of work, instruction and recreation, his social and religious behaviour and customs, his marital and sexual conduct, his isolation and aggregation, his travels, festivals, famines, wars, his emigration and immigration, his commerce and occupation, all powerfully influence his liability to suffer from or to disseminate infective disease."

This range of behaviour exceeds that found in the average child, but the following social factors might be expected to have an influence upon ringworm of the scalp due to *microsporon audouini*.

1. Housing. Variations in types of houses, their surroundings in respect to space or crowding together, and in the number of occupants per house, may be expected to influence the incidence of infectious disease by providing variation in the facilities of its transmission. From the figures available, cases of ringworm of the scalp were noted in 270 houses within the Burgh boundary of Inverness in the years 1943-46 inclusive. These houses were varied in type, proximity, and surroundings and an attempt has been made to classify their differences in relationship to the/

the incidence of ringworm of the scalp.

A preliminary assessment showed that of these 270 houses, 124 were of modern design, being built subsequent to the 1914-18 war, and spaced according to standards customary since that time, while 146 houses were older property, with, on the whole, less spacious surroundings. Of the total of approximately 6,200 houses in the Burgh at the end of 1946, approximately 2,500 were built subsequent to the 1914-18 war, and the findings show that this outbreak of ringworm of the scalp had no predilection for old property.

The sites of the affected property were then studied (see map) and a glance shows that there appears to be a concentration of cases in certain parts of the town. A division of the houses and the total number of cases into Wards relative to the findings at the 1931 census gives findings as shown in Table XVIII.

Table XVIII/

TABLE XVIII.

Case Incidence of Ringworm of the Scalp in Inverness
according to houses having cases in the various Wards.

Name of Ward.	No. of Cases.	No. of houses with cases.	Total population (1931).	Occupied houses.
Merkinch	170	123	4,041	926
Muirtown.....	32	60	3,256	856
Park.....	49	35	3,719	907
Southside.....	12	9	3,519	822
Crown	13	11	2,797	742
Central	16	12	2,042	508
Harbour	30	29	3,208	703
Fringe area of Burgh.....	12	-	-	-

This shows clearly that there was a preponderance of houses, in which there were cases of disease, in the Merkinch Ward. Although there is a considerable amount of old property in this ward at least half of the houses are of modern construction and comprise Municipal housing schemes. It is unlikely, therefore, that the actual type of house exerted any influence upon the incidence of ringworm of the scalp in this outbreak. The spaciousness of the surroundings did not appear to exert any influence upon the incidence of the disease as shown in this ward for the houses in the municipal schemes were well spaced with adequate/

adequate areas for play.

What was considered to be a representative sample of affected households was studied to determine the average number of occupants per room. These households, totalling 50, show the average number of occupants per house to be 5.5 and per room 1.83. Such an average is markedly above the general average for Scotland as revealed by the census of 1931, and also above the figures for the Burgh of Inverness at the same census, these latter being 3.93 persons per house and 0.97 persons per room.

This suggests that overcrowding was a definite social factor in the incidence of ringworm of the scalp due to *microsporon audouini* and the relative overcrowding in the households with cases of the disease is shown further when the occupants per room are tabulated in a manner corresponding to the findings of the census of 1931 in the Burgh of Inverness.

Table XIX /

TABLE XIX.

Comparison of occupants per room in 50 representative households containing cases of ringworm of the scalp to the general findings in Inverness revealed at the Census in 1931.

	Not more than 2.	2 - 3	3 - 4	More than 4.
Percentage of population living per room	85.0	11.7	2.7	0.6
Percentage of persons living per room in 50 households with cases of ringworm of the scalp.....	60.5	28.5	6.9	4.0

Adopting the view that overcrowding exists when the standards of 2 persons in 1 room, 3 persons in 2 rooms, 5 in 3 rooms, $7\frac{1}{2}$ in 4 rooms, 10 in 5 rooms, and an additional 2 persons in respect of each room in excess of 5, are exceeded, (Vernon, 1939), the findings in the 50 representative households investigated show overcrowding in 25, or 50%. This is greater than the maximum figure of overcrowding for Scotland of 44.9 per cent in Clydebank in 1936. (Vernon, 1939).

A survey of all the affected households in the Burgh confirms this finding. In all the wards, except the Merkinch Ward, the households affected practically all lived in overcrowded areas. Thus of the total of 61 households in the Southside, Crown, Central and Harbour Wards, i.e., all/

all the affected households south of the River Ness, 50 were situated in property considered to show a tendency to overcrowding.

For the purpose of assessing the sanitary arrangements in the 50 households investigated, these facilities were divided into satisfactory and unsatisfactory, the index of the latter being the necessity to use an outside privy. Adopting this classification it was found that 28 households had satisfactory sanitary facilities, whereas in 22 cases these were unsatisfactory. The division by Wards was as follows:-

	<u>Merk-</u> <u>inch.</u>	<u>Muir-</u> <u>town.</u>	<u>Park.</u>	<u>Harbour.</u>	<u>Cen-</u> <u>tral.</u>	<u>Crown.</u>	<u>South-</u> <u>side</u>
Satisfactory....	23	1	2	1	-	1	-
Unsatisfactory..	8	4	3	4	2	-	2

Although hardly extensive, these figures suggest that the presence or absence of satisfactory sanitary facilities per house do not influence the incidence of ringworm of the scalp.

The general conclusion regarding the effect of housing upon the incidence of ringworm of the scalp in Inverness appears to be that there was an increased incidence in relation to overcrowding, other conditions of housing being of relatively little importance.

In/

In this respect ringworm of the scalp conforms to other infectious diseases such as measles and tuberculosis as noted by Parkinson, (1944), but it should be stated that selective analysis has been adopted in reaching this conclusion for ringworm of the scalp and that no attempt has been made at multiple correlation necessary, as Greenwood, (1935), points out, to determine the true influence of domestic overcrowding upon the incidence of infectious disease.

2. Social Status. Vernon, (1939), has brought together considerable evidence to show that health is greatly influenced by conditions of social environment, and that these conditions are largely dependent on economic causes. The findings in Inverness in respect to ringworm of the scalp show that the incidence appeared to bear some relationship to social status. It has already been stated that the Merkinch Ward of the Burgh showed the highest incidence of the disease, (Table XVIII), and that 61 households were affected in that part of the Burgh south of the River Ness, leaving 213 households north of the river. Although compared to many burghs and cities in Britain, Inverness shows a considerable variation in housing and social status in each of its wards, it can be stated that the part of the burgh to the south of the River Ness is generally the more "fashionable" part, and the Merkinch Ward the least "fashionable."

The heads of the affected households in wards other than the Merkinch Ward generally appeared to be those of social classes (4) and (5) adopting the Registrar-General's classification of (1) professional etc., (2) intermediate, (3) skilled workers, (4) intermediate, and (5) unskilled workers; but it is worthy of note that no cases of the disease were found in some aggregations of households where the heads were of class (4) and (5).

Two methods can be used in this case to determine the incidence of ringworm of the scalp according to the social class of the head of the household.

The first of these is based on the house occupied, taking the Inverness Burgh Directory of 1941-42 as a guide. The residential streets listed in this directory have been divided into five classes in accordance with the occupation of the majority of the householders in the street, using the Registrar-General's classification, and the incidence of cases in the streets has been noted. Where a small side street containing less than 10 houses leads off a main street it has been included with the larger street.

Table XX. /

TABLE XX.

Incidence of households with cases of ringworm of the scalp in the streets in Inverness, classified according to preponderant social class of householders.

Class of street according to occupation of majority of householders, using Registrar-General's classification.	Total number of such streets.	No. of households with cases of ringworm of the scalp.				% of streets not affected.
		0.	1-5	6-10	11-15	
Class (1)	22	21	1	-	-	95.4
Class (2)	26	18	8	-	-	69.2
Class (3)	37	13	22	2	-	35.1
Class (4)	40	11	26	3	-	27.5
Class (5)	28	5	4	3	5	17.8

The findings are given in Table XX and show a clear diminution of the number of streets with households free from cases of the disease as one proceeds from Class (1) to Class (5). Furthermore, the liability to an increased number of affected households per street is shown in the same progression. It may be argued that streets containing houses of Classes (4) and (5) tend to contain more houses per street, but it is not thought that the results are appreciably weighted by this in Inverness.

The numbers of male heads of households in the Registrar-General's Classification of Classes (1) to (5) in 1931, is not given for Inverness in Volume 1, part 18 of the/

the Report on the fourteenth decennial census of Scotland, but an approximate estimation of the numbers in Classes (1) to (5) has been made from this volume and is shown in Table XXI, together with the number of heads of households in which cases of ringworm of the scalp occurred. This table confirms the relative progressive preponderance of cases in Class (3) to (5).

TABLE XXI.

Incidence of Ringworm of the Scalp in Inverness according to the social class of the heads of the affected households.

Social class (adopting Registrar General's classification)	(1) Total No. calculated from 1931 census.	(2) No. of heads of affected households.	Percentage of (2) and (3)
Class (1)	693	-	-
Class (2)	274	2	0.73
Class (3)	3,081	51	1.65
Class (4)	1,361	42	3.08
Class (5)	1,099	54	4.91
<hr/>			
Heads of households with ringworm of the scalp, not classified.			
<hr/>			
Females (no occupation stated) ..	-	25	-
Not stated in Directory	-	12	-
Not traced in Burgh Directory	-	68	-

The greater frequency of cases of ringworm of the scalp in conditions of overcrowding and in social classes (3) to (5) has been shown and generally there is a relationship between the two as shown in 50 households investigated and tabulated. (Table XXII)

TABLE XXII.

Relationship of Social Class to overcrowding in 50 households with cases of ringworm of the scalp in Inverness.

Social Class of heads of households.	(1) No. of heads of households.	(2) No. of households showing overcrowding.	Percentage of (2) to (1).
Class (1).....	-	-	-
Class (2)	1	-	-
Class (3)	12	4	33.3
Class (4)	15	7	46.6
Class (5).....	22	14	63.6
Total....	50	25	50.0

A similar finding in relation to social classes and overcrowding has been noted by Vernon, (1939), who notes that, "overcrowding means a reduction of air space and ventilation, and consequently a greater risk of the spread of respiratory and other infectious diseases, but it also implies a lowering of social standards and amenities. The congestion is apt to result in a diminution of cleanliness and/

and sanitation, while the expenditure on food, clothing, and other necessities is usually lower. There may be a reduction of parental skill and care, and some loss of efficiency in running the household, especially in the purchase of the most suitable food and its cooking."

From this statement it appears that there are a number of sub-factors relative to overcrowding and social status and these are listed below as being those with a possible bearing upon the incidence of ringworm of the scalp in children.

1) Nutrition. Of recent years much attention has been devoted to the nutrition of school children and the improved health subsequent to extra nourishment being provided. (Vernon, 1939). In the outbreak of ringworm of the scalp in Inverness, no evidence was found to show that nutrition influenced the incidence of the disease. All the children seen personally appeared to be adequately nourished and no under-nourishment in cases of the disease was noted by other observers. Rationing of foodstuffs was in force throughout the period of the outbreak, and varied social incidence of the disease at a time when standards of nutrition tended to be equal, suggests that nutrition had little to do with the incidence of the disease.

2) /

2) Cleanliness and Sanitation. It has been shown that the incidence of ringworm of the scalp was not related to sanitary facilities available, but it remains to be seen whether these facilities were put to adequate use in relation to the occurrence of the disease. For this purpose the 50 households studied have been classified into "clean" and "dirty." Such a classification is difficult to define with scientific exactitude, there being degrees of both, and for the purpose of this assessment a household has been defined as "dirty" in which there was sufficient evidence of appearance, smell, and general reputation to justify the term.

Using this basis 24 of the 50 households could be described as "dirty." This number is sufficient to suggest that lack of cleanliness plays a part in the incidence of ringworm of the scalp for one hardly expects to find 48% of households "dirty" in an average town in Great Britain, and certainly the majority of the inhabitants of Inverness would object to the statement that 48% of the households of the whole town are "dirty." It is to be expected that personal cleanliness and the frequent ablution which this implies, would lessen the incidence of the disease, for concentration of the causal organism, occurring as it does on the epidermis, is likely to be lessened thereby.

3) /

3) Parental skill and care. It is not the nature of ringworm of the scalp, in its early stages at least, to bring itself readily to the notice of parents unless they are in the habit of washing or inspecting the scalps of susceptible children. In the affected child with a careless parent the disease is likely to escape notice for a longer time and the opportunities for the spread of infection are multiplied. In Inverness, this was confirmed by the large proportion of cases which were first noticed by the school nurse. Lack of parental skill, or knowledge, was found to be a factor in promoting the spread of the disease, as, in some instances, although the disease was apparent, its significance was not appreciated, and in others, the after treatment, consisting of shampoos and the application of fungicidal ointment, was not carried out in a satisfactory manner.

4) Social Standards and Amenities. Children who show deficient social standards have often had the name of "roughs" applied to them, and this term is of significance when considered in relation to ringworm of the scalp. The word brings to mind the picture of children fighting, thereby increasing bodily contact and liability to infection. The fighting, in Inverness, was generally observed to be of the playful and wrestling type favourable to contamination of the scalp, if one of the contestants was affected with ringworm./

ringworm. Children suffering from ringworm of the scalp were generally found to be acutely aware of their disability and the taunts which ^{were} commonly made by their fellows, often resulted in attempts at retaliation by bodily assault. Such behaviour and reaction are no doubt common to most of social classes but the degree seems to vary with the social standard of the children.

Lack of social amenities also provides opportunity of increased contact amongst children susceptible to ringworm. The high rate of cinema attendance in children suffering from the disease has been noted and this appears to be one of the principal amenities of those with overcrowded homes. In parenthesis it may be noted that this lack plays its part when an affected child is excluded from school. In overcrowded conditions the mother may well be tempted to send the child to the cinema; where he is out of the way and off the streets.

5) Space and Ventilation. Lack of these has been noted above as favouring the spread of infectious disease, and certainly, in so far as space is concerned, ringworm of the scalp appears to follow the rule as this gives increased opportunity for bodily contact and the influence of this upon the spread of ringworm of the scalp has already been noted and discussed.

From/

From the foregoing it appears reasonable to conclude that the incidence of ringworm of the scalp bears some relationship to social status, it being relatively more frequent in its occurrence and showing a greater liability to spread amongst those classified in groups (4) and (5) particularly. This finding appears to be borne out by popular opinion and description of the disease, particularly during years when differences in social status were stated bluntly, and present day Groups (4) and (5) might well have been described as the "lower orders." Thus in 1913, in Inverness, (MacDonald, 1913), Dr. Gordon A. Lang is found to refer to "Ringworm, the most loathsome of all skin diseases found in schools." This attitude appeared to be confirmed in the folk-lore of Inverness. During the outbreak, discovery of the disease evoked in many of the parents alarm and disgust out of all proportion to the appearances of the lesions, and by some the finding of ringworm of the scalp in their children was regarded as in the nature of a social disgrace.

3. Social Habits.

Recreation and work may be expected to influence the occurrence of ringworm of the scalp and these have been discussed in relation to the transmission of the disease.

4./

4. War.

The influence of war upon the spread of infection has been noted in relation to many diseases, (Stallybrass, 1931), and during the war of 1914-18 in Europe there was a marked increase in ringworm of the scalp due to microspora. (Fruhwald, 1924). A marked increase of microsporon ringworm of the scalp during the war of 1939-45 has been noted in Great Britain by Ingram, (1945), and Duncan, (1945), and in the United States of America by Lewis et al. (1944), and Schwartz et al, (1946). The outbreak of the disease under study, occurred in its greater part, during years of war, and in Inverness the recent war brought changes to the town which may well have affected the occurrence of ringworm of the scalp. In Inverness these changes consisted of (1) an influx of newcomers; (2) an increase in overcrowding; (3) an apparent or real increase of income in many families.

The recent war, with its risk of air attack, involved many shifts of the juvenile population. Inverness, being a town in what was considered to be a safe area, received its quota of children moved from centres where they were expected to be exposed to danger. In addition, in years subsequent to 1939, there was a considerable concentration of military forces in the north of Scotland. Many members of/

of the Forces endeavoured to find accommodation for their families in the area and this added to the number of newcomers amongst the children of Inverness. Amongst these newcomers there were likely to be cases of ringworm of the scalp and two such cases were noted personally. In view of the low incidence of the disease prior to 1943 there was likely to be a lowered standard of general immunity to the disease in Inverness, favouring spread of infection. The influx of healthy children over these years might well have played a part in the increase in incidence of the disease in the same way that the importation of unsalted immigrants into heads of mice affected with *Aertrycha* infection was found to prolong and increase the disease. (Greenwood, 1935).

Practically no new housing was constructed during the years 1939 to 1946 in Inverness, and although there was no destruction of houses, there appeared to be an increase of the population and also of overcrowding as a result. No official estimate of the population of the Burgh has been given for years subsequent to 1939, when it was estimated at 23,419, (Annual Report of the Registrar-General for Scotland, 1943. H.M. Stationary Office, Edinburgh), but unofficial estimates agree that the population of the Burgh increased during the war years.

The findings in respect to overcrowding and the incidence of ringworm of the scalp have already been stated and/

and there is little doubt that the advent of war played a part in this overcrowding.

In normal times an increase of income might be expected to lead to improved social circumstances and a diminution of the economic factors noted as favouring the spread of ringworm of the scalp. This effect was not found to be appreciable in Inverness during the years of the recent war. Amongst the households noted with cases of ringworm of the scalp, there was a general relative improvement in circumstances in terms of money, as compared with the years preceding the War. Owing to scarcities this was not translated into terms of food, clothing, and housing, but an increased indulgence in purchaseable recreation was noted. Thus many children of families classified in Social Group (5) were found to be attending the cinema three times weekly, and in many of these families a sum of approximately five shillings per week must have been spent on cinema attendance alone, a marked change from the days when one penny to sixpence a week was considered a reasonable allowance for the recreation of children.

The finding that cinema attendance appeared to be related to the spread of the disease has already been discussed so that an increase in income, in terms of money, during War, had the paradoxical effect, in respect to some recreation, of tending to increase the incidence of the disease.

CONTROL OF RINGWORM OF THE SCALP.

The control of infectious disease can be considered as a corollary to the epidemiological findings and certain principles applicable to the control of an infectious disease are described by various authors. (Harries, & Mitman, 1944); (Parkinson, 1944)

These may be summarised as:-

1. Notification and isolation of cases;
2. Disinfection of articles;
3. Quarantine of contacts;
4. Immunisation of susceptibles;
5. Improvement of social conditions;
6. General measures to prevent transmission of the causal organism.

It is proposed to review the control of ringworm of the scalp in children in relation to these principles.

Notification and Isolation of Cases.

Ringworm of the scalp is not a notifiable disease under present regulations, although such a recommendation has been made by Walker, (1911), and Lewis et al. (1944), but the value to the Medical Officer of Health of information regarding the occurrence of cases in certain circumstances was shown during the outbreak of the disease in Inverness. These/

These circumstances are when the disease appears to be assuming epidemic proportions and when there is reason to doubt the efficacy of the treatment prescribed by attendant general practitioners. In this outbreak, and it also appears to have been the custom at times in other places, (Calcott Fox, 1892), teachers in the schools supplied some information. This method is open to objections. Firstly, cases of the disease in pre-school children are not brought to notice, and secondly, general practitioners attending cases may feel that there is an unwarranted usurpation of their function by lay persons. The necessity of informing the Medical Officer of Health of the occurrence of cases of the disease is likely to be an aid to the general practitioner in promoting efficient treatment. One can readily imagine circumstances in which a general practitioner having a case of the disease with slight symptoms, and not being conversant with all the data relevant to the illness, is tempted to avoid the apparently drastic treatment involved for its cure, and to temporise with the prescription of ointments or lotions which may be capable of giving a spurious appearance of recovery, leading to a potentially infective case being at large amongst the population for longer than is necessary. As stated before, such was often an occurrence during the early stages of the outbreak of the disease in Inverness.

The/

The necessity of informing the Medical Officer of Health regarding a case of the disease, apart from the opportunity given thereby of discussing appropriate treatment, gives the general practitioner the weight of official backing in his explanation of the treatment necessary to the parents or guardians.

Notification of a disease implies its previous discovery and the discovery of a case of ringworm of the scalp has not always been found simple. Various administrative and clinical measures, as described so completely by the Chief Medical Officer of the Board of Education, 1933, are advisable and these may be summarised thus:-

- (1) Efficient and frequent examination of the scalps of school children by a nurse or medical officer together with examination of home contacts.
- (2) Instruction of mothers and teachers of the appearances of the disease and the advisability of prompt medical advice.
- (3) The provision of facilities for the microscopic examination of affected hairs. Recently, (Duncan, 1945); (Andrews, 1946), attention has been drawn to the advisability of cultural investigation/

investigation of the causal organism as more conservative treatment may be permissible in the case of infection due to an animal type of microsporon. This appears to imply delay in the exact recognition of a case, together with the availability of expert and proved technique if the findings in Inverness, in regard to culture of the causal organism, can be taken as a guide.

(4) Use of "Wood's Glass."

Isolation of cases of the disease has generally, in practice, consisted of the exclusion of affected children from school and instruction to parents designed to minimise the risk of spread of the disease in the home. At various times special schools (Scottish Board of Health, 1928): (Percival, 1932), have been used for cases of the disease and special classes for affected children have been advocated. (Department of Health for Scotland, 1930).

Opinion regarding the advisability and necessity of excluding cases of the disease from school appears, when surveyed, to be rather contradictory. Thus, in the report of the Chief Medical Officer of the Board of Education for the year 1927, it is stated on page 168, that, "Prompt exclusion of the affected child from school is the most satisfactory method to adopt," whereas on page 169 the statement/

statement is made that, "Ringworm rarely, if ever, spreads in school." Three years later in Scotland, (Department of Health for Scotland, 1930), the position is taken that "exclusion from school is often necessary," and, "there are several districts where the children are allowed to attend school provided certain regulations are observed."

As the risk to bodily health caused by ringworm of the scalp is comparatively trifling, the principal disability which generally results is loss of education, often of a prolonged nature. It appears important, therefore, to assess whether this disability should be incurred. Morris, (1892), has observed,

"On the one hand the schoolmaster who is watchful and zealous as to the physical well-being of the children under his charge, refuses to admit a child with ringworm to his school; whereas, on the other hand, he who is lax is apt to overlook or minimise the importance of the disease. In both cases, in my opinion, a grievous injustice is committed, for in the former case, a child, presumably in good health, is banished from school and all its advantages, both moral and educational, for a prolonged period, at a time of life when these are essential for its well-being. In the second case, the spread of the disease to other children is inevitable, and the community at large as well as the individual children must suffer."

If school attendance provides favourable means of spread of the disease, one would recommend, as Morris, (1892) does, exclusion from school attendance with the provision of special schools or classes as being most advisable.

Whereas, /

Whereas, if school attendance plays little part in the spread of infection, exclusion of an affected child from school, is likely, unless the child is strictly confined, to provide enhanced opportunities for any extra-mural activities concerned in the spread of the disease. The evidence available from the outbreak of the disease in Inverness led to the conclusion that school attendance provided relatively little likelihood of spread of infection. General evidence suggests that the disease spreads by contagion, usually by means of close contact, and even amongst those who have recommended exclusion from school, close contact is given first place as the mode of spread.

Surely, therefore, if special schools or classes are not available, the lessons gained by experience of "barrier nursing" of infectious disease might be applied to cases of ringworm of the scalp attending school.

That this is recognised, in part at least, is shown by the use of the "cap system" (Chief Medical Officer, Board of Education, 1927). This system appears to have given good results, and although it entails sympathy and co-operation from teachers, there appears to be no reason why school nurses or medical officers should not aid the teachers in the application of this system; such aid to consist/

consist of advice regarding the application of the system in particular circumstances with special emphasis upon measures appropriate to the avoidance of contagion in the school. By this means the risk, if any, of the contraction of the disease in school would be minimised; parents should be satisfied that the school authorities are taking all feasible precautions against spread of the disease; and the progress of individual cases together with the thoroughness with which prescribed treatment is carried out can be assessed.

Isolation of cases of ringworm of the scalp in the home is usually impracticable but in the outbreak in Inverness, parents were advised to keep affected children apart from other children in the household as far as possible, particularly in the matter of sleeping accommodation. Advice was also given regarding the advisability of personal towels, and other toilet articles.

As ringworm of the scalp is not a notifiable disease within the meaning of the Public Health Act, 1936, and as no regulations have been made under powers granted by the Act, making the disease notifiable, there is no statutory control of cases of the disease in public places or conveyances. It was found in Inverness that children suffering from ringworm of the scalp pursued their usual outside/

outside activities apart from school attendance and invariably, in the absence of advice, cinema attendance continued as usual. Such activity, as discussed previously, probably aided spread of infection, but it hardly appears to be of such a degree as to justify the application of the statutory restrictions relevant to cases of notifiable disease.

If considered necessary, failing satisfactory results from advice given to parents of children suffering from the disease, much could probably be achieved from the methods of modern publicity. Thus, in the matter of cinema attendance, publicity could be directed either to keeping the affected or the unaffected children out of the cinema. Whilst medical thought would probably favour the first of these alternatives, perhaps to some there is educational or cultural advantage in the second, presuming that unaffected children are in the majority.

Disinfection of Articles.

The part played by various articles in the transmission of ringworm of the scalp has been discussed previously and it has been considered that toilet articles are the articles most likely to be concerned in the transmission of the disease. Headgear worn when suffering from the disease must/

must also be considered to be contaminated and to require disinfection. Boiling has been recommended as a method of sterilisation where this is suitable for the material. (Chief Medical Officer, Board of Education, 1927).

Dodge, (1936), reviewing methods of sterilisation applicable to articles contaminated with fungi, (dermatophytes), states that standard laundry practice will result in cotton goods being returned free of dermatophytes while sterilisation of woollens and silks is doubtful. Standard dry-cleaning solvents are said to have a negligible action, and he refers to suggestions of the use of formaldehyde for leather goods and of the use of denatured alcohol followed by rinsing in water and drying for woollen materials.

When one visualises the extensive range of materials and articles liable, in theory, to contamination from cases of ringworm of the scalp, complete disinfection of such articles appears to be impracticable. For example, there are the varied and numerous chairs with which one would have to deal; and when one considers articles liable to contamination from a hand previously contaminated by the scalp, the possibilities seem endless.

In such circumstances it appears better to limit the disinfection to those articles where the method is simple, effective, /

effective, and likely to be carried out thoroughly. Thus, contaminated personal towels, pillow-cases, cotton headgear as recommended in the "Cap System," should be sterilised by boiling twice weekly. The destruction of the contaminated linings of cloth caps by burning is preferable to attempts at sterilisation of the complete article, and brushes and combs may either be replaced or subjected to a day's soaking in some strong disinfectant, such as a solution of formaldehyde, prior to normal washing. For other articles which may be contaminated normal cleansing would appear to suffice.

Quarantine of Contacts.

This has not been recommended for ringworm of the scalp and the mildness of the disease together with lack of precise information regarding the incubation period render this procedure unsuitable.

Immunisation of Susceptibles.

No record has been found of this procedure being applied to ringworm of the scalp due to *microsporon audouini*. It has been argued previously that immunity to the disease develops in children affected with the disease, so that artificial immunisation may be possible. Although "vaccines" of ringworm fungus have been used in the treatment /

treatment of the disease, (Klehmet, 1919); (McKenna, 1939); with poor results, it does not appear to be known whether this may be a suitable agent for the purpose of immunisation.

The rarity of the disease after puberty has led to the use of endocrine preparations in the treatment of the disease. (Poth and Kaliski, 1942). The effect does not appear to be certain, (MacKee & Cipolloro, 1946), and as an immunising agent should not lead to unpleasant reactions. (Harries and Mitman, 1944), the use of such substances in immunisation does not appear advisable. The possibility of protecting the susceptible scalp, particularly in boys, by means of chemicals used in industry as mildewproofing agents in fabrics, and other materials, does not appear to have been attempted. Thus it may be possible to use such a preparation as Salicylanilide Ointment, (Schwartz et al, 1946), as a hair cream amongst susceptible children liable to infection. Schwartz et al. (1946), do not record any toxic effects when this preparation is used in treatment and as they appear to have found the remedy most efficacious as a fungicide, its use as a prophylactic in susceptible children may be worthy of study.

Improvement of Social Conditions.

The findings regarding ringworm of the scalp in respect/

respect to overcrowding and social classes have already been stated and there is a similar general finding in respect to infectious disease. (Harries & Mitman, 1944). Improvement in social conditions might therefore be expected to result in a decrease in the incidence of ringworm of the scalp and perhaps their improvement over the past 25 years was a factor in the decreasing incidence of the disease in Scotland in the years following 1918, (Scottish Board of Health, 1928), when there was an improvement in housing conditions in respect to overcrowding. (Census of Scotland, 1932).

The findings in Inverness suggest that the provision of improved housing does not in itself lessen the incidence of the disease when overcrowding and poor social conditions exist in such houses. Methods designed to secure improvement of the latter are a general problem hardly relevant to ringworm of the scalp in particular.

General Measures.

Of these, in ringworm of the scalp in children, the most important appears to be efficient treatment of the individual cases, as a rapid cure lessens the time in which an affected child may infect other children. It is generally stated that epilation of the scalp by means of X-rays/

X-rays together with the application of fungicidal ointments provides the quickest cure. By some observers, (Chief Medical Officer, Board of Education, (1927), and (1933), a lessened incidence of the disease in years prior to 1939 was attributed to the adoption of this form of treatment. In Inverness, writing of the year 1911-12, Dr. Gordon A. Lang, stated, (MacDonald, 1913), "This disease might be stamped out in the Burgh could the parents be persuaded to allow the children to go through the X-ray treatment."

Unfortunately the disease was not stamped out but the statement reveals the importance attached to adequate treatment of the disease. In the use of X-rays for epilation the question arises whether epilation should be confined to the affected areas or whether the whole scalp should be epilated. Andrews, (1946), and MacKee & Cipollaro, (1946), both state that epilation of the affected portion or the scalp may suffice although it is usually necessary to epilate the whole scalp. This was found to be the case in treating the disease in Inverness, but it was considered that epilation of the whole scalp was preferable as a routine practice as recurrence or spread of the disease in affected scalps was much less when the whole scalp was epilated, as noted before, and time spent under treatment before return to school was much shorter as shown in Table XXIII.

TABLE XXIII.

Average time off school related to epilation of scalp from figures available in 239 cases occurring between 1st. January, 1943 and 30th September, 1946.

Initial area of epilation.	No. of Cases.	Average time off school.
Whole head	78	64 days
One area	109	84 days
Two or more areas.	62	80 days.

The details of treatment carried out in Inverness were as follows:-

No ointment was applied to the scalp prior to exposure to X-rays, the dosage of which was 360 -400 r. depending on the type of hair.

After exposure to X-rays, in cases treated in the Public Health Department, the parents were supplied with spirit soap for use as a shampoo twice weekly and Ung. acid benzoic co. (B.P.C.) for application to the scalp daily. In addition, the parents were advised to cut short the hair of affected children, and to cover the head with a washable cap.

Such a scheme of treatment conforms, in its essentials, to that usually advocated. Variations in detail are advocated by different authors. Thus, as a fungicidal preparation/

preparation to be applied after exposure to X-rays, Savill, (1945), recommends mercurial or iodine ointment; McKenna, (1937), recommends antiseptic ointments or iodine; Andrews, (1946), recommends 5 per cent sulphur ointment or 5 per cent ammoniated mercury ointment and the same author advises the use of adhesive plaster to form a skull cap when the hairs commence to loosen, the removal of the cap after a night's application facilitating epilation.

It has been stated that following exposure to X-rays, epilation of the scalp commences in about seventeen days, (Andrews, 1946), and this was found to be the general rule in cases observed in Inverness. Apart from occasional slight malaise within two hours of exposure to X-rays, no ill effects resulted from this form of treatment. Of cases treated by X-rays and observed in the Public Health Department between January, 1943, and September, 1946, inclusive, there was none in which there was not satisfactory regrowth of hair. This is in accordance with the customary findings following this procedure. Curliness in the new hair growth was found occasionally, as noted by Andrews, (1946), and this was usually a welcome feature to the parents and an effective inducement when persuading them to give permission for epilation.

Sometimes/

Sometimes residual hairs were found on areas of the scalp exposed to X-rays and, as recommended by Andrews, (1946), these were epilated with forceps.

Of other methods of treatment, the administration of thallium acetate has been discouraged, (Chief Medical Officer, Board of Education, 1927), and no case, as far as is known, was given this drug in Inverness. Prior to the introduction of treatment by X-rays various remedies, (McKenna, 1937), principally designed to promote an inflammatory reaction in the lesion, and self cure, were used, but none of these were practiced in cases observed, although a number of cases were treated by the application of Ung. acid. benzoic co.,(B.P.C.) and plucking of affected hairs.

Thus, there is available for this disease, an effective form of treatment, the thorough application of which can be expected to lessen the period of infectivity and incidence of the disease.

There remains the necessity for the efficient correlation and application of measures designed for the control of ringworm of the scalp. It has been stated that in Inverness, the disease appeared to extend when treatment was not thorough, and there was reason to suppose that, in many cases not seen in school, the diagnosis was not established/

established as speedily as possible. The latter is to be expected, as a busy general practitioner may well hesitate to express an opinion which involves epilation of the scalp until the appearances are very definite, when he lacks a "Wood's Glass" and time in which to search for and remove hairs for examination.

The Education Act of 1944 provides powers to treat children between the ages of 2 - 18, and as it is recognised that the recommended treatment by means of X-rays is best carried out by experts, (Lewis et al., 1944), it appears logical that facilities for expert diagnosis, with the aid of suitable apparatus, should be provided. Above all, routine inspection of children with the aid of a mercury vapour lamp with Wood's Glass, of which there are portable models, leading to early detection and treatment of the disease, appears to offer the best initial step to curbing the incidence of the disease.

GENERAL SUMMARY AND CONCLUSIONS.

1. The epidemiology of ringworm of the scalp has been discussed in relation to 384 cases of the disease noted in Inverness, Scotland, in the years 1943 to 1946.
2. The predominant causal organism appeared to be *microsporon audouini*.
3. The clinical appearances conformed to those usually noted and the predominant site of the lesion appeared to be the occipital region of the scalp.
4. Susceptibility appeared to be greater in boys, and in the age group 6 to 8 years, in all children affected. Reasons are advanced that resistance to the disease develops in children affected and the "carrier" condition is discussed.
5. It is suggested that the disease is transmitted by close contact and that the communal use of toilet articles in the family, contact in play and cinema attendance, is more likely to lead to transmission of the disease than school attendance, which is considered to be a minor factor in transmission. The theory is advanced that it is/

is necessary for the causal organism to be inoculated by mild trauma in order to cause clinical infection.

6. The incubation period of the disease has been undetermined but it is suggested that it is not likely to be greater than eight weeks.

7. In Inverness, ringworm of the scalp showed an epidemic wave and seasonal prevalence. The relationship between dispersibility of the disease and measures used in control in respect to seasonal prevalence is discussed.

8. It appeared that overcrowding, low social status, and war conditions increased the incidence of the disease.

9. Methods adopted for the control of the disease are outlined and discussed.

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