STUDY ON THE EPIDEMIOLOGY OF TYPHOID FEVER.

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(With 5 Charts.)

Typhoid has become one of the serious infectious diseases in Palestine, and one of the acute problems confronting the health authorities. Aware of the seriousness of the situation, the Health Department appointed a special Typhoid Commission to study the epidemiology of the disease, and propose methods of control. The Commission presented an elaborate and carefully prepared *Report*[1] containing a considerable amount of valuable data. It established on the one hand that the disease was endemic in the country, and on the other that the infection was not water-borne. The report leaves us, however, totally in the dark as to the essential causes of the recent epidemic extension of the disease after a period of endemic equilibrium. As a corollary of this failure to discover the causative factors of the epidemic, the recommendations for the control of the disease are of necessity general, extensive and not well defined.

Parallel with the work of the Commission, Felix (1925) presented the results of an independent study of the epidemiology of typhoid. This report is based on part of the data contained in the general report of the Typhoid Commission, and is purported to establish three facts: (1) that water supply was not the cause of the 1925 epidemic; (2) that there is no relation between immigration and the epidemicity of the disease; (3) consequently, the vaccination of immigrants alone can have no effect on the course of the disease which is essentially endemic in character. The second and third conclusions are based on an insufficient and superficial analysis of the statistical data. The second inference is drawn from a partial analysis of the data for one year, 1925; while the third conclusion is based on the fact that the general case mortality remained practically the same in years when vaccination of immigrants was practised by the health authorities as in those when it was not. The author does not indicate how thorough the vaccination was, and brings no data showing the relative incidence of the disease and the relative fatality among groups of vaccinated and non-vaccinated people.

Both reports referred to above fail to throw light on the underlying factor or factors associated with, or responsible for, the sharp epidemic extension of the disease. For this reason, and because the proper method of the control of a contagious disease must, ultimately, rest on the elucidation of its epidemio-

[1] *Report of the Typhoid Commission*, 1925.

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logy, I have attempted to subject the available data to a somewhat more thorough analysis, in the hope of throwing additional light on this problem.

SOURCE OF DATA[1].

Morbidity and mortality data. The raw statistical data on which this study is based consists almost entirely of Health Department returns. Part of the material has been taken from the Typhoid Commission Report and part of it directly from the records in the statistical division of the Health Department[2]. Some of the data used for checking the Health Department figures were furnished by the Hadassah Medical Organisation.

Population. The basic population figures were taken from the Official Census Report issued in October, 1922. The data for the Jewish population as a whole were kindly furnished by Dr Gurewich, Chief Statistician of the Zionist Executive. The data for Tel Aviv were taken from the census made by the Municipality during September, 1925.

Accuracy of the raw data. Since the establishment of the Mandatory Government, considerable progress has been made in the registration of births and deaths, particularly in the larger cities. The notification of communicable diseases, however, and the correct reporting of the specific causes of death, leaves much to be desired. This is particularly the case with respect to the non-Jewish population even in the larger population centres. These points are illustrated by the data for 1926, shown in Tables I and II. Table I shows the morbidity and fatality in different age groups in the non-Jewish population in some of the larger cities. In contrast with these figures, Table II shows the corresponding data for the Jewish population in the same cities. It is apparent from these tables that in all cities except Haifa the fatality is two or more times as high in the non-Jewish as in the Jewish population. Furthermore, the wide variations, both in the corresponding specific age fatalities and in the average fatality for the different cities, indicate that the returns fall far short from the actual figures. These discrepancies in the fatality rates render the morbidity data for this section of the population useless for the purpose of a statistical epidemiologic analysis.

Morbidity data in the Jewish population. In contradistinction to the apparent lax reporting in the non-Jewish population, that for the Jewish population is quite uniform and in all probability reasonably correct. In any event it seems reasonable to assume as a result of this uniformity that the same proportion of the total are reported each year. Table II shows the reported morbidity and fatality among the Jewish population in the same centres as shown for non-Jews in Table I. It is evident from the comparison

[1] I am greatly indebted to Dr Harkness, Assistant Director of Health in charge of the division of Sanitation and Epidemiology, and to Dr Bluestone, Director of Hadassah Medical Organisation, for furnishing the statistical material which forms the basis of this study.

[2] I am indebted to Mr Brumberg for assistance in copying and tabulating much of this material.

of the two tables that in only one city (Haifa) is there a correspondence in the fatality among the two population groups. In so far as the Jewish population is concerned, reporting during 1926 seems to fall short particularly in Tel Aviv-Jaffa. This is indicated by the facts that (1) the fatality for the age groups 5–9 seems unusually high and contrary to the usual experience that the mortality in this age group is lower than in the preceding and the following ones; (2) the total fatality is about 50 per cent. higher than the average for the

Table I. *Specific age morbidity and case fatality among non-Jews*, 1926.

	Jerusalem			Jaffa			Nazareth			Haifa			Total		
Age	Cases	Deaths	Case mortality	Cases	Deaths	Case mortality	Cases	Deaths	Case mortality	Cases	Deaths	Case mortality	Cases	Deaths	Case mortality
0–4	10	0	0·0	2	1	50·0	3	1	33·3	10	0	0·0	25	2	8·0
5–9	26	1	3·8	6	0	0·0	12	2	16·7	19	0	0·0	63	3	4·8
10–19	42	6	14·3	18	1	5·5	4	2	50·0	24	0	0·0	88	9	10·2
20–29	35	6	17·1	6	2	33·3	0	0	0·0	24	0	0·0	65	10	15·4
30–39	10	1	10·0	8	2	25·0	3	1	33·0	9	2	8·4	30	2	6·7
40–49	3	1	33·3	2	1	50·0	0	0	0·0	6	0	0·0	11	2	18·1
50	1	0	0·0	1	0	0·0	1	0	0·0	6	0	0·0	9	0	0·0
Total	127	15	11·8	43	7	16·3	23	6	29·1	98	2	2·0	291	28	9·6

Table II. *Specific age morbidity and case fatality among Jews*, 1926.

	Jerusalem			Jaffa-Tel Aviv			Haifa			Nazareth			Beisan			Total		
Age	Cases	Deaths	% deaths	Cases	Deaths	% deaths	Cases	Deaths	% deaths	Cases	Deaths	% deaths	Cases	Deaths	% deaths	Cases	Deaths	% deaths
0–4	26	2	7·7	22	3	13·6	11	0	0·0	17	1	6·0	9	0	0·0	85	6	7·0
5–9	43	1	2·3	30	3	10·0	18	1	5·5	24	0	0·0	6	0	0·0	121	5	4·1
10–19	40	3	7·5	60	2	3·3	45	1	2·2	9	0	0·0	4	0	0·0	158	6	3·8
20–29	38	0	0·0	138	13	9·4	96	4	4·2	10	1	10·0	28	2	7·1	310	20	6·4
30–39	12	2	16·7	40	2	5·0	8	0	0·0	4	0	0·0	6	1	16·7	70	5	7·1
40–49	4	0	0·0	15	3	20·0	6	0	0·0	1	0	0·0	1	0	0·0	27	3	11·1
50	8	1	12·5	9	2	22·2	5	0	0·0	0	0	0·0	4	0	0·0	26	3	11·5
Total	171	9	5·3	314	28	8·9	189	6	3·2	65	2	3·0	58	3	5·2	797	48	6·0

five cities—a difference probably greater than the fluctuations one might expect for various reasons. One must, however, allow for the fact that 1926 was a year of severe economic depression which affected Tel Aviv especially. The resulting malnutrition must have appreciably affected the resistance of the patients.

The above analysis indicates that the only data available for our purpose are those of the Jewish population. But here we are confronted by another difficulty, namely, that not all the cases reported are classified on the basis of nationality. From the general data, it appears that in the years 1923, 1924 and 1925 70 to 80 per cent. of the total cases reported were Jewish. These percentages correspond in a general way with the percentage of the total reported cases diagnosed in the Hadassah laboratories, or cared for in the Jewish hospitals. Because of this high proportion of Jewish cases one is warranted in accepting the data for the Jewish population as significant of the general trend; and conversely the Health Department returns may be accepted as representing the intensity of the infection in the Jewish population.

From another standpoint also it is more satisfactory to deal with the Jewish material. The data concerning the Jewish population and its net annual increase are fairly satisfactory, while the figures for the rest of the population (particularly with regard to immigration and emigration) are bare approximations. Even in the Jewish population, however, there are no trustworthy records of the distribution of the immigrants in various sections of the country.

It is evident that the material available for the statistical analysis attempted in this paper is far from satisfactory. Nevertheless, much useful information exists, and with due caution a critical statistical analysis of this material has proven of value, as will be seen below, in indicating at least one of the important factors in the epidemiology of typhoid.

ANALYSIS OF DATA.

Seasonal incidence. The seasonal prevalence of typhoid in Jerusalem and the country as a whole is shown in Charts 1, 2 and 3 respectively. The first chart shows the trend of typhoid in the country as a whole during 1923–6. Chart 2 presents the corresponding data for Jerusalem only. Chart 3 is a summary chart based on the mean median incidence and shows the general seasonal epidemicity of the disease (see Table III). These data constitute an extension and confirmation of those presented by the Typhoid Commission. It is of interest to note that in the country as a whole, the disease is bimodal, while in Jerusalem there is also a low rise in February. In the country as a whole the months of greatest prevalence are July and October. In Jerusalem there is a low rise in the winter (February), in addition to the summer outbreaks, with peaks in July and September respectively. The typhoid prevalence in Palestine as a whole is, therefore, referable to the usual seasonal spread, probably chiefly by contact, the reason for which is still obscure. The low winter outbreak in Jerusalem is in the nature of a water-borne epidemic, and is most likely due to the contamination of the cisterns by the winter wash. The causes underlying the specific seasonal prevalence of typhoid remain, however, obscure and require detailed study.

Table III. *Mean median monthly incidence of typhoid* (1923–6) *in the country as a whole, in the country without Jerusalem and in Jerusalem only.*

	Country as a whole		Country without Jerusalem		Jerusalem only	
	Cases	% of total	Cases	%	Cases	%
January	12·5	2·6	9·5	3·3	4·0	2·2
February	28·0	5·8	10·5	3·6	10·5	5·9
March	17·0	3·5	9·5	3·3	5·5	3·1
April	7·5	1·5	2·0	0·7	5·5	3·1
May	22·0	4·6	12·5	4·3	9·5	5·3
June	42·0	8·7	23·5	8·1	18·5	10·4
July	51·5	10·7	27·0	9·4	23·0	13·0
August	47·0	9·8	25·5	8·8	21·0	11·8
September	71·0	14·7	35·5	12·3	31·5	17·8
October	82·0	17·0	52·0	18·0	28·5	16·1
November	65·0	13·5	53·0	18·3	12·0	6·8
December	36·5	7·6	28·5	9·9	8·0	4·5
Total	482·0	100·0	289·0	100·0	177·5	100·0

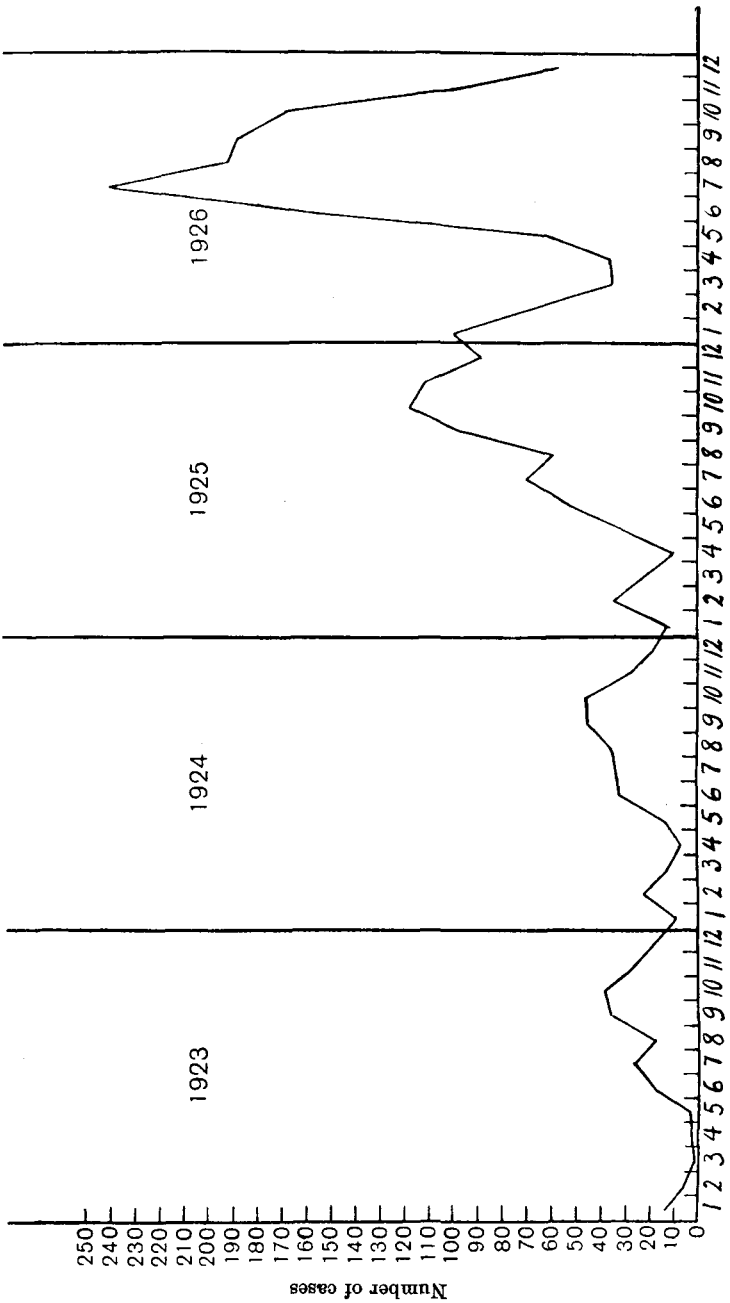

Chart 1. Cases of typhoid fever in Palestine.

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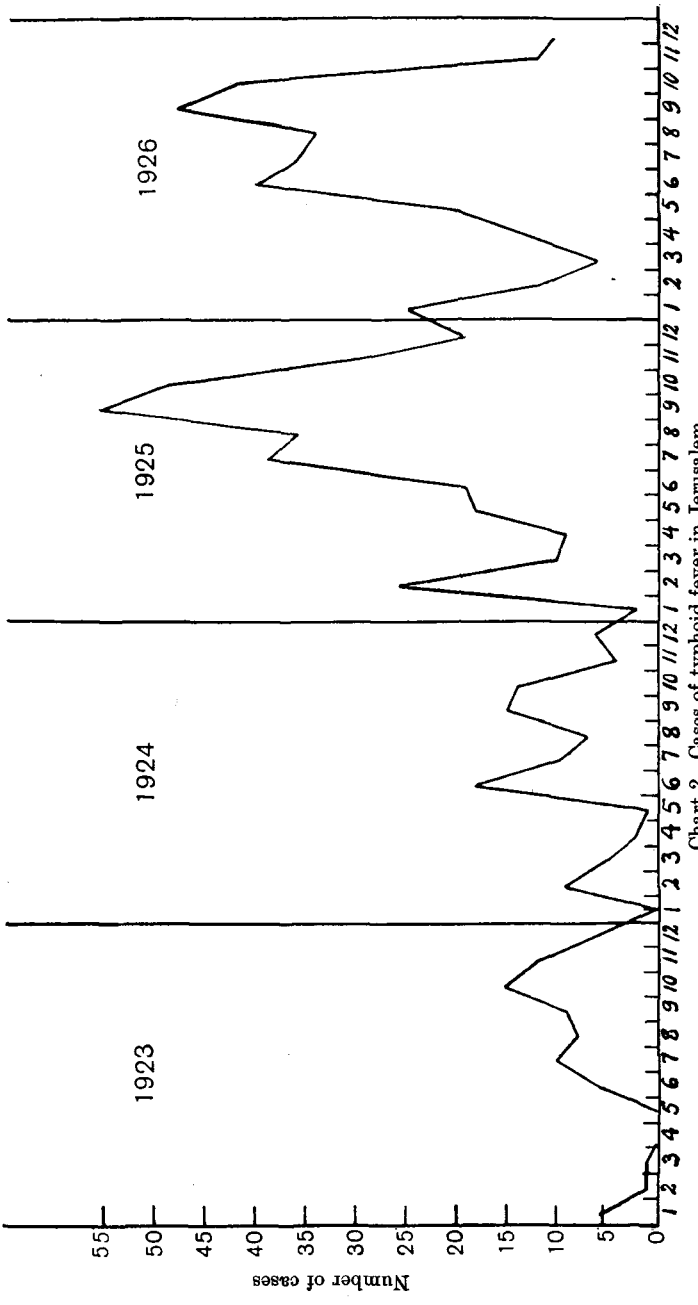

Chart 2. Cases of typhoid fever in Jerusalem.

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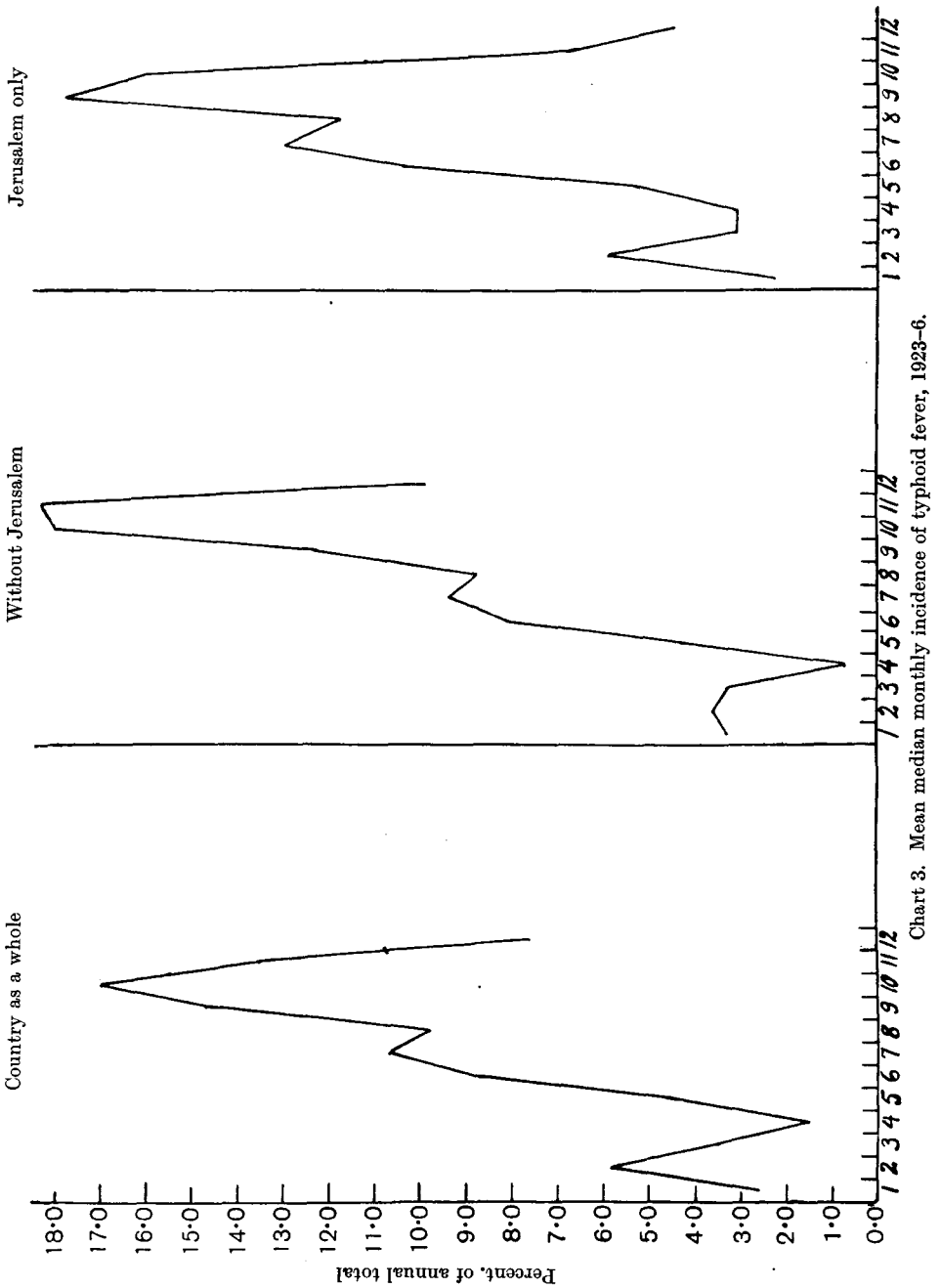

Chart 3. Mean median monthly incidence of typhoid fever, 1923–6.

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Table IV. *Age incidence of typhoid in Jaffa-Tel Aviv area and in Jerusalem.*

Age period	1924 Jerusalem Cases	1924 Jerusalem Deaths	1924 Jaffa-Tel Aviv Cases	1924 Jaffa-Tel Aviv Deaths	1924 % of cases Jerusalem	1924 % of cases Jaffa-Tel Aviv	1925 Jerusalem Cases	1925 Jerusalem Deaths	1925 Jaffa-Tel Aviv Cases	1925 Jaffa-Tel Aviv Deaths	1925 % of cases Jerusalem	1925 % of cases Jaffa-Tel Aviv
0–2	2	1	4	–			2	2	1	–		
2–5	7	–	8	1			34	8	10	1		
5–10	18	1	9	–	*Under 15 years*		66	6	20	1	*Under 15 years*	
10–15	13	1	9	–	*of age*		57	3	24	3	*of age*	
15–20	18	3	18	1			48	3	24	2		
20–25	15	1	46	2	44·5	22·38	40	4	59	5	51·29	26·82
25–30	7	2	16	4			26	4	31	1		
30–35	1	–	10	–			13	–	16	2		
35–40	2	1	6	1			7	–	8	1		
40–45	3	1	3	–	*Over 15 years*		5	2	6	1	*Over 15 years*	
45–50	1	1	1	–	*of age*		3	–	4	–	*of age*	
50–55	2	–	2	1			6	2	–	–		
55–60	1	–	2	–	55·5	77·62	2	–	1	–	48·71	73·18
60–65	–	–	–	–			–	–	–	–		
65–70	–	–	–	–			–	–	–	–		
70–75	–	–	–	–			–	–	1	–		
75–80	–	–	–	–			1	–	–	–		
80–	–	–	–	–			–	–	–	–		
Total	90	12	134	10			310	34	205	17		

Age and sex incidence. A superficial examination of the morbidity data indicates a peculiar age and sex distribution of the disease. In Table IV we reproduce the figures of age distribution of typhoid for Jaffa and Jerusalem respectively, as presented in Table VII of the Typhoid Commission Report. It appears from this table that there is a striking difference in the age distribution of cases in these two cities. The Commission cites this difference as further evidence of the endemicity of the disease in Jerusalem.

On analysing, however, the data with respect to the age distribution of the population in these two cities, this difference in specific age morbidity assumes a different aspect. As indicated above, there is no accurate complete census of the population in Palestine. However, the 1922 Census Report gives the approximate division of the population of Jerusalem into certain broad age groups; and a more detailed classification of the Tel Aviv population is given in the census made by the Municipality of Tel Aviv in September, 1925. These figures of the age distribution of the population in these two cities may be accepted as representative, not only of the census years, but of other years as well. It is generally recognised that, since it has absorbed but a small fraction of the immigration, the composition of the Jerusalem population has undergone little change since 1922. Consequently, it is correct to assume that the percentage distribution of the different age groups has remained constant. In so far as Tel Aviv is concerned, it seems reasonable to assume that the percentage age distribution in 1925 is typical for 1924 and 1926, the years before and after the census.

On the basis of these population figures, it was possible to calculate the relative specific age incidence of typhoid for the two cities. The results are shown in Table V and Chart 4. The table contains the percentage age distribu-

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Table V. *Age distribution of typhoid*, 1924–6.

	Jerusalem								Tel Aviv							
	% age distribution of population	% of total cases			Ratio			Average three years	% age distribution of population	% of total cases			Ratio			Average three years
Age	(*a*)	1924 (*b*)	1925 (*c*)	1926 (*d*)	$\frac{b}{a}$	$\frac{c}{a}$	$\frac{d}{a}$		(*a*)	1924 (*b*)	1925 (*c*)	1926 (*d*)	$\frac{b}{a}$	$\frac{c}{a}$	$\frac{d}{a}$	
0–4	11·7	10·0	11·6	12·1	0·9	1·0	1·0	1·0	10·3	8·9	5·4	9·4	0·9	0·5	0·9	0·8
5–14	23·1	34·4	39·7	37·7	1·5	1·7	1·6	1·6	16·9	13·5	21·4	18·8	0·8	1·3	1·1	1·1
15–24	20·8	36·6	28·4	26·6	1·8	1·4	1·3	1·5	37·4*	59·4	55·6	51·6	1·6	1·5	1·4	1·5
25+	44·4	19·0	20·3	23·5	0·4	0·5	0·5	0·5	35·2	17·7	17·6	20·1	0·5	0·5	0·6	0·5

N.B. The age grouping is that used in the census reports. In Tel Aviv the census figures are divided correctly up to 15 years and thence 15–18, 19–29, 30–39, etc. In Jerusalem only the classification used above is given.

*15–29.

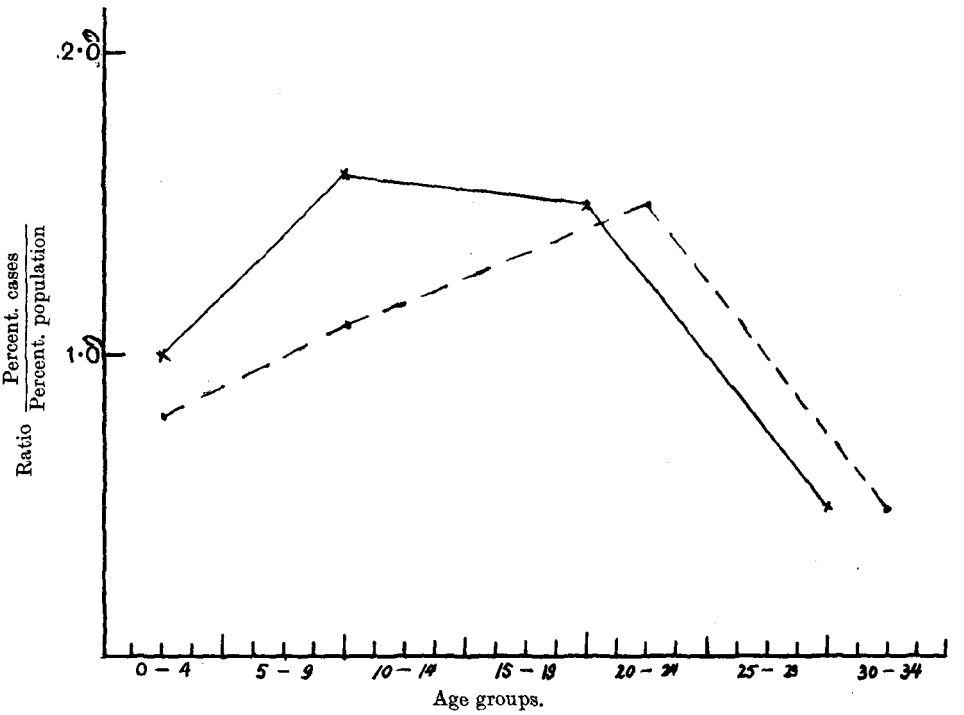

Chart 4. Specific age incidence of typhoid fever, Jerusalem and Jaffa-Tel Aviv. (Average 1924–6.)

Jer. = ———— . Jaffa = — — — — .

tion of the population (column *a*), and the percentage of the total cases in each age group, for the years 1924, 1925 and 1926 respectively (columns *b*, *c*, *d*). The division of columns *b*, *c*, *d* respectively by column *a* gives a ratio which corresponds to the annual specific age morbidity. It is apparent from these ratios that in Jerusalem there is no appreciable difference (apart from the annual fluctuations), between the morbidity in the age groups 5–14 and 15–24 respectively. Nor is there any difference in the susceptibility of age group 15–24 in Jerusalem and Tel Aviv. In both towns this age group shows an equally high ratio.

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There does, however, seem to be a considerable difference between the respective morbidities in age groups 5–14 and 15–24 in Tel Aviv. This difference is, however, more probably ascribable to differences in risk and exposure than to differences in susceptibility. In Jerusalem the population consists chiefly of families, and the degree of exposure or risk is equally great for the two susceptible groups 5–14 and 15–24. In Tel Aviv, on the other hand, the higher age group consists largely of workmen dwelling in groups, often several in one room, and eating in common workmen's kitchens or restaurants. The greater exposure of greater numbers of the higher age group results in a greater absolute number of cases in this group; but the specific morbidity is the same as in the corresponding age group in Jerusalem.

Sex incidence. The sex distribution of the disease is also of interest. From the crude data it appears that the disease is more prevalent among males than females. The figures for 1924 show 60·7 per cent. males and 39·3 per cent. females, and for 1925, 56·9 per cent. males and 43·1 per cent. females. This difference also appears to be due to the numerical difference in the sexes. The immigration, being predominantly male, throws the balance of numbers in favour of the males. The only place where the division of sexes is recorded is Tel Aviv. According to the census in 1925, there were 17,748 males and 16,452 females. The cases treated in Hadassah Hospital that year were 110 males and 93 females respectively. The rate per 1000 was, therefore, 6·2 for males and 5·7 for females, a difference which can hardly be considered significant. In 1926 the Jewish cases in Tel Aviv consisted of 111 males and 112 females, and in Jerusalem 89 males and 82 females.

Racial susceptibility. A great deal has been said concerning the greater susceptibility of the Jewish population to the disease. The basis for this assertion is not clear. There is no question that there are more Jewish cases on record, but it is doubtful whether that in itself can be accepted as an indication of greater susceptibility. One reason for the larger number of Jewish cases on record is undoubtedly the fact that the reporting on the whole is much better among the Jewish than among the non-Jewish population. At the same time it is of interest, if possible, to ascertain whether a difference in racial susceptibility really exists. The only data which might be relied upon to throw light on this point are those of Jerusalem. In this city the various communities live side by side; both groups of the population are indigenous and approximately equal; and, finally, the reporting in the non-Jewish population is better than in other cities. Consequently, a comparison of the morbidity data in the Jewish and non-Jewish population of Jerusalem respectively, should throw light on this question.

Such a comparison for the years 1924, 1925 and 1926 is shown in Table VI. It is evident from the figures presented in this table that there is no difference in the racial susceptibility to the disease. The annual morbidity per 1000 for the three years is practically identical in the two groups of the population. The mean morbidity per 1000 for the three years is 3·8 among the Jews and

Table VI. *Comparison of typhoid morbidity in Jewish and non-Jewish population. Jerusalem*, 1924–6.

		1924				1925				1926			
	Population*	Cases	Deaths	Morbidity per 1000	Mortality per 1000	Cases	Deaths	Morbidity per 1000	Mortality per 1000	Cases	Deaths	Morbidity per 1000	Mortality per 1000
Jews	34,431	61†	6	1·6	0·16	168†	20	4·9	0·58	171‡	9	5·0	0·26
Non-Jews	28,147	43	9	1·5	0·32	150	16	5·3	0·57	127	15	4·5	0·53

* The population figures are taken from the 1922 census. The present population of Jerusalem is estimated by the Municipality at 70,000, of which about 40,000 are Jews. Since accurate figures are not available, and since we are concerned only with the comparative data, the crude census returns of 1922 are used.

† The figures used are taken from Table X of the Typhoid Commission Report. These figures are somewhat at variance with those given in the annual report of the Department of Health.

‡ These data are taken from the records in the Bureau of Vital Statistics, Department of Health.

3·7 among the non-Jews, while the respective mean mortalities are 0·34 and 0·47, or nearly 40 per cent. higher in the latter. The supposition that the Jews manifest a higher susceptibility to the disease is, therefore, unfounded.

Factors responsible for the epidemic extension (1925–6).

In attempting to explain the epidemic extension of 1925, the Typhoid Commission admits that it is entirely at sea. "The increased incidence in 1921 and 1925 in Palestine must at present be attributed to those natural or unnatural influences whose interaction epidemiologists have not yet been able to appreciate or gauge," writes the Commission. It is to this phase of the problem that attention was particularly directed, because on the elucidation of this problem depends the institution of adequate measures for the control of future epidemics.

Briefly summarised, the information thus far adduced is as follows. Typhoid in Palestine is endemic, and has the normal seasonal prevalence characteristic of this disease. The conclusion is therefore warranted that the disease as it occurs in Palestine is spread by contact, in the broad sense of the term, and not by water or other indirect means. The age and sex incidence is the same as in any other endemic centre. There is no difference in racial susceptibility. Epidemic outbreaks occurred in 1921 and again in 1925 and 1926.

Two questions naturally present themselves. (1) Are we dealing with sporadic epidemic outbreaks, or with a series of epidemic waves of increasing magnitude? (2) What changes of conditions have occurred coincident with these outbreaks that might offer a clue to the factor or factors concerned in these epidemics?

A glance at Charts 1 and 2 and Table VII shows that in the country as a whole there has been a steady upward trend since 1923 which reached a maximum in 1926. The epidemicity of the disease is not, therefore, fortuitous, and must be the result of a continuation of circumstances which favour the progressive intensification of the epidemic waves.

The recent publications on experimental epidemiology by Topley (1919) in England, and Flexner (1922) and his associates in America, offer a clue to our problem. These investigators, working with colonies of mice and mouse

Table VII. *Reported typhoid cases and deaths.*

1922	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Fatality
Cases	8	2	3	2	11	34	15	35	29	38	20	11	208	
Deaths	2	1	1	0	1	3	5	1	3	9	4	2	32	15·4
1923														
Cases	13	5	1	2	3	18	26	18	35	38	26	17	202	
Deaths	2	0	0	0	0	0	3	0	3	2	4	3	17	8·4
1924														
Cases	9	22	12	6	13	32	33	35	45	46	28	18	299	
Deaths	2	1	4	0	1	1	4	3	9	3	3	1	32	10·7
1925														
Cases	12	34	22	9	31	52	70	59	97	118	112	89	705	
Deaths	2	3	2	1	2	3	6	6	12	14	8	11	70	9·9
1926														
Cases	100	66	34	35	61	159	241	192	188	169	102	55	1402	
Deaths	9	9	1	0	3	10	17	12	17	20	9	3	110	7·8
Total cases	142	129	72	54	119	295	385	339	394	409	288	190	2816	
Total deaths	17	14	8	1	7	17	35	22	44	48	28	20	261	9·6
Monthly % of cases	5·6	4·6	2·6	2·0	4·2	10·5	13·7	12·0	14·0	14·5	10·2	6·7	100·0	
Monthly % of deaths	12·0	10·9	11·1	1·9	5·9	5·8	9·1	6·5	11·2	11·7	9·7	10·5	9·3	

typhoid bacilli as the infecting micro-organisms, found that they could produce epidemic waves of different amplitude and intensity under certain conditions. These investigators found that all that is necessary to convert a sporadic endemic infection into an epidemic is to introduce previously unexposed mice into the infected cages or mice villages. Amoss (1922) found that an epidemic can be brought about in a mouse village where the disease has reached an equilibrium by introducing cages of healthy mice. In a subsequent publication, Greenwood and Topley (1925) showed that if the daily increments of healthy mice were large the interepidemic periods were small, and the epidemic or mortality curve tended to assume a high level. On the other hand, when the daily increments were small the interepidemic periods were marked and the height and duration of successive epidemic waves were increased. In other words, by affecting the rate of immigration these investigators were able to modify the interepidemic intervals and to control the extent and character of the successive epidemic waves. Pritchett (1926) went a step further by demonstrating, that by varying the dosage of infectious microbes by more or less frequent cleaning of the cages, she obtained results similar in character to those obtained by Greenwood and Topley by varying the immigration rate.

These experimental facts have a direct bearing on our problem. In some respects the conditions in Palestine offer an excellent opportunity to test in a human population the applicability of the experimental data obtained in the mouse populations. Here we have in nature a set of conditions comparable to those established experimentally in the rat colonies. Into a country limited in area where typhoid fever is endemic, masses of susceptible populations[1] are being introduced annually in greater or lesser numbers. Moreover, the hygienic and economic status of the country favour the increase in concentration and

[1] The bulk of the immigrants are of ages below 30 and most of them between 15 and 25.

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dissemination of the infectious agent. Relative lack of personal cleanliness owing to scarcity of water, crowding, uncontrolled central eating places, all tend to increase the dosage of infectious micro-organisms and to facilitate their spread. It seemed, therefore, of particular importance to analyse the available data in order to ascertain whether the progress of events during the last four

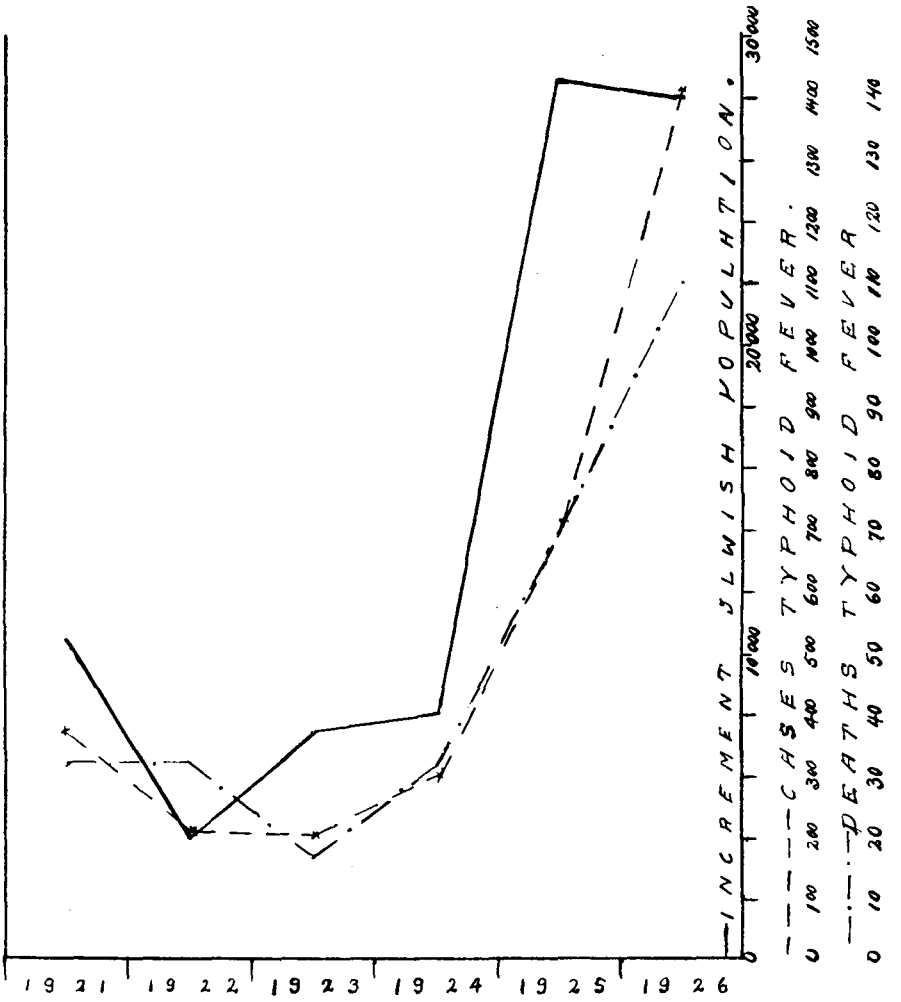

Chart 5. Correlation annual net increment Jewish population and cases and deaths from typhoid.

years corresponds in any way with those described in the experimental mice colonies.

As indicated above, the general statistical material available is of limited value. The data with regard to the Jewish population, however, is sufficiently reliable for a statistical analysis. This is particularly fortunate, because the bulk of the immigrants are Jews. Furthermore, the Jewish and non-Jewish popu-

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lation are so segregated, especially outside of Jerusalem, as to make it possible to follow the progress of events in this part of the population without taking the rest of the population into account.

For the purpose of this study, three sets of comparisons were attempted. First, we compared the curve of the annual net increment of Jewish population with those of cases and deaths from typhoid. The results presented in Chart 5 show a remarkably close parallelism between these curves.

The experience is too short to render a mathematical calculation of the correlation coefficient of the annual net increment of the Jewish population and the annual deaths from typhoid conclusive. It may be of interest, however, to point out that the coefficient of correlation based on the figures of the last six years (1921–6) is very high (0·89) and that it is fourteen times as great as the probable error.

Relative incidence of typhoid in immigrant and indigenous population. The third comparison was between the incidence of typhoid in the immigrant population two years or less in the country and that in the rest of the population. Owing to the inadequacy of the statistical data this relationship had to be determined indirectly instead of directly. In the first instance the relation of total immigrant and indigenous cases to that of the immigrant and indigenous Jewish population was determined. Such a comparison is warranted by the fact that over 70 per cent. of the cases reported and over 90 per cent. of the immigrants are Jewish. The data are shown in Table VIII. It will be noted

Table VIII. *Relative incidence of immigrant and indigenous cases with respect to the net immigrant* and indigenous† Jewish population.*

	1924 (1922)	1925	1926	Average		1924	1925	1926	Average
Indigenous† population	83,800	91,400	99,300	—	Immigrant* population	16,500	36,500	56,700	—
Indigenous† cases	246‡	520‡	440§	—	Immigrant* cases	52‡	185‡	346§	—
Deaths	26	58	21	—	Deaths	4	12	26	—
Fatality	10·6	11·1	4·5	—	Fatality	7·7	6·5	7·5	—
Morbidity (per 1000)	2·1	5·7	4·4	4·4	Morbidity (per 1000)	3·2	5·1	6·1	5·3
Mortality (per 1000)	0·3	0·6	0·2	0·4	Mortality (per 1000)	0·2	0·3	0·5	0·4

* Two years or less in the country.
† Over two years in the country.
‡ Total immigrant and indigenous cases. This is reasonably correct since 70–80 per cent. of the cases were Jewish.
§ Only Jewish cases for Jerusalem, Jaffa and Haifa districts and Nazareth and Beisan, Tiberias and Safed.

that for the three years during which records are available there is an indication of periodicity: in 1924 the morbidity was higher among the immigrants; in 1925 it was somewhat higher in the indigenous population; and in 1926 it was again higher in the immigrant population. The average for the three years shows a higher morbidity in the immigrant group, while the mortality is the same in both classes of the population.

Another approach to this problem is shown in Table IX. This table presents a comparison of the typhoid morbidity and mortality in the Jewish populations of Jerusalem and Jaffa-Tel Aviv respectively for the years 1924, 1925 and 1926. This comparison has a direct bearing on our problem because in Jerusalem the immigrant factor is negligible while Tel Aviv is practically an immigrant city.

Table IX. *Comparison of typhoid incidence in the Jewish population in Jerusalem and Jaffa-Tel Aviv*, 1924, 1925 and 1926.

	1924		1925		1926		Average	
	Jeru-salem	Jaffa-Tel Aviv	Jeru-salem	Jaffa-Tel Aviv	Jeru-salem	Jaffa-Tel Aviv	Jeru-salem	Jaffa-Tel Aviv
Population*	39,000	28,000	41,000	40,000	43,000	40,000	—	—
Cases	61	122	168	191	171	223	—	—
Deaths	6	9	20	17	9	22	—	—
Fatality	9·8	7·4	11·9	8·9	5·3	9·9	—	—
Morbidity (per 1000)	1·6	4·4	4·1	4·8	4·0	5·6	3·2	5·0
Mortality (per 1000)	0·16	0·32	0·49	0·40	0·21	0·55	0·28	0·44

* Estimated mid-year population.

The data in Table IX serve, therefore, as an indication of the relative prevalence of typhoid in the two classes of the population. It is noteworthy that the results are similar to those shown in Table VIII. In 1924 the morbidity and mortality were two or more times as high in the immigrant (Tel Aviv) as in the indigenous (Jerusalem) population; in 1925 both groups were equally affected; while in 1926 the immigrant group again suffered more severely.

A direct comparison of the relative morbidity in the immigrant and resident groups in the same city is shown in Table X. This table presents the morbidity

Table X. *Comparison of incidence of typhoid in the resident* and immigrant* population of Tel Aviv in* 1926.

	1926†	
	Resident (1924)	Immigrant (1925–6)
Population	25,000	15,000
Cases	103	120
Deaths	8	12
Morbidity (per 1000)	4·1	8·0
Mortality (per 1000)	0·3	0·8

* The term "immigrant" is applied to people two years or less and "resident" to those more than two years in the country.

† Estimated population in Tel Aviv on basis of 1925 census.

and mortality data for Tel Aviv in 1926. Corresponding data for previous years are not available. The results show clearly that in the same community the morbidity and mortality in 1926 was about twice as high in the immigrant as in the resident population.

The higher primary incidence of the disease among the immigrants and the subsequent tendency to equalise are especially interesting in view of the experimental findings by Topley, Flexner and others. These investigators found

that on the introduction of new mice into an endemic centre the new-comers were the first victims; as the epidemic intensified the old residents were attacked; and at the end both population groups suffered equally. In a human population, the contact is never as close as in rat cages or rat villages; nor is the dosage and distribution of micro-organisms as great. The results cannot, therefore, be expected to be identical particularly with respect to the time required for equalisation. It would seem that in a human community, although the general trend is the same as in the rat community, the time period elapsing until the indigenous population is fully drawn into the epidemic wave is about one year. This difference is in reality what might be expected, since the extension of the epidemic is as dependent on the rate of dissemination as on the dosage of the infecting micro-organisms.

Discussion. The analysis presented above reveals factors in the epidemiology of typhoid which, if confirmed by subsequent observations, are of first importance from the standpoint of prevention. So long as the cause of an epidemic is obscure, it is impossible to adopt any direct procedure to combat it. As a result, the proposals are usually as numerous as the various measures employed at various times to combat epidemic outbreaks of the particular disease. This inevitable uncertainty is apparent in the measures proposed for the control of typhoid in Palestine. These proposals include various phases of general sanitation, hospitalisation, etc., all of which are interesting and some even important, but they fail to present an effective solution for the immediate problem.

It is clear, however, that control of an epidemic situation can best be brought about by applying certain specific measures on which all efforts can be concentrated. That is why water and milk epidemics are so readily stopped, while the control of contact epidemics has thus far proved a failure. The findings presented above, and their concordance with the remarkable experimental data furnished by Topley, Flexner and their associates, suggest a simple mode of attack which would serve as an effective solution of the typhoid problem in Palestine. If the flare-up of typhoid epidemics, after a period of endemic equilibrium, is brought about by the introduction of large numbers of susceptible population, the simple remedy is to render these new people non-susceptible. And fortunately, in the case of typhoid, this is easily possible. Topley and Wilson (1923) have shown that vaccination of mice prevents the spread of mouse typhoid in the mouse community. Lange (1924) has similarly protected mice by *per os* vaccination. It would seem then that the procedure which promises prompt and effective results *is the thorough vaccination of every immigrant coming into the country* (*particularly those between the ages* 5–30), *against typhoid.*

On the other hand, the reduction of cases in the indigenous population can best be brought about by the early detection of cases and the discovery of carriers. It is a self-evident axiom that the sick person in bed is relatively innocuous in comparison with the ambulant case and the patient in the early

days of the illness before he takes to bed. No amount of hospitalisation will put an end to a typhoid situation, because the patients rarely come there before the end of the first week of illness. As a matter of fact, hospitalisation of typhoid is much greater in Palestine than elsewhere. In 1925, 79 per cent. of the total typhoid cases were hospitalised in the Jewish hospitals alone. Yet this had little effect on the course and progress of the 1925 and 1926 epidemics. Concentration of efforts on the early diagnosis and detection of cases and prompt vaccination of contacts would probably cost much less and yield larger returns, because it would strike at the root of the problem.

Summary and conclusion. A study was made of the available statistical data bearing on the epidemiology of typhoid in Palestine. It appears from this analysis that:

1. The typhoid epidemicity is not due to a single source such as contaminated water or food. The seasonal prevalence of the disease corresponds with the normal seasonal incidence of typhoid, and is, therefore, in the nature of a contact infection.

2. There is no striking difference in age, sex or race susceptibility. In Tel Aviv the age group 5–14 shows a lower incidence than the corresponding age group in Jerusalem or the higher age group 15–29 in Jerusalem and Tel Aviv. There is, however, no difference in susceptibility between the age group 15–29 in Jerusalem and that in Tel Aviv.

3. From a graphic comparison, the calculation of the coefficient of correlation of the limited experience (six years), and a comparison of the prevalence of the disease in the immigrant and indigenous population, there appears to be a significant correlation between the net population increment and epidemicity. These results, if confirmed by a longer experience, are in accord with those obtained in the remarkable mice experiments conducted by the English and American investigators.

4. Although, at the beginning, the morbidity and mortality is higher in the immigrant group, there is an evident tendency at equalisation, and in the second year the incidence in the indigenous population is the same as that among the immigrants.

5. The above results indicate the path of control: (*a*) every immigrant, particularly those between the ages 5–29, should be properly vaccinated against typhoid. By raising the resistance of the new population, the possibility of epidemics among them, and consequently later among the resident population, will be averted; (*b*) the reduction of endemic typhoid can be brought about by reducing the dosage of the infectious microbes. This can only be brought about by concentration of effort on the early detection and isolation of cases and the vaccination of all contacts. These two measures would seem to offer a prompt and relatively simple solution to the typhoid problem in Palestine.

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