indicated in young children, and less desirable in older children, than other methods at our command. Arthrodesis of the astragalo-calcaneal joint, so performed as to correct any lateral deviation in the foot, is proving of increasing value, for excessive lateral mobility without stability is difficult of control by mechanical means. Arthrodesis of the shoulder is of considerable advantage when the deltoid is irrecoverable and the function of the rest of the arm is good. Before it is performed the muscles of the shoulder girdle must be working, as the object of the operation is to fix the head of the humerus into the glenoid at an appropriate angle so that the arm may be moved by the scapular muscles. In children over 10 the scapular movements become very free as they grow up, and after an arthrodesis the arm can be placed to the back of the neck, and into the trouser pocket. This operation should be but rarely performed in the adult, and its limitations should always be fully described to the patient.

In a technically successful operation in an adult the patient was dissatisfied with the result because previously she could do her hair and fasten the back of her dress by placing the paralysed arm in position with the other, whereas after the arthrodesis the inability to mobilize the scapula sufficiently in adult life prevented the extremes of motion required in these two movements. As a preliminary to arthrodesis of the shoulder intensive exercises for the scapular muscles are needed, and unless the patient can shrug the shoulder with considerable power arthrodesis is contraindicated.

If an arthrodesis is performed on the adult the arm should be fixed in abduction at a lesser angle than in the case of a child. In the child the scapular movement can be considerably increased over the normal range during the years of growth. In the adult there is a danger, if the abduction is extreme, that the arm cannot be brought to the side. This is a very serious functional result.

Tendon transplantation is beginning to appear in its true perspective, and the complicated operations in vogue some years back are no longer performed. Its object is to improve or to restore muscular balance, and it is to be condemned unless it is performed with a reasonable chance of improving function. The transplanted muscle should become a true substitute for the muscle which is paralysed. It may be performed in order to prevent or correct deformity, and the recent tendency of surgical practice is to employ it in conjunction with operations designed to improve stability. Its task in that case is not so responsible as when the transplanted tendon is called upon to do the whole of the work itself. Tendon transplantation is a procedure which calls for sound judgement and irreproachable technique.

Every case represents a separate anatomical problem, and it is not indicated unless there are normal tendons to transplant. The question of operation does not arise when the muscles are all partially paralysed. If nothing has been done in order to relieve the paralysed muscles from tension an operation is not justified until relaxation has been tried, and it is fundamental that all deformity should be fully corrected before a transplantation is done. Naughton Dunn of Birmingham has lately made a distinct advance in the treatment of paralysed feet which require apparatus, by shortening and stabilizing the foot. The operation consists of arthrodesis of the astragalo-calcaneal joint and the removal of various portions of bone from the tarsus, retaining the function of the ankle-joint and fortifying plantar flexion by transplantation of the muscles which pass to the sole into the tendo Achillis. I examined some fifty cases upon whom this operation had been performed, and the results were excellent, most of the patients walking without apparatus.

Associated with the success of tendon transplantation is the recognition of those principles which bear upon the relaxation of muscle and fatigue. Any attempt to overwork a transplanted tendon results in weakening it, and until it gains strength it should be treated as if it were partially paralysed. Massage and re-education should be conducted in the absence of weight-bearing.

With improved technique the operation of tendon fixation has gained in surgical esteem, and has made much headway since Tilanus introduced it, much of the improvement being based on the experimental work of Gallie. It consists of the utilization of paralysed tendons as ligaments. The success depends largely upon the anchorage being made very near the articular ends of bone on both sides of the joint, so that a very short piece of tendon is under strain. For instance, in paralytic foot-drop, the tendon of the paralysed calf muscles is divided, and the lower end split longitudinally, one half

being brought through the tibia and the other through the fibula, with the foot kept at a right angle. In this way we form a very firm ligament, which prevents dorsiflexion of the foot. These fixation operations have supplanted the employment of silk ligaments, but the practical point wants emphasizing—that it is essential the tendons should be fixed just above and below the joint, in order to minimize the danger of stretching. More lately free fascial transplants are being used to form ligaments, but our experience is not sufficient to allow a considered judgement.

The tendency of modern surgery is to stabilize the ankle, and the surgeon calls to his aid a variety of methods. If he deals with a calcaneo-cavus where only the flexors of the toes are working, and perhaps the peronei, he first performs arthrodesis of the calcaneo-astragaloid joint to give lateral stability, and then of the front of the foot, shortening it at the same time. He does not touch the ankle-joint. The peronei and flexors of the toes are passed through the back of the os calcis. If the muscles are weak and will not bear the full strain of body weight, the lower portion of the impotent tendo Achillis is transformed into a strong ligament. In short, he employs arthrodesis to shorten the foot so that leverage is rendered less harmful, and to prevent lateral instability; he employs tendon transplantation to supplant a paralysed calf muscle, and he limits the movement of the ankle by a tendon fixation in order that the transplanted tendons may be saved from fatigue. This is excellent team work, in which all the structures of the foot participate. For pronounced knock-knee, so often found in neglected paralysis, subcutaneous osteotomy is sufficient.

The deformity produced by shortening can now be overcome by an operation devised to lengthen the femur, just in the same way as we lengthen a tendon. If the shortening is the result of a paralytic dislocation the displacement can be reduced and the capsule plicated. In fact, there is no deformity to be met with that should baffle surgical art. Operations, however, are but incidents in the treatment of paralysis, and it is upon recognition of sound principles in the after-care that we depend for the restoration of function.

Nerve transplantation, which at one time seemed so reasonable, is no longer practised, and our observations during the war upon nerve transplantation in paralysis of the peripheral nerves confirm us in discouraging it in infantile paralysis. The direct neurotization of paralysed muscle is only in its experimental stage, and the result will be followed with great interest and considerable misgiving.

My apology for bringing before so learned an audience these elementary but practical principles is that I fear that, even in high places, men are content to give them a mere academic homage.

The Milroy Lectures

ON THE

INFLUENCE OF INDUSTRIAL EMPLOYMENT UPON GENERAL HEALTH.

DELIVERED BEFORE THE ROYAL COLLEGE OF PHYSICIANS
OF LONDON ON MARCH 9TH, 14TH, AND 16TH, 1922,
BY

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LECTURE II.

I HAVE pointed out the difference between the courses of the death rates at ages in England and Sweden through the last sixty years, how greatly our mortality has improved both absolutely and relatively to that of Sweden in the younger age groups, how unfavourable is the comparison at later ages. Our later adult mortality was indeed still deteriorating relatively to that of Sweden as recently as 1890, and a subsequent improvement has only brought it within 42 per cent. of the Swedish rate. Nor if we compare typical districts of England can it be said that the regions with a high initial rate, such as Lancashire, have improved much faster than those, such as the South-Western Group of Registration Counties, with an initially low rate. If the comparison be extended to other countries the same conclusion is reached, that expressed by Dr. Stevenson in the following words:

"Considering the whole country as a single area of urban type in comparison with other countries the same feature is observed. Our position is relatively very favourable in early adult life, and

TABLE I.—Death Rates per 1,000 Living from Pulmonary Tuberculosis in Sweden.

Age.	1911.		1912.		1913.		1914.		1915.		England and Wales, 1901-10.		
	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.	Age.	Males.	Females.
0-5	0.416	0.371	0.375	0.368	0.271	0.347	0.394	0.354	0.429	0.392		0.351	0.304
5-10	0.186	0.370	0.219	0.232	0.190	0.277	0.224	0.336	0.187	0.286		0.137	0.194
10-15	0.310	0.733	0.303	0.848	0.757	0.725	0.318	0.867	0.421	0.61		0.171	0.396
15-20	1.578	2.153	1.727	2.236	1.546	2.057	1.601	2.323	1.690	2.483		0.756	0.988
20-30	2.681	2.938	2.623	3.041	2.632	2.325	2.125	2.987	2.972	3.158	20-25	1.521	1.235
30-40	2.146	2.120	2.204	2.360	1.893	2.410	2.153	2.158	2.085	2.838	25-35	1.965	1.475
40-50	1.741	2.084	2.125	2.094	1.700	2.002	1.748	1.953	1.730	2.219	35-45	2.446	1.551
50-60	1.736	1.551	2.069	1.729	1.773	1.599	1.871	1.641	1.965	1.576	45-55	2.753	1.310
60-70	1.831	1.571	1.890	1.609	1.935	1.415	1.977	1.432	2.004	1.588	55-65	2.379	1.047
70-	1.423	1.049	1.170	1.066	1.133	1.070	1.155	0.963	1.068	1.036	65-75	1.521	0.756
											75	0.567	0.357

very unfavourable when the middle of life is past, and particularly at 45-65." (Supplement to Seventy-fifth Annual Report of the Registrar-General, Pt. III, p. xxxiii.)

Bearing in mind the actual stages of economic development of England and Sweden, it may be said that there is some analogy between the position of Sweden now and that of England fifty years ago. Most of Sweden's economic development has occurred since 1870. In that year only 20 per cent. of her population depended upon industrial pursuits; this proportion had reached 45 per cent. in 1910. Consequently the very high rates of adolescent mortality in Sweden are perhaps correlative with the changes of environment and of survival values which an economic revolution imposes. Such is indeed the opinion of the most competent Swedish writers. The proximate cause of the excessive Swedish mortality is pulmonary tuberculosis (see Table I). At the beginning of the nineteenth century (see Sundbärg, II) phthisis was of the "old age" type, and its frequency in the middle of the century was either stationary or increasing (Runborg and Sundbärg). Sundbärg thought that the responsible factor was industrialization. Of the increasing mortality at ages 15 to 20 he wrote:

"The cause of this difference between earlier and more recent times seems to us to lie in the fact that formerly the adolescent boy and girl remained at home for a longer time. Nowadays one goes more frequently and at an earlier age to the city or the factory. The new conditions of existence bring in many cases increased dangers to health and life—dangers which, especially in the case of women, often lead to tuberculosis" (Sundbärg, I, 204).

Widell has recently (see *Dödlighets och Lifslängdstabeller för Åren, 1816-1910*, p. 13, and *Dödlighets och Lifslängdstabeller för Årtiondet, 1901-10*, p. 19) affirmed this conclusion.

But there are two important distinctions between the circumstances of England a generation ago and of Sweden now. The first is that Sweden has been an emigrating country—she has lost on balance 843,281 persons in the last fifty years; the second is that Swedish late adult mortality is less than ours is now, and, *a fortiori*, less than ours was a generation ago. Both Sundbärg and Widell think that the decline of spirit drinking has been an important cause of the decreasing mortality at later adult ages. The consumption of spirits reached a maximum in 1871-75, and declined until 1909, since when it has been almost stationary, with, if anything, a slight upward tendency. The cause of the decline seems to be a matter of controversy (see *Sweden*, vol. i, p. 743).

Of the effects of emigration upon the rates of mortality of the home-keeping population I shall not speak in these lectures; they are too complex to be fitly discussed incidentally. The same must be said of a different form of selection—that imposed by the operation of mortality itself. Upon neither subject do my inquiries throw light, yet both must be kept in mind, and I mention them here to warn you against too absolute inferences from the contrasting series of mortality rates which I have examined.

INFLUENCE OF MIGRATION.

But although I am not prepared to discuss the wider aspects of migration, I do desire to examine in some detail one part of a subject to which Dr. Hamer has devoted close

attention (see in particular Hamer, 1912, and Hamer, 1921), because its importance is suggested by the quotation I have just made from Sundbärg.

It is difficult to summarize a connected argument in a few words, but I think the gist of Dr. Hamer's contentions is as follows. So far as concerns the influence of emigration in the popular sense of the term—that is, migration from one country to another—Dr. Hamer thinks that those European countries in which economic prosperity has advanced but which have lost population by emigration and have also experienced a decline in the death rate from phthisis, have parted with a large proportion of their weaker citizens, and he shows that the decline in the phthisis rate has been correlated with an outward movement of population in search of health to Australia, America, and elsewhere. On the other hand, in some countries—notably Ireland, where domestic, social, and economic conditions have been bad—emigration has removed a larger proportion of the healthy young adults, and the death rate from phthisis amongst home keepers has either remained stationary or declined but little. This branch of the subject I shall not discuss, but turn at once to the problematical effect of internal migration. Dr. Hamer has shown (making skilful use of the late Sir George Buchanan's report upon phthisis in Kent, Surrey, and Sussex) that rural districts especially ravaged by phthisis are precisely those which a study of age distribution and of other local circumstances proves to have suffered a heavy loss by townward migration. He has also pointed out the favourable rates of mortality experienced by the urban districts as a whole in comparison with country districts at adolescent ages. Hence he attaches much importance to the lure of the towns for the young, vigorous, and ambitious adolescents. But, it may be said, this goes no way to account for the very heavy excess mortality at ages of maturity in towns. Dr. Hamer, however, remarks that there is a townward trend of immigration at later ages of life, but the quality of the immigrants is different. In adolescence and young manhood it is a migration of the vigorous and hopeful; at later ages it tends to be a migration of those broken in the struggle for life, seeking, not perhaps with much hope, what has hitherto escaped them. The immigration of the young and healthy lowers, the immigration of the middle-aged and unhealthy increases, the urban death rate.

I am not quite sure whether Dr. Hamer is prepared to press his theory of the importance of migration as a factor of mortality beyond the point just reached, so that any discredit belonging to the very speculative extension I am about to make belongs exclusively to me, while, should it be found worthy of consideration, the credit is entirely Dr. Hamer's.

It is possible that the change of environment from town to country may have an extremely unfavourable effect upon the immigrants, the supposition invoked by Sundbärg to explain the Swedish experience at ages 15 to 20. Before theorizing about this we may inquire whether the scale of internal migration is large enough to make any supposed effect upon the health of migrants a substantial factor of mortality.

The report of the Census of 1911 (General Report, Cd. 8491 of 1917, pp. 203 et seq.) contains an experimental tabulation of the age distribution of immigrants in certain large towns and boroughs. The age group of greatest immigration proves to be 25 to 35, in which decennium the proportion is of the order of

20 per cent. of the enumerated urban population in that age group. In the districts examined it was as high as 22.4 per cent. in the industrial borough of Swindon, 19.4 in Bradford and Burton-on-Trent, 18.9 in the county of London, and only so low as 16.4 in the non-industrial borough of Hastings. If we take 20 per cent., as found in this experimental tabulation, to be a fair characterization of industrial towns as a whole, is there a sufficient supply of country-born persons to furnish the immigrants, or must they be no more than transfers from one town to another?

A precise answer cannot be made to this question, but the difference between actual increase and natural increase of rural districts is very large. Thus, the increase of the *de facto* populations of the registration counties of Huntingdon, Bedford, and Shropshire between 1901 and 1911 was 31,506, the excess of annual births over annual deaths 57,221, leaving an outward balance of 25,715. Numerous examples of urban trends are to be found in Mr. T. A. Welton's book. One cannot doubt that in most manufacturing towns the numbers of country born and bred immigrants are very large, so that Dr. Hamer is almost certainly correct in supposing there to be ample material for the revelation of effects.

In the brief discussion I devoted to the topic in my paper on tuberculosis (Greenwood, 1920) I tacitly and too lightly assumed that the supposedly healthy and ambitious immigrants from the country died in the towns at a lower rate than the town-born coevals and so depressed the average mortality at adolescent ages. I suggest that the very reverse of this may be the truth. A considerable literature has arisen of recent years around the question of bringing "unsalted" populations into contact with urban civilization (Colonel Bushnell's monograph is an admirable introduction to the subject); perhaps what happens to an extreme degree when Dryden's noble savage becomes a townsman happens to a less degree when Corydon repairs to the tenement, the picture palace, and the factory. Adolescent migration perhaps increases mortality in both populations—rural mortality by the withdrawal of those best fitted to survive under the rural environment, urban mortality by the introduction of those ill adapted to survive under urban conditions. I shall show that the mortality at ages 25 to 35 of bootmakers in Leicestershire and Northamptonshire is much greater than that of the north-western cotton operatives, in particular the mortality from phthisis. The statistically rural population of these counties lives under conditions much more closely approximating to what the Londoner thinks of as "country" than does the rural population of Lancashire and Cheshire. But this is a faint argument, and until by such an inquiry as that of Dr. Perry in America we can gather more knowledge of the provenance of factory workers the subject must remain obscure. In any case I do not suggest that migration is all-important. Thus the rate of mortality of cotton operatives passes above that of the Leicestershire and Northants bootmakers at 45, and there can be little probability that the townward movement of failures at ages over 45 has a substantial effect upon the mortality rates of a highly skilled industry such as the cotton manufacture. I have, however, some other relevant facts.

Dr. Miyagima has been kind enough to give me some suggestive particulars respecting mortality in Japan. In that empire mortality from tuberculosis has tended to increase, and in 1901-05 was 50 per cent. higher than in 1886-90. According to the statistics of 1908-12 the excess over English rates is especially noteworthy between the ages of 20 and 30; at 25 the mortality in Japan is more than twice that of England and Wales. According to some investigations of Dr. I. Ishiware, the rate of mortality upon girls employed in cotton mills is especially severe. Annually not less than 210,000 girls are invited from the country districts into the mills, and the annual rate of discharge from ill health is 80,000—that is, more than a third of the numbers recruited (not of course the same individuals). Of the 80,000 discharges, 6,000 are said to be due to tuberculosis, and 70 per cent. of all deaths amongst those discharged are due to tuberculosis. The Government has been led to take special action to deal with the sanitary condition of the factories.

These results are consistent with the hypothesis I have suggested, but naturally a foreigner ignorant of the language and customs of the country is not in a position to make full use of the statistics. The apparent partial immunity of Jews to phthisis (Fishberg) is also a relevant circumstance.

So I must leave this important question with no more than a speculative answer. Yet enough has been shown to justify a closer research. Notwithstanding the bureaucratic interference with the lives of citizens which our newspapers bewail, there is a surprisingly large number of quite simple but important facts which we do not record.

POVERTY.

Sundbärg's remarks upon mortality in Sweden invited this not, I hope, unseasonable digression. I now return to more obvious subjects of inquiry. A very large proportion of townsmen and women are desperately poor, and the hygienic evils of poverty, the radii of its vicious circles (well described in Dr. Hurry's recent book), smaller in industrial towns than in the country. I will not overstate the case; the eclogues, whether of Virgil or Pope, are not a reliable guide to life even in the sheep-raising districts. Many agricultural labourers are wretchedly housed and miserably poor. But the etiological importance of unsuitable housing is so largely a function of density, of mere aggregation, that the hygienic evils of tenement houses which Dr. Wanklyn described in 1913 as constituting a "gigantic tax on the public health," or of the back-to-back houses which Dr. Robertson so recently stigmatized, are essentially town evils. Bad housing, however, is not the only consequence of poverty: low real wages mean the deprivation of other things besides house-room. The housing conditions of a town are not absolute measures of the economic prosperity of its inhabitants.

The question, then, may be asked whether mortality can be adequately expressed as a function of the two variables—housing and real income; if so we need seek no farther. But that the general etiology of the death rate in industrial towns cannot be fully expressed in terms of these two variables is suggested by the researches of Professor A. L. Bowley and Professor Burnett-Hurst. Their inquiry was no doubt prompted by the well-known book of Mr. Rowntree on the industrial conditions of York, but it followed a different plan.

No study on the scale of Mr. Rowntree's, *a fortiori* none such as the late Charles Booth's investigation, can be carried out save at enormous expense of time and money. The method of exhaustive enumeration must be reserved for such relatively simple particulars as are ascertained by a census; in fact, some statisticians hold that the census authorities already ask too much. But if we cannot measure the "universe" we can at least measure a sample of it, and, in a majority of cases, the sample will tell us all we need to know. The theory of the method is expounded in all textbooks of statistics, and its practical application is subject to various limitations, but none of these are of much importance in the particular circumstances of the inquiry I am about to describe.

A Sampling Inquiry.

Professors Bowley and Burnett-Hurst inquired into housing accommodation and economic circumstances in each of the four county boroughs of Reading, Bolton, Warrington, and Northampton (they also investigated the urban district of Stanley, but this district is not comparable with the others from the present point of view). In assessing housing accommodation the census standard was modified. "An adult (including boys over 18 years and girls over 16 years) is counted as one, other boys and girls over 14 as 3/4, children from 5 to 14 as 1/2, and children under 5 as 1/4. The household is then reckoned as containing so many equivalent adults. It is then found on examination that five equivalent adults can be accommodated in a five-roomed house, allowing 500 cubic feet per adult, with a little give and take; and one person or less per room on this basis may be regarded as a reasonable standard of sufficiency" (Bowley, p. 677).

In his work on York Mr. Rowntree adopted a minimum standard of diet and minimum requirements for fuel, clothing, and house rent. The three latter depend on local conditions, the former on physiological evidence. Actually the diets quoted in Mr. Rowntree's book as obtained by his poorest observed class yielded about 2,600 calories per "man" (Greenwood and Thompson), a provision which would now cost at least three times the sum allowed in Mr. Rowntree's scheme—namely, 3s. per week; the theoretical standard was 3,500 calories. Professors Bowley and Burnett-Hurst modified Mr. Rowntree's theoretical food standard by assuming the purchase of two pounds of meat weekly, and this, allowing also for rise of prices between 1899 and 1913, brought the estimated per caput expenditure for an adult to 4s. 6d. weekly—rather less than half of what it would cost now.

"In making comparisons with the standard, it is to be observed that nothing is allowed for insurance (other than State), pocket money, tram fares, beer, betting, newspapers, or any of the other ordinary objects of expenditure other than necessities. On the other hand, we do not reckon profit from allotments (which are numerous in Reading and can provide perhaps a weekly shillings-worth of potatoes, beans, etc., together with less nourishing vegetables), and have, no doubt, omitted small earnings of the school children and wives" (Bowley, p. 685).

The authors, having made the necessary calculations, determined the percentages of working-class families below the poverty standard as just defined; these, and the percentages of overcrowded families computed by their method (owing to certain special difficulties—see Bowley and Burnett-

TABLE II.—*The Relation of Working-Class Households to New Standard of Poverty* (op. cit., p. 239).

Percentages of all Working-Class Households.

	Bolton.	Northampton.	Warrington.	Reading.
<i>Above line.</i>				
40s. or more	11	14½	9	1
30s. to 40s.	10	10	6	3
20s. to 30s.	17	22	13	6
10s. to 20s.	27	30	24	20
0s. to 10s.	20	12½	31	44
Unknown	7	3	4	3
Total above	92	92	87	77
<i>Below line.</i>				
Unknown	1	1	2	1
0s. to 10s.	7	7	11	18
10s. or more	0	0	0	4
Total below	8	8	13	23

TABLE III.—*Number of Overcrowded Houses* (Bowley and Burnett-Hurst, op. cit., p. 21).

No. of Rooms:	1	2	3	4	5	6	7	8	Total Overcrowded.	Total No. of Working-Class Homes.	Percentage Overcrowded.
Northampton	0	0	2	13	14	29	2	0	60	693	8.7
Warrington	0	3	14	67	22	18	1	1	126	640	12.7
Reading	1	0	6	27	48	2	0	0	84	622	13.5

Hurst, op. cit., p. 225-6—this overcrowding index could not be computed from the Bolton data; by the Census test, however, Bolton was better than Warrington, worse than Reading, and much worse than Northampton) are shown in Tables II and III. The death rates at ages 25 to 45 and 45 to 65, computed from the vital statistics of 1911, 1912, and 1913, are shown in Table IV, and as percentages of the rates in Reading in Table V. If we take the percentage of working-class

TABLE IV.—*Death Rates from All Causes per 1,000 Persons (1911-13).*

Ages:		0-5.	5-15.	15-25.	25-45.	45-65.
Bolton.	Males	47.7	3.2	3.7	7.0	27.7
	Females	41.8	3.0	3.1	5.6	21.0
Northampton.	Males	36.0	2.4	4.3	5.6	18.0
	Females	30.9	2.6	3.8	4.7	15.1
Reading.	Males	26.8	2.2	3.0	5.5	16.8
	Females	23.5	2.0	2.5	4.5	12.2
Warrington.	Males	43.4	3.8	3.5	7.5	25.4
	Females	44.1	4.0	3.0	5.9	21.0

TABLE V.—*Mortality Rates from All Causes Expressed in Terms of Reading 1911-13.*

Ages:		0-5.	5-15.	15-25.	25-45.	45-65.
Reading.	Male	100	100	100	100	100
	Female	100	100	100	100	100
Northampton.	Male	134	109	143	102	107
	Female	131	130	152	104	124
Bolton.	Male	178	145	123	127	165
	Female	178	150	124	124	172
Warrington.	Male	181	173	117	136	151
	Female	188	220	120	131	172

families below the standard as an average measure of poverty in the economic sense, we see that there is no close relation between mortality and real wages in these towns. Reading, which is by this test far the most poverty-stricken of the towns, has the least mortality at every age. On the other

hand, the two Lancashire towns which (except in the age group 15 to 25) have the worst mortalities have also the most overcrowded dwellings. But the housing conditions of Northampton are better than those of Reading, yet only at ages 25 to 45 (of course, a very important exception) are the Reading and Northampton mortalities upon a par.

It is sufficiently well known that the industries of these towns are widely different. In Reading the principal employer of industrial labour is a great biscuit firm upon which a fifth to a quarter of the working class directly depend (Bowley and Burnett-Hurst, op. cit., p. 160); this branch of manufacture does not need a large proportion of skilled industrial workers. The staple industry of Northampton is the manufacture of boots and shoes, which, with ancillary processes, employs 42 per cent. of occupied males and 43 per cent. of occupied females (after excluding professional occupations, Government employees, and soldiers). Warrington contains some of the largest ironworks in the country, and iron work is by far the largest single industry, but there are numerous other branches of manufacture. Bolton is one of the great textile towns. There is, then, no homogeneity between any two of the towns in respect of industrial processes, but Bolton and Northampton probably employ a larger percentage of skilled industrial workers than the other two cities (in the iron trade alongside of the skilled men there work many labourers on small wages; when the inquiry was carried out many of the latter earned 20s. to 24s. per week of fifty-three hours).

Can we say that there are any obvious conditions common to the highly skilled Northampton population and the lowly skilled Reading population, on the one hand, and not characterizing the highly skilled Bolton and the moderately highly skilled Warrington population on the other? There are some noticed by our authors.

"Northampton," they remark, "for a manufacturing town is remarkably clean; the boot and shoe factories do not require tall chimneys pouring out dense volumes of smoke, and the number of factories from which pollution takes place is very small. Warrington, on the other hand, is at times 'one mass of smoke'" (op. cit., p. 93).

Bolton, although less smoky than Warrington, is nearer to Warrington in this respect than to Reading or Northampton. In Northampton and Reading Professors Bowley and Burnett-Hurst remark upon the plentiful provision of allotments (op. cit., p. 81; Bowley, p. 685). Perhaps we have here a distinction of some importance; I do not mean that the contributions to family supplies derived from allotments—after all only a minority of the working population can cultivate gardens even in Reading—invalidate the authors' economic classifications, but that the general conditions which render gardening possible at all for the working classes may be significant of much. That treeless desert which saddens the traveller by the North-Western Railway, and inspired so much excellent mid-Victorian prose, is not, perhaps, only an aesthetic blemish. Socrates' remark, "Now shall I go on and mention to you also windless air, calm sea, and all that sort of thing, and say that stillness causes decay and destruction and the opposite brings preservation?" (*Theaetetus*, IX), has found a brilliant exponent in Dr. Leonard Hill, who has displayed a factor of mortality we cannot neglect.

I do not mean that the Lancashire towns are surrounded by a windless air; I only suggest that the squalid monotony which seems to be the external characteristic of some of our north-western manufacturing towns may promote decay and destruction. This is certainly not the whole explanation. If one considers the details of the death rates, it will be found that the greatest discrepancy between Northampton and Reading on the one hand, and Bolton and Warrington on the other, is under the articles of deaths from pneumonia. At 45 to 65 the Bolton and Warrington rates per 1,000 living were 2.1 and 2.8 on males, 1.1 and 1.9 on females; the Northampton and Reading rates were 0.9 and 0.8 on males, 0.3 and 0.5 on females. But Bolton and Warrington are in the north-western area, while Northampton and Reading are in the south-midland district.

It is notorious that the rate of mortality from pneumonia is higher in the north than in the south of England; that of rural districts in the north is higher than the urban district rate in the south. What portion, then, of the excess mortality from these causes should be debited to climatological factors?

The obvious test is to compare urban with rural mortality in the north-west, but unfortunately the industrialization of Lancashire is so great that the districts which are more than nominally rural contain a very small population. An

unsatisfactory test, but the best available, is to make use of the decennial returns of registration counties.

A comparison extended over a whole decennium is affected by the fact that prior to 1911 the death rates were not corrected for institutions. However, the accompanying table (VI), based on the decennium 1901-10 and comparing

TABLE VI.—Rates of Mortality from Certain Causes 1901-10.

	Ages 45-55.		Ages 55-65.	
	Pneumonia.	Bronchitis.	Pneumonia.	Bronchitis.
England and Wales:				
Male	1.53	0.73	2.49	2.66
Female	0.75	0.62	1.44	2.29
Lancashire:				
Male	2.45	1.43	3.85	5.09
Female	1.20	1.33	2.27	4.60
Northants:				
Male	0.85	0.37	1.29	1.41
Female	0.34	0.28	0.69	1.46
Cumberland:				
Male	1.94	0.44	2.83	1.93
Female	0.91	0.37	1.60	1.75
Westmorland:				
Male	0.91	0.19	1.76	0.95
Female	0.56	0.29	0.89	0.53

England and Wales, Lancashire, Northants, Cumberland, and Westmorland, is instructive. If we assume that the whole of the excess mortality in Cumberland above the all-England rate is due to climatological factors and ignore the rates of sparsely populated Westmorland entirely, we see that Lancastrian males die of pneumonia in the age group 45 to 55 26 per cent. faster than the males of Cumberland and 36 per cent. faster in the next age group. They die more than three times as fast as the Cumberland males of bronchitis at 45 to 55 and more than two and a half times as fast in the age group 55 to 65.

Speaking of pneumonia in 1912, Dr. Stevenson remarked:

"The range of mortality is extreme, being almost four times as great for males in county boroughs of the North as for females in the rural districts of the South, and three times as great when males alone are compared. Even when comparison is restricted to the same class of area in each case the mortality of the North is in no instance very much less than twice that of the South. No doubt this depends to some extent upon industrial conditions, but these can scarcely explain the great difference between the North and the Midlands. Evidently pneumonia is to a large extent a preventable disease, and the North of England has still much to learn with regard to its prevention" (75th Annual Report of the Registrar-General, Cd. 7028 of 1914, p. xciv).

Time does not permit of other detailed comparisons, but the course of phthisis mortality is interesting. At 15 to 25, Northampton is the worst of the towns (2.5 per 1,000, males, 1.8 per 1,000, females), and, excepting women in Warrington, there is nothing to choose between Reading and the northern towns (Reading 0.9 and 0.9, Warrington 1.0 and 1.5, Bolton 0.8 and 0.9). In the next age group, Warrington is worse, but not significantly worse than Northampton. At 45 to 65 Warrington and Bolton differ considerably from the other two towns (Warrington 3.9 and 1.7, Bolton 2.8 and 0.9, Northampton 2.1 and 0.6, Reading 1.5 and 0.9).

This comparison, while sufficient to make it probable that variations of real wages do not account fully for great discrepancies of mortality—thus refuting the newspaper contention that if we only abstain from national and local taxation for medical and hygienic "fads" all would be well—certainly does not unerringly reveal some one industrial factor in the northern towns which destroys life. Yet these figures do bring to light an important industrial correlation. In the year 1913 Northampton experienced the highest death rate at ages 20 to 25 (males) of any county borough in England and Wales, and at 15 to 25 the death rates for both sexes were much higher than in the other towns of our series. Turning to the causes of deaths, it appears that the phthisis mortality was very high. We certainly cannot explain it by the generally unfavourable sanitary conditions of the town; we have seen that at later ages Northampton stands better than Warrington or Bolton. We may of course say that the low Northampton mortality at 25 to 45 is partly owing to the high and selective mortality at 15 to 25, but it remains to consider what these influences are which make for so high a mortality at the earlier age. The mortality of boot and shoe manufacturers from phthisis is very great, disproportionately great in comparison with their mortality from all causes. Using the comparative mortality figures of the Registrar-General

(1910-12), shoemakers are found to have had a mortality from all causes 88 per cent. greater than that of the clergy; their mortality from phthisis exceeded that of the clergy by no less than 356 per cent.

Dr. Jacques Bertillon summarizes an analysis of thirteen set of tables in the following words:

"The results of these different tables are sufficiently concordant except the French table, the mortality is average (rather slightly less than average at all ages in the four English tables, the Swiss table, and the Parisian table for 1890-99). It is slightly above the average in the two Scottish tables, the Paris 1885-89 table, and that of Leipzig. It is very sensibly above the average (especially below 35) in the French table. All the tables agree in showing that phthisis is frequent at all ages. Other diseases of the respiratory system are, on the contrary, rare" (p. 171).

The occupational incidence of disease I propose to examine in the next lecture; I mention the case of shoemakers here, since it arises in connexion with our study of the four towns; as perhaps the best instance they afford of an industrial correlation not associated with specially low wages or bad housing.

I have dwelt upon the vital statistics of these four towns because for them alone we have contemporaneous measurements of economic status, and only when such are available over a much wider area can we hope to know the real mass etiology of death rates. The field covered was too small to render it probable that definite hygienic inferences could be drawn. But even this small experiment has taught us much, and suggested that investigations on the lines of Professor Bowley and Professor Burnett-Hurst's inquiries would be of sanitary as well as economic importance—if, indeed, in a civilized commonwealth economic and hygienic interests can ever be separated.

I conclude with a few remarks upon the significance of some wider data.

Working Life.

Hygienists are grateful to Dr. E. C. Snow for devising, and to the late Registrar-General, Sir Bernard Mallet, for arranging the publication of, a long series of sectional life tables based on the experience of the years 1911 and 1912.

It is of course easy to overrate the importance of the life table as an instrument of hygienic research. The beauty of the technical methods used for its construction and graduation appeal to the professional statistician, the symbolical notation in which those methods are (necessarily) displayed strikes awe into the heart of the non-actuarial medical officer, who is apt to suppose that there is a special intellectual prestige attaching to those who can freely utter such mysterious phrases as "curtate expectation of life" or "osculatory interpolation." One sometimes forgets that life-table constants are subject to precisely the same difficulties of interpretation as the death rates themselves from which they are deduced. The life table of any district is based upon the death toll taken of contemporaneously existing lives. Could we make a life table for persons followed individually from the cradle to the grave, the result would probably differ greatly from such tables as we can construct. I am a less enthusiastic admirer of the life table as an instrument of research than is Dr. Brownlee. The life tables we have do, however, answer some important questions.

By the age of 25 the period of apprenticeship is almost over; by 55 the prime of working power in the industrial classes is past. Of the possible term of thirty years here covered what is the average number actually lived in areas of different industrial and geographical types? In the table I provide such approximations to the answer as can be deduced from sectional life tables (the short tables of the General Register Office have been used).

TABLE VII.—"Partial" Expectation of Life for Males during the Thirty Years from Attained Age 25.

NORTH-WEST OF ENGLAND.	
Great Industrial Towns.—Bolton, 26.8; Burnley, 27.3; Halifax, 27.1; Huddersfield, 27.1; Leeds, 26.7; Oldham, 26.5; Preston, 26.6.—Average, 26.9 years.	
Non-Industrial Areas.—County of Cumberland, 27.1; County of Westmorland, 27.7; Rural Districts of the West Riding, 27.5.—Average, 27.4 years.	
SOUTH-WEST OF ENGLAND.	
Industrial Towns.—Bristol, 27.1; Plymouth, 26.4; Southampton, 26.2.—Average, 26.6 years.	
Non-Industrial Areas.—Dorset, 27.8; Wilts, 27.8; Devon (rural), 27.7.—Average, 27.8 years.	
MIDLANDS.	
Industrial Towns.—Coventry, 27.7; Derby, 27.6; Nottingham, 26.8; Leicester, 27.3.—Average, 27.4 years.	
Non-Industrial.—Derbyshire (rural), 27.8 years.	
EAST ANGLIA.	
Industrial.—Norwich, 27.6 years.	
Non-Industrial.—Rural Districts of Norfolk and Suffolk, 27.9 years.	

At a glance such figures as these are reassuring. The difference between the best and worst in the table, between Oldham and the rural districts of Norfolk and Suffolk, is only 1.4 years. But were we able to take them at their precise face value these figures would

be very depressing. The average value of the seven Lancastrian industrial towns is 26.9 years. Between the rural areas of different parts of the country the administrative counties of Westmorland, Dorset, Wiltshire, the rural parts of Norfolk, Suffolk, Devon, and Derby there is hardly any difference—the lowest is 27.7, the highest 27.9, the average 27.8. Therefore every man who passes his productive years from 25 to 55 under the rural conditions will have 0.9 of a year more to live in that productive period than a man of the same entering age in the industrial towns; the urban man power is 96.76 per cent. of the rural man power, defining man power as years of life lived from 25 to 55. Put in other words, were the urban conditions hygienically as good as the rural conditions the urban population might be reduced to 96.76 per cent. of its strength, and it would possess precisely the same productive power as now, although these rural samples themselves only yield 92.67 per cent. of the theoretically possible span, thirty years.

As a further illustration, I consider the partial expectation at 20 for the thirty-five years to 55 (males). Having applied the method to the ten industrial registration districts of Stoke-on-Trent, Wolverhampton, Walsall, West Bromwich, Dudley, King's Norton, Birmingham, Aston, Leicester, and Nottingham, and to the agricultural district formed by excluding the registration district of Lincoln from the registration county, the following results were reached:

In 1851-60 the urban man power was 95.7 per cent. of the agricultural man power; in 1901-10 it was 97.1 per cent. of it. Sixty years ago the Lincolnshire males lost 13 per cent. of their possible time, and now lose 8.4 per cent. Sixty years ago the urban males lost 16 per cent., and still lose 11 per cent. (Greenwood, p. 178). Again, I make the reservation that results based upon the mortality of two years (which is the case of the figures used above and referring to 1911-12) have only the value of samples, and are subject to errors of sampling. Space does not permit me to discuss the evaluation of the error of sampling for a somewhat complex expression such as the partial expectation, but I find it to be of the same order as that of the death rates, and there is little reason to doubt that the kind of difference shown in these few examples is of the order of magnitude of the "true" difference.

THE VALUE OF VACCINES IN THE TREATMENT OF WHOOPING-COUGH.

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THE object of this paper is to record some observations on and the results of vaccine treatment of cases of whooping-cough. The majority were out-patients, a few being in-patients, at the Hospital for Sick Children, Great Ormond Street, during the months of January, February, and March, 1922.

For purposes of age and sex incidence we have included all those cases of whooping-cough which attended the out-patient department of this hospital during the year 1921 and the first 196 cases that attended in 1922, making 1,000 cases in all. The seasonal incidence has been taken from the 804 cases attending during 1921.

CHART 1.—Seasonal incidence, 1921. (Based on 804 cases.)

As will be seen from Chart 1 the seasonal incidence reached its maximum in June, when there were 109 cases, and fell to the minimum in November, when there were 25 cases. The sex incidence shows 530 girls to 470 boys. The age incidence (see Chart 2) shows the maximum at 1 to 2 years, and the vast majority occur before the age of 6 years, or within twelve months of starting school.

Symptoms.

The average duration of the cough before the onset of the whoop in 100 of our cases seen during January, February, and March, 1922, was two weeks. In some cases the whoop started

within a few days of the onset of the cough, but in other cases was delayed as long as three to four weeks.

The onset, duration, and termination of the whoops and vomits were on the average identical. At the onset the

CHART 2.—Age incidence. (Based on 1,000 cases.)

whoops were much more severe and frequent during the night than by day. As the disease declined the whoops became gradually less during the night, and in the later stages of the disease were entirely confined to the day.

In very young children gross wasting as a result of the incessant vomiting was a very serious feature, and was of importance even in the older children. Where vomiting was severe obstinate constipation was a concurrent symptom.

A sublingual ulcer was looked for on at least one occasion in 62 cases; it was present in 11, or 18 per cent. In several it was not present at the first examination early in the disease; it was usually found to develop during the second or third week. In 9 of these cases, or 82 per cent., the age of the children was between 1 and 3 years. The ulcer healed very rapidly; a careful and continuous search would, we have no doubt, reveal this ulcer in a much larger proportion of cases.

Bronchitis is present in the majority of cases. The signs may be scattered rhonchi; and early in the disease, almost at the level of the diaphragm, a girdle of fine crepitations is very frequently heard. In small children massive collapse, dyspnoea, and cyanosis sometimes complicated the clinical picture and gave rise to the diagnosis of bronchopneumonia. These physical signs are, in our opinion, brought about by the thick tenacious secretion present in the bronchi plugging the smaller bronchioles of the most dependent parts of the lungs, thus giving rise to collapse in this area with consequent fine crepitations.

In 4 out of 80 cases the tonsils had been removed. In 18 cases there was injection but no enlargement; 18 others showed moderate enlargement with injection; in the remaining 40 cases, or 50 per cent., the tonsils were grossly enlarged and injected. The injection is, no doubt, secondary to the coughing.

Duration.

The average duration of the disease in our 100 cases, as measured from the onset of the cough to the termination of the whoop or vomit, was six and a half to seven weeks, while the average duration of the whoop was four and a half to five weeks.

Complications.

Epistaxis was a not infrequent complication, and was much commoner in older children, though of minor importance. Bronchopneumonia, on the other hand, occurred in 5 per cent. of 200 cases, but gave rise to grave anxiety, 4 out of our 10 cases proving fatal. Among other complications were subconjunctival haemorrhages and laryngitis; puffiness of the face was not infrequent, and in the more severe cases called for an examination of the urine to exclude nephritis. Pain, referred to the diaphragm, the intercostals, and the abdominal muscles, due to the violent straining and coughing, was frequently complained of by the older children. Convulsions occurred only in association with bronchopneumonia, and the two cases we observed both proved fatal. Post-mortem examination in one of them showed on microscopical examination marked cerebral congestion only.

In 5 to 10 per cent. of our cases a fresh attack of bronchitis caused a recurrence of the whoops.