

THE RELATION OF THE DECLINE IN THE NUMBER OF HORSE-DRAWN VEHICLES, AND CONSEQUENTLY OF THE URBAN BREEDING GROUNDS OF FLIES, TO THE FALL IN THE SUMMER DIARRHOEA DEATH RATE.

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(With 1 Chart.)

CHARTS, illustrating observations over several years, have been published by Hamer (1908-10) for London, by Niven (1910) for Birmingham and by Hope (1920-21) for Liverpool, which show that in the third quarter of the year the summer diarrhoea death curve usually reaches its maximum about a fortnight after the curve representing the numbers of flies caught in traps has reached its highest point.

It has been suggested on the one hand that this relationship is due to the distribution of infection by flies, and on the other that both curves are influenced independently by the rise in the air temperature, which usually precedes them.

Mellanby (1916) suggests that the "child's alimentary canal is capable of being deranged by many causes not necessarily bacterial in their nature. . . . A child suffering from diarrhoea and vomiting owing to loss of fluid, loss of bile salts, with an empty intestine and in a starving condition is in an ideal position for allowing toxic substances normally present in the alimentary canal and mucous membrane to be rapidly absorbed and have their full toxic action. . . . The association of this disease with a high atmospheric temperature in an epidemic form is to be explained largely by the additional loss of fluid due to evaporation of water, whereby the child keeps down its body temperature."

This view affords no explanation of the fact that in some years, for example 1916 and 1919, the death rate in Liverpool reached its maximum five and seven weeks after the respective mean air temperatures had fallen from their maxima, or that in Australia the death curve drops two months before the temperature reaches its highest point (Peters, 1911). Again in Mesopotamia during July and August, the hottest months of the year, "Flies all but disappear. . . . There are two seasons of fly prevalence which correspond fairly closely with the spring and autumn dysentery seasons" (Ledingham, 1920).

Those who support the infection hypothesis consider that each case is connected directly or indirectly with some previous case or carrier. Flies, however important they may be as vectors, cannot be regarded as the sole agents of distribution, since uncleanly habits, direct contact and possibly infected food seem to play some part in the dissemination of the disease.

Unfortunately the causal agent of summer diarrhoea, if it exists, is not definitely known, though in England suspicion attaches to members of the non-lactose-fermenting group, and especially to Morgan's bacillus No. 1.

If a bacillus of the Morgan type is proved ultimately to be the causative agent additional interest will be lent to the observations of Scott (1926), who isolated Morgan's bacillus in pure culture from the bile, liver and spleen of two monkeys (*Cercopithecus patas*) which had died of enteritis, of Lovell (1929), who isolated it from the intestinal contents of two orang-utans (*Simia satyra*) and a squirrel monkey (*Saimiris sciurea*), from the blood and organs of an Abyssinian monkey (*Cercopithecus aethiops*) and of a green-billed toucan (*Rhamphastos dicolorus*), and from the organs of four snakes all of which had succumbed to enteritis in the Zoological Gardens, and also to the work of Wilson (1927), who has shown that this bacillus under conditions he is unable to define, but which are probably associated with the dietary, may spread epidemically and give rise to fatal infection in mice. Lovell found that all his strains killed mice within three days, when inoculated intraperitoneally in 0.5 c.c. doses. The organism could be recovered from the heart's blood. Enteritis was found to be present in 57 of the mammals, 88 of the birds, and 20 of the reptiles which died in the Zoological Gardens, London, during 1925 (Scott, 1926).

Flies are attracted, when opportunity offers, to both human excrement and the faeces of some animals, and it may turn out, if the relationship of Morgan's bacillus to enteritis in animals is demonstrated, that summer diarrhoea is sometimes transmitted from animals to man by the agency of flies.

In towns *Musca domestica* breeds chiefly in horse manure, and if this species has any appreciable influence on the spread of the disease, the diminution in horse-drawn vehicles, and consequently of horse manure, should be accompanied by a diminution in the diarrhoea death rate.

Previous to the outbreak of the war in 1914 comparatively little attention was paid to the possibility of the dissemination of disease by the agency of flies, and great fluctuations in the diarrhoea death rate occurred, usually associated with seasons either suitable or unsuitable for flies. Soon after the declaration of war large numbers of horses were requisitioned for army purposes, and various measures were adopted to limit the breeding of flies in camps. As the war progressed the potentiality of the fly as a vector of disease became widely recognised, and in the war zones extensive measures were taken against flies in all stages of their life-history. The publicity given to these measures influenced the civil population to take a more active interest in the insect, and no doubt some of the recent diminution in the diarrhoea death rate is due to more cleanly habits, including the protection of food from flies and attempts to eliminate their breeding places near dwellings.

Statistics relating to the numbers of horses kept in the larger towns are not available, but the gradual diminution of licences for horse-drawn vehicles suggests that during the last 20 years the numbers of horses have decreased

greatly. Presumably there has been a proportionate decrease in the available food for fly larvae, and consequently of flies.

From 1906 to 1916 the numbers of licences for horse-drawn vehicles decreased by one-third at an approximately uniform rate, but from 1916 to 1921 the numbers remained nearly constant. From 1921 to 1927 the numbers decreased rapidly and uniformly, and in the latter year the number of licences taken out was less than one-quarter of those taken out in 1906.

After 20 years of great fluctuations, during which the diarrhoea death rate for England and Wales seldom fell below 15 and frequently rose above 30 per 1000 births, a steady fall in the rate commenced in 1913, and continued with only one interruption in 1921, a year in which July was "remarkable for heat and drought," to 1922; when the lowest level recorded, namely 6, was reached. In the period 1922-6 the rate remained at a very low level. These years, with the exception of 1926 in which July and August were mainly fine and warm, have been unfavourable for fly activity.

The figures for each year are given in Table I, and shown in graphic form in Chart 1.

A chart for the city of Liverpool, showing the diarrhoea death rate (all ages) per 100,000 population is very similar (Mussen, 1926).

In the period 1906-27 the licences for mechanically-propelled vehicles increased from 67,000 to nearly 2,000,000.

The next hot summer will undoubtedly cause a rise in the death rate, but it is unlikely that it will again reach the high level of 1911.

"The term 'Diarrhoea and Enteritis under 2 years of age' is not the name of a disease, but includes a number of diverse conditions; the majority of deaths so classified, however, perhaps three-quarters of the total, appertain to the acute disease commonly termed 'summer diarrhoea.' . . . The majority of deaths from diarrhoea and enteritis (*i.e.* 79 per cent. of the whole) occur under 1 year of age. About three-quarters of the whole number are artificially fed, and an even larger proportion of the definitely infective cases. Breast feeding is a very real protection against this disease, and no child should, if possible, be weaned between July and October" (Mussen, 1926).

Since the returns on which the rate is calculated undoubtedly include some deaths from diseases other than summer diarrhoea, and since other means of distribution exist, the eradication of flies would not be likely to reduce the rate to zero, but might bring it down to a very low level.

At the present time, though much has been done to reduce their breeding places in the larger towns, flies are still too numerous, especially in the smaller towns and villages. Too often manure and garbage are stored or disposed of in such a manner that flies have every opportunity of breeding in them. Burial of garbage, far from destroying the larvae, protects both larvae and pupae from their enemies, and therefore increases the numbers of flies.

If the simple, inexpensive and fool-proof method, devised by Baber (1925), and now extensively used in South Africa, of destroying larvae in manure,

Table I. *Showing the number of motor and horse-drawn vehicles licensed, and the summer diarrhoea death rate in each year from 1906 to 1927.*

Year	Motor vehicles	Horse-drawn vehicles	Diarrhoea deaths	Weather in the third quarter of each year
1906	67,115	411,334	31	July, first 3 weeks dry; Aug. 25-Sept. 12, no rain fell
1907	76,149	402,307	13	"In June, July and August 'maxima' below 60° were experienced very generally"
1908	83,803	389,904	20	"Between July 17th and August 19th many places had 15 or more consecutive rainless days"
1909	89,411	391,994	13	"June and July were notable for their deficiency of sunshine.... In the first 18 days of August there was a rainless fortnight over Southern England"
1910	124,479	382,099	13	"One of the principal features of the year was the exceptional dullness of July." August, thunder-storms common. "September was a record month for dryness"
1911	—	—	36	"A long succession of rainless spells marked this year." July and August very hot and dry
1912	161,973	360,208	8	"Cool in summer.... Sunshine very feeble and scanty"
1913	208,314	341,268	19	"Summer very dry, but neither sunny nor warm.... In June, July and August many districts reported long dry or partially dry periods"
1914	263,221	324,677	17	"August was extremely dry over a large area in the South-East of England." Early September dry
1915	288,238	280,694	15	July was wet; August 14-28 "partial drought over a large part of the kingdom." Early September dry
1916	306,865	264,774	11	Early July, "heavy downpours plentiful.... Many places had practically no rain between July 10 and August 10." Later "rain came in heavy falls"
1917	237,762	252,290	10	June and most July fine. "A very wet period began before the end of the month and lasted through August"
1918	156,569	262,812	10	July, sunny. August, "as a whole warm and dry." September temperature "much below the normal"
1919	235,540	248,896	9	July, "dull." August, "sunshine abundant." September, "fine, dry and quiet"
1920	483,784	261,140	8	"A dull year.... July was dull, wet and cool.... August was characterised by dull, cool weather"
1921	873,665	269,200	14	June, "dry." July, "remarkable for heat and drought.... Generally unsettled throughout August." September, warm
1922	979,000	237,342	6	"Hot spell in May and continued low temperature from June to November"
1923	1,411,400	215,083	7	July, "fine and sunny." August, first fortnight warm, later cool and wet. September, first ten days fine and sunny, later "unsettled and cool"
1924	1,335,600	181,416	6	July, noted for "general heavy rains." August, "mainly cool and unsettled"
1925	1,547,000	153,487	7	July, "sunshine deficient.... August was mainly dull and unsettled.... September was a cold and windy month"
1926	1,729,000	127,248	8	July, "mainly fair, dry and warm." August, "on the whole fine and warm and relatively dry"
1927	1,898,000	103,857	—	

The figures for "motor vehicles" and for "horse-drawn vehicles" represent the total numbers of vehicles licensed in Great Britain as shown up to 1920 in the Reports of the Commissioners of Customs and Excise and from 1921 in the Reports on the Administration of the Road Fund. The figures for "diarrhoea deaths," representing the annual deaths from diarrhoeal diseases of infants under one year of age per 1000 births in England and Wales, together with the remarks on the weather prevailing during the third quarter of each year were obtained from the Annual Reports of the Registrar-General.

without impairing its agricultural value, and also in such garbage as is not incinerated was strictly enforced throughout the country the numbers of house-flies would be very greatly diminished.

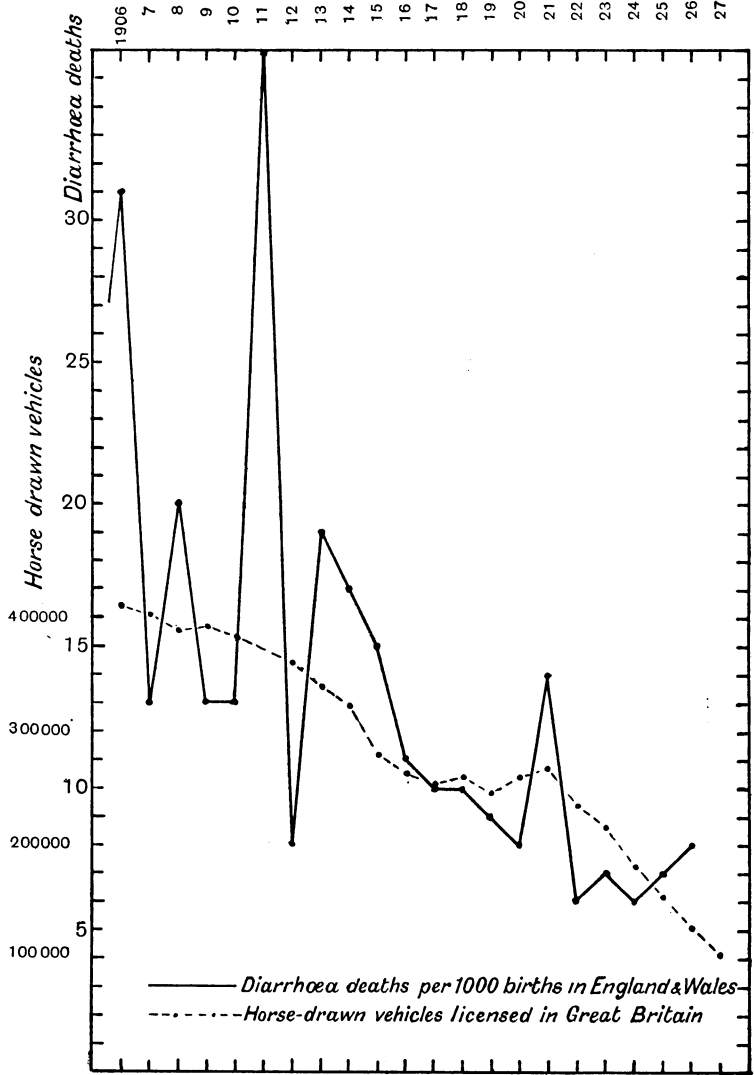


Chart 1. Showing the number of horse-drawn vehicles licensed and the summer diarrhoea death rate in each year from 1906 to 1927.

Even the rigid enforcement of such a measure over a period of years in a well-chosen area, of sufficient extent to eliminate the influx of flies by immigration, in conjunction with records of the numbers of flies caught in traps and of the diarrhoea deaths would be of great assistance in determining the influence of flies.

In another way the influence of flies on the spread of this disease within restricted areas has been demonstrated in Liverpool. "For a number of years, wherever an excessive prevalence of flies is reported, this is referred to the sanitary department for investigation. Excessive prevalence of flies coincides with outbreak of diarrhoea in epidemic form, as has been repeatedly shown in former reports of the Medical Officer. It was noticed in this investigation that excessive prevalence of flies was reported in Exchange district three weeks before it was reported in the rest of the city, and this corresponds to the earlier appearance of the disease in epidemic form in Exchange district and to the greater extent of the epidemic wave" (Mussen, 1926).

In rural districts modifications, suitable for the districts concerned, of Allnutt's (1926) method of trapping flies reared in human excrement would be beneficial.

CONCLUSIONS.

During the last 20 years the numbers of horses kept in the larger towns has decreased, probably by three-fourths, and consequently there has been a great decrease in the available breeding places for *Musca domestica*.

Except in the hot year 1921, the summer diarrhoea death rate in England and Wales fell steadily from 1913 to 1922, when it reached the lowest level recorded. It has since remained at or near this low level.

It is suggested that the decrease in the numbers of flies together with the effect of a more widespread knowledge of their capacity for distributing disease have been responsible to a considerable extent for the reduction in the death rate.

By the rigid enforcement of a simple and inexpensive method such as that devised by Baber (1925) of destroying larvae in manure, which does not impair its agricultural value, and also in such garbage as is not incinerated, the numbers of flies in towns could be reduced immediately to a very low level.

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