WHILE many of the great problems of epidemiology may be said to be still unsolved, much has been done recently to bring them nearer solution. Contagia have been traced to their habitats outside the body; the conditions and surroundings under which the organs proliferate have been ascertained; the changes through which they pass, when conditions vary, have been followed up, and many factors inimical to their growth have been discovered. A complete and satisfactory explanation of all the peculiar variations seen in infectious diseases, and in their spread, is still remote, but the present results have shown the paths we must rely on to conduct us to a successful issue.

The position is bristling with difficulties, as, to mention only a few factors with which we have to contend: variations in temperature, air supply, light, food, etc., each exercises such a marked effect on the ultimate result, that the compilation of the results of all these acting together seems, at present, almost impossible.

In enteric fever we have a disease which is recognised by all writers on the subject as peculiarly one in which the infection is water-borne. Occasionally one meets with an example of enteric being spread by direct personal contact, but these instances are rare.

The relation between the excreta of enteric fever patients and the spread of the disease has also long been recognised, and more recently it was discovered that the urine might also transmit the infection. It has only quite recently been shown that in a limited proportion of persons recovered from the disease, the bacillus may maintain a prolonged existence. These cases are apparently those in which complications in connection with the gall-bladder have occurred, and seem to be most commonly met with in females. Assuming that the organism gets installed in the gall-bladder, on being voided by the bowel, these patients become capable from time to time of transmitting the disease to others.

Such a carrier case would appear to have been the cause of an epidemic of enteric fever, amounting to 126 cases, which recently occurred
in Glasgow and neighbourhood, and a resumé of this epidemic would probably serve as an excellent introduction to a discussion on the subject of carrier cases, while at the same time it would illustrate the difficulties which have to be surmounted in dealing successfully with an epidemic.

Before dealing with this epidemic in detail, however, it may be advisable to mention here another class of infective person occasionally met with. I refer to those fortunately rare instances where a patient, after recovery from an attack of enteric fever, continues for a time to shed typhoid bacilli in his urine or faeces. An example of such a case came under notice as these notes were being prepared, and the particulars have been appended as having some bearing on the subject under review. This latter, or "physiological" carrier must be carefully distinguished from the "pathological" carrier who, as mentioned above, is only occasionally infective.

The following particulars are summarised from the report on this outbreak by Dr. Chalmers, Medical Officer of Health:

**The Cases as Notified.**

The first notification was received on December 17th, two others followed on the 18th and 19th, and again on the 23rd and 27th two more were received. At this point an interval of six days occurred, but on January 3rd a series began which was practically unbroken until the outbreak ceased.

The interval is important. It separates the notification of five cases irregularly distributed over eleven days from a series of others which present the true characters of a milk-borne epidemic, in the rapid increase in the numbers notified daily and in the numbers sickening simultaneously.

The significance of this interval will be better appreciated when considered in the light of the dates of sickening of the cases notified before and after it occurred.

**The Dates of Sickening.**

The five cases notified during December sickened between the 8th and 14th of the month. One case had already occurred among the Partick consumers on December 5th, and another sickened on the same day as the first two Glasgow cases. In the early part of December the sicknesses were infrequent and irregular, and it was only after the close of the week ending 21st that they began to be of daily occurrence. Indeed, the mass of infection represented by the sicknesses which occurred after this date and reached their maximum daily number towards the middle of the fortnight.
ending January 11th, was in striking contrast with the irregular distribution of those sickening early in December.

It suggests two distinct waves of infection, and subsequent inquiry showed not only that this would appear to have occurred, but that the source of each was fairly distinguishable.

**The Number of Persons Attacked.**

Excluding four cases which were secondary to others occurring at an earlier date in a corresponding number of households, 92 cases were registered as occurring in 79 households of consumers in Glasgow, there being 10 households in which multiple primary infections, 23 in number, occurred.

Among the Partick consumers Dr. Brown reported that 21 cases had occurred, and I had information regarding 13 others who only sickened after leaving Glasgow. In 8 of these 126 cases the attack proved fatal.

The number of consumers of this milk in the 500 households receiving it is not known, but the number of inmates therein may be put at not less than 2,500, and on this basis the attack-rate lies between 4 and 5 per cent., while the case fatality-rate has been equal to 5.5 per cent.

**The Sources of the Milk Supply.**

The milk distributed from Flemington Farm was received from five other farms, and the quantities from each were as follows:—K. (Paisley), 70 gals.; S. (Annie'sland), 60 gals.; A. (Balfron), 70 gals.; G. (Beith), 20 gals.; Parkhouse, 40 gals.

A sixth farm had ceased sending milk on December 5th. As the milk from Balfron and Beith arrived too late for the morning's delivery of the day of arrival it was sterilised. The milk of the three remaining farms, K., S., and Parkhouse, was not sterilised before the morning delivery, and whether any of it was ultimately so treated depended on the daily fluctuation in the demand. The channels by which the milk from these several sources reached the consumers will emerge in considering the order in which the several deliveries became implicated.

**The Incidence of Attacks on the Several Deliveries from Flemington.**

All the cases notified between December 17th and January 6th obtained their milk from cart D. Our information at this time was that the morning milk of this cart had been obtained from the Annie'sland Farm prior to 29th November, and from the Paisley Farm thereafter. The first sickening, however, occurred in Partick on the sixth, and three others,
including two in Glasgow, on the ninth day after this change had taken place, and as the duration of the incubation period of the disease is, in the majority of cases, about fourteen days, it was provisionally regarded as unlikely that the Paisley farm milk was the source of infection. This opinion was ultimately established by a report from the Medical Officer of Renfrewshire that no illness was present there.

The Anniesland farm milk, at the beginning of the inquiry, was being distributed partly in the district of Temple and partly in Hillhead and neighbourhood.

The portion delivered in Temple was sent direct from the Anniesland farm, whereas that which was delivered in Hillhead was taken, in the first place, to Flemington Farm, and thereafter sent out in carts other than cart D. In neither of these sections of its distribution was there evidence of infection.

But when it became apparent early in January that sicknesses were also occurring among the customers of the other carts the information first given was corrected, and we were told that the portion of the Anniesland farm milk distributed by cart D. prior to November 29th was frequently supplemented by milk from Parkhouse. This is more fully described hereafter.

It was possible, of course, that the portion of the Anniesland milk distributed by cart D. prior to November 29th had become exposed to contamination only after reaching Flemington Farm, but the early enquiries definitely excluded from suspicion both the family and resident employees at Flemington Farm, as well as the driver of the cart and the boys who accompanied it as carriers.

On January 6th and 7th, however, two sickenings were notified among the customers of cart McG., on January 9th one was notified on cart McA., and on January 11th two were notified on the service of the boy carrier from the farm, and one on the Hydepark portion of the supply.

And if, instead of the dates of notification, we take those of sickening, it will be seen that, while cases began to occur among the customers of cart D. as early as December 5th and 8th, none occurred among the customers of the other delivery services until December 19th, 23rd, 25th, and 30th respectively.

It thus became important to discover whether any antecedent change had occurred in the distribution from Flemington Farm which would explain the extension of infection from cart D. to the other deliveries, which the notifications received between January 6th and 11th disclosed.
For this purpose it is necessary to revert to the information first obtained regarding the farm from which cart D. obtained the milk for its morning delivery.

As already stated, this was said to have been from the Anniesland Farm prior to November 29th, and this in a sense expressed the general practice. But when revised, in view of the attacks occurring among the customers of the other carts, it was ascertained that the Anniesland milk fell short of the quantity required for cart D.'s morning delivery about three times out of seven, and was on these occasions supplemented by milk from Parkhouse Farm in quantities varying from 8 to 10 gallons out of a total of about 40 gallons obtained from this source.

Moreover, as it was the object of the purveyor to supply as much non-sterilised as was available for the delivery of cart D., the remaining quantity of Parkhouse milk was, by preference, reserved for the mid-day delivery of this particular cart, until the introduction of Paisley milk, on November 9th, set free Parkhouse milk for distribution also by the other carts in their morning deliveries.

Indeed, until after November 29th, the other carts, in these morning deliveries, mostly delivered sterilised milk from the other farms.

On the hypothesis, therefore, that the Parkhouse milk was the vehicle of infection, the limitation of the attacks to the customers of cart D. at the beginning of the outbreak, and the ultimate implication of all the delivering channels would have reasonable explanation.

**Relation of the Parkhouse Illness to the Outbreak in Glasgow.**

We have now to consider the relationship of this case at Parkhouse to the outbreak in Glasgow, and particularly to the two waves of infection which have been suggested. The patient at Parkhouse remained unrecognised as suffering from any infectious disease from December 7th to the 24th, and it is reasonable to associate her illness with the true epidemic incidence in Glasgow, which culminated towards the middle of the fortnight ending January 11th. But it will not explain those prior to December 14th, and would only explain those sickening on December 19th and 20th by assuming the coincidence of an unusually early accession of infectivity in the Parkhouse patient, and an unusually short period of incubation in the four cases then sickening. But with regard to attacks which developed after the week ending 21st December there is no difficulty, and the illness at the farm may be regarded as
sufficient to explain those occurring among the consumers after this date.
But the Parkhouse patient is apparently one of the earlier group of
sicknesses which began on the 5th December, and cannot, therefore, have
been the source of infection of the other members of this group.

Coincident but independent sources of infection for herself and the
others might, of course, be suggested, but it is more important to consider
whether evidence exists to support the suggestion that she sickened
because she was herself a consumer of milk distributed from Flemington
Farm.

That she was in this sense an occasional consumer seems likely, from
the circumstance that it was part of her brother's morning work, on his
return journey from Flemington, after delivering his milk there, to take
about ten gallons to the Hydepark Locomotive Works Cooking Depot,
and any occasional surplus not required at the Depot was taken on to
Parkhouse by him, and there consumed.

If, then, the Parkhouse illness could be ascribed to this returning
stream, the larger quantity delivered at Hydepark Works would be likely
also to have produced somewhat similar results. And while it is true that
cases did ultimately develop among the consumers at Hydepark, the first
sickness there began only on the 30th December, or fully three weeks
later than the Parkhouse illness. In other words, the Hydepark cases
belong to the later epidemic wave, and not to that which began on the
5th December.

And, as matter of fact, it was only after unsterilised milk from Park-
house began to be occasionally delivered to Hydepark that cases developed
among the consumers there, and this date can be definitely fixed as not
earlier than December 5th, and may have been some days later.

The Position of the Parkhouse Illness among the First
Group of Cases.

Although occurring contemporaneously with the early sickenings
among the Partick and Glasgow customers of Flemington Farm, it may
be suggested that the patient at Parkhouse was infected from a different
source. This seems scarcely tenable, in view of the fact that the others
were on a common milk supply, that this was occasionally at least obtained
from Parkhouse Farm, and that the farmer's family there used their own
milk. Infecting material at the farm gaining access to this milk before it
was despatched to Flemington would explain both the Parkhouse case and
the others. But of the source of this the evidence was not immediately
forthcoming.
REPORT BY DR. BUCHANAN, BACTERIOLOGIST.

"On making inquiries at this farm, attention was attracted to a milker, a young man, who had suffered from an obscure illness consistent with enteric fever about three years ago, and who had some possible association, on more than one occasion during 1907, with enteric fever outbreaks. It was found, however, that any suspicion attaching to this milker was soon set aside by the bacteriological tests, which entirely failed to substantiate it. Subsequently it was discovered in the course of investigations at the farm that another milker, an elderly woman, had a history of previous associations with enteric fever which attached suspicion to her with still more probability as a source of the infection which had contaminated the milk.

This milker suffered from enteric fever, along with most of her family, sixteen years ago, and had now and again since that time been associated more or less closely with outbreaks of illness which proved to be enteric fever. She was taken into Lightburn Hospital for a few days in order that reliable specimens of the dejecta and urine might be obtained for bacteriological examination. Dr. Wilson very kindly afforded every facility for a thorough investigation by supplying as many specimens as were required for the bacteriological tests. These tests have resulted in the discovery of the bacillus of enteric fever in the dejecta, and in establishing the existence of a source of infection which, doubtless, directly accounted for the early cases of the outbreak, and indirectly gave rise to the epidemic wave. The bacillus did not appear in great number in the dejecta, a rough estimation computing it at 5,000 per cubic centimetre. Her blood gave a positive Widal reaction with the laboratory strain of *Bacillus typhosus*.

It may be observed that bacteriological research has revealed the fact that persons passing through an attack of enteric fever, as a rule, give off the infection (the *Bacillus typhosus*) by the intestine, and frequently also by the urine, during some stage of the illness. The bacillus may appear in the stools as early as the first day of illness, although the largest percentage of cases yield it in the second and third weeks of the disease. It may continue to be shed throughout convalescence in a certain proportion of patients; while in a small residuum of cases, probably about two per cent., the germ takes up a lodgment in the body, and continues to be excreted for months or years, or, it may be, throughout life. These chronic typhoid carriers are a discovery mainly of the last two years. They have been found at periods ranging from ten weeks to forty-two years after the attack of the fever. Moreover, several instances are
recorded of persons acting as carriers of the infection in this way, although they never had any clinical manifestation of the disease, or had no recollection themselves of being ill. It is to be remembered, however, that enteric fever is often very slight or obscure in its manifestations, and has sometimes been regarded as influenza, pneumonia, bronchitis, rheumatism, meningitis, or neurasthenia. Amongst chronic typhoid carriers, women form by far the largest proportion (about 75 per cent.) The bacillus in these exceptional carrier cases finds a lodgment in the gall-bladder, from which it passes to the intestine, to be voided with the intestinal dejecta.

This persistence of the Bacillus typhosus in certain persons for so many years after an attack of enteric fever is a matter of great importance from a public health point of view; for such persons, acting as unsuspecting and unsuspected carriers of infection, communicate the disease to others.

During the present fortnight a return case occurred in connection with the dismissal from hospital of an enteric fever patient, and the facts are interesting as illustrating the method by which infection may be conveyed.

On May 6th a male patient was dismissed from Belvidere Hospital recovered from enteric fever, for which he had been under treatment from March 13th. His household consisted of his wife and two children, and on June 13th the wife sickened of enteric fever, for which she has since been removed to hospital. The circumstances led to a bacteriological examination of the excreta, with the result that the organism was recovered from the urine.

The possibility of infection by this means has for some years been recognised, but it happens only rarely that a concrete illustration is obtained, and it has been thought desirable to draw attention to the case. This instance is also instructive from the point of view that the carrier was a male, and not a female, as is usually the case.

[For Discussion on this paper, see page 595.]