Section of Epidemiology and Preventive Medicine

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DISCUSSION ON THE EPIDEMIOLOGY AND TREATMENT OF SALMONELLA INFECTIONS IN MAN AND ANIMALS WITH SPECIAL REFERENCE TO *SALM. DUBLIN*

Dr. Joan Taylor [*Abstract*]:

Salmonella infections in man are still very common, the number reported having increased in recent years. This increase is partly the result of improved methods of collecting reports and partly a true increase. Excluding the enteric organisms, *Salm. typhimurium* is the most common, being responsible for almost 75% of the 5,094 cases which occurred during 1949–51.

In the same period 92% of cases were due to endogenous types, those recognized in this country before 1939. The endogenous type *Salm. dublin* was responsible for comparatively few cases, about 2%. Irrespective of the type of infecting organism, the total number of patients in epidemics always exceeds the number of sporadic cases. An analysis of patients' clinical histories in relation to the type of infecting organism was made to determine whether there was any indication that some types caused a more serious disease (Table I).

TABLE I.—SEVERITY OF INFECTION (LENGTH OF ILLNESS)—1949, 1950, 1951

Cultures, Total No.	*S. enteritidis* 310		*S. thompson* 272		*S. dublin* 102		*S. newport* 197		Salmonellæ (exogenous) 154	
Duration of illness	No.	%	No.	%	No.	%	No.	%	No.	%
Nil	18	5·8	19	7·0	13	12·7	23	11·7	22	*14·3*
Up to 3 days	25	8·1	22	8·1	9	8·8	11	5·6	10	6·5
4–7 days	30	*9·7*	46	*16·9*	11	10·8	23	*11·7*	15	9·7
7–14 days	28	9·0	24	8·8	9	8·8	17	8·6	14	9·1
Over 14 days	14	4·5	24	8·8	18	*17·7*	18	9·1	9	5·8
Fatal cases Primary	5	1·6	3	1·1	4	*3·9*	5	2·5	1	0·6
Fatal cases Secondary	6	1·9	2	0·8	6	*5·9*	2	1·0	3	2·0
No information	184	59·4	132	48·5	32	31·4	98	49·8	80	52·0

Salm. dublin infection appears to cause a longer period of illness and a higher proportion of fatal cases than do the other organisms. It is also not uncommon to isolate this organism from blood culture and from sites suggestive of spread via the blood stream.

Dr. R. Lovell: A few salmonella are pathogenic for man alone; some are pathogenic for animals alone, but most are pathogenic for man and animals and, in this group, it is difficult to find an association between a specific type and the animal species which constitutes its reservoir. *Salm. typhimurium* and *Salm. enteritidis* are catholic types and cause a large number of the cases of human food poisoning, whereas *Salm. dublin* is associated with cattle and, at the moment, *Salm. thompson* is associated with poultry. Surveys of the type and incidence of salmonella in the different animal species are made from time to time; it is hoped thereby to reveal a picture, not only of the incidence, but of a possible pattern of the reservoirs of the different types. The pattern may exist but is obscured by the different results which are obtained, according to the geographical area and the time of year the survey is made. The frequency of actual infections, and the results obtained in surveys, may also vary according to the presence of other diseases.

It is not safe to argue from one area to another for what is true in one may be false in another. The greatest reservoir of salmonella infection in U.S.A. in 1939 was poultry; this was not true in U.K. at that time.

In 1949 salmonella were recovered from the fæces of 1% of dogs examined in London (Cruickshank and Smith, 1949) whilst in Florida in 1952 there was a different picture. Salmonella were recovered from 15% of rectal swabs of normal dogs, from 17·9% of those in kennels, from 36·5% of greyhounds and from 87·78% of greyhounds undergoing treatment. There were 52 different serological types and many of them were also found in man. The infection was often multiple and of short duration and each greyhound had an average of three infections per month (Galton *et al.*, 1952; Stucker *et al.*, 1952).

The high frequency of infection of cattle in Wales with *Salm. dublin* is not found in other areas in U.K. In S. and W. Wales 10% of 2,552 samples of bile from cattle yielded salmonella, most of them *Salm. dublin* (Field, 1948).

The importance of concurrent infections in a given animal species is also frequently overlooked in the appraisal of the incidence of infections and of the carrier state. History teaches us that two virus diseases, swine fever and psittacosis, were at one time thought to be due to salmonella. *Salm. choleræ suis* and other types participate in the former disease and *Salm. typhimurium* has been recovered from parrots in the latter. The high mortality in relapsing fever of man in S.E. Russian areas some years before the war was associated with a concomitant infection with *Salm. paratyphi C*. A similar position confronted Giglioli (1930) when he investigated the highly fatal cases of "quinine-resistant malaria" amongst the personnel of the sugar plantations in British Guiana; *Salm. paratyphi C* was isolated from the blood of 72 of 77 patients examined. Smith and Buxton (1950) were unable to find salmonella more frequently in rectal swabs from dogs ill with distemper or hardpad, than in swabs from healthy ones; both surveys were made on dogs in the London area but salmonella was at one time frequently recovered from the tissues of dogs dead from distemper. Evidence from East Africa and South Africa has been presented showing that calves with piroplasmosis and anaplasmosis are more prone to infection with *Salm. dublin* and suffer more severely than those with one infection alone (Daubney, 1927; Henning, 1939).

The pattern of the range of host susceptibility of any given salmonella is subject to considerable change and these changes may frequently be caused by variations in diet. The high carrier rate in dogs in Florida is probably associated with the particular diet and the different types of salmonella recovered from our pigs and poultry to-day were influenced by the imported wartime diets, camp-swill and kitchen waste. If the paths of infection in salmonella food-poisoning are to be revealed then we must accept a changing pattern of host-specificity. In any enquiry therefore some consideration must be given not only to the type of salmonella involved but to those factors which may have caused a change in the pattern of host reservoir.

Few of the food-poisoning ones appear to be relatively stable in this respect and *Salm. dublin* is one in which there is an apparently limited host range. Smith and Scott (1930) demonstrated its association with calves and cow's milk; it was soon realized to be the cause of a specific calf dysentery which is known in this country, in India, and E. and S. Africa and on the European continent. Calves from one week upwards in age may be affected with a septicæmia, a hæmorrhagic enteritis and a bronchopneumonia; necrotic foci are found in the liver and kidneys. In Africa, protozoan infections, which in themselves are mild, may predispose to the disease and increase the mortality which is very variable. The acute form is rare in adult cattle except in Wales where animals of 2–6 years old are commonly affected. Such occurrences on a farm should excite suspicion as to the possible danger to man especially from milk prepared for human consumption. The dangerous animal is the symptomless and apparently healthy carrier cow, which may have no history of illness, or may have recovered from a prolonged attack. Information of such an animal may come first from the victims of food-poisoning and in 1936 an outbreak of this nature occurred in Wiltshire (Conybeare and Thornton, 1938). About 100 children were involved and the common factor was milk and *Salm. dublin* was recovered from the milk. The sera of all the cows in the suspected herd were examined for agglutinins against *Salm. dublin*; 3 of the 51 cows examined were selected for other examinations as they possessed higher levels of agglutinins. *Salm. dublin* was isolated from the fæces of one of them and this carrier cow appeared quite healthy. The reasoning for this method of approach was based on facts which are valid to-day.

(1) Normal healthy livestock possess in their sera agglutinins against many salmonella antigens; the techniques of workers vary and it is not easy or practicable to state categorically a critical titre which may be accepted as evidence of infection. It is therefore better to examine samples of blood from all the animals in the herd, and some from other herds may be included; any abnormal titres can be detected easily against this background. The labour involved is not great and most practising veterinary surgeons are expert at collecting samples of blood from many cows in a surprisingly short time.

(2) The direct examination of fæces and milk for salmonella of all the cows in a large herd is laborious and no simple screening method is sufficiently reliable to be adequate.

In this type of outbreak the milk usually becomes contaminated with infected fæces although the milk itself may be infected in acute cases. *Salm. dublin* multiplies readily in fresh raw milk stored at 15° C. and rapid multiplication also occurs in commercial grades of raw and heat-treated milk.

Pullinger and Kemp (1938) showed that strains of typhoid bacilli recently isolated from man multiplied much more rapidly in milk than did stock laboratory cultures: it may be that a variation in the rapidity of multiplication occurs with strains of other salmonella.

The elucidation of outbreaks of food-poisoning is essentially a medical problem but I suggest that such problems might yield their solution more readily if approached as detached biological problems. The pig, the cow and the sheep should be viewed as equal in importance with man and aid sought from the farming and veterinary services.

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Dr. A. M. McCall: *Salmonella infections in Somerset.*—Since 1947 there have been 14 outbreaks in Somerset due to *Salm. dublin*; 10 were bovine, 3 concerned humans and 1 was a serious outbreak among foxhounds. In addition there were 2 cases of septicæmia, 1 of which proved fatal. Of the human outbreaks 2 occurred in 1947 at Bishopsworth, Bristol, where there were 30 known cases and another at Wadeford, near Chard, where there were 29 cases. The largest outbreak occurred in 1952 in Chard and district where there were more than 600 known cases. I shall describe only the 1952 outbreak and its possible connexion with the 1947 outbreak at Wadeford.

One Friday morning at the end of September a teacher in a large school telephoned to say that there were about 100 absentees and several of the children in school were complaining of sickness and diarrhœa. I contacted general practitioners immediately, informing them of the outbreak and asking for their co-operation in sending specimens of vomit or fæces to the Public Health Laboratory, which had been warned. All schools in the area which were on the telephone were contacted and some had a number of children absent. These schools were asked to make a rapid analysis of the absentees under the following headings:

Of the number absent, those that took milk and/or dinner, those that took neither. These reports were then collected and suspicion fell upon the milk supply. Being the School Medical Officer in the area, I knew the source of the supply of school dinners and milk with the exception of two private schools, and I and my Sanitary Inspector then proceeded to follow up the milk. The dairy from which it was distributed was inspected. All employees had been well and the plant, though aged, was in good working condition and clean. It was found that the bulked milk from their farm arrived in the late afternoon, was bottled and then refrigerated overnight and left about 7.30 next morning for the various schools and for public distribution. All the milk came from one T.T. herd. We next went to the farm which was large and well conducted. The stock-yard and milking sheds were concreted and electric milking machines were used. All the employees were well and all the herd were in good shape. However, on further enquiry we discovered that one cow, Ladybird, had been removed three days previously with mastitis and was being treated in a separate building. I immediately contacted the veterinary surgeon and he re-examined the cow and stated that he now thought that it could be suffering from a salmonella infection. Samples of Ladybird's milk and fæces were sent immediately to the laboratory by road; general practitioners were informed of the possibility that the upset was due to a salmonella and all the milk was ordered to be pasteurized. The milk supply from this herd was ordered to be heat treated forthwith. By the next morning the laboratory were able to tell us they had recovered *Salm. dublin* from a sample of fæces from 2 patients and also from Ladybird's milk. All the general practitioners were again contacted and informed of the laboratory's findings and the sensitivity of this strain of salmonella to chloramphenicol was mentioned. Although there was no fear of further primary cases from this source, the possibility of secondarily infected cases was borne in mind and a letter was sent to all the schools emphasizing the importance of personal hygiene and cleanliness of the cloakrooms, and the general public was similarly advised.

Symptoms.—The order in which the symptoms presented themselves varied but all had nausea frequently followed by vomiting. Some who did not vomit had severe abdominal pain and later diarrhœa occurred in nearly every case. A fairly common and marked symptom in the early stages was very severe headache, mainly frontal, and some giddiness; very marked pallor was a striking sign. Temperatures varied from 99·5 to as high as 105 but the majority were between 100 and 102° F. Most cases recovered in three to four days. There were no deaths. Incubation varied from four to forty-eight hours but the majority were affected between twenty-four and thirty hours after taking the milk.

TABLE I

Name of school	No. on roll	No. of children taking milk	No. of children ill	No. of school days lost	Adults affected
Buckland St. Mary	43	42	28	90	—
Chaffcombe	32	32	11	31	—
Chard Infants	135	134	43	75½	—
Chard Junior	304	240	127	243	—
Chard Grammar (Boys) ..	118	118	34	53	2
Chard Secondary Modern ..	357	133	95	229	3
Combe St. Nicholas	71	50	43	72	—
Otterford	26	26	14	14½	—
St. Gilda's Convent	210	192	82	195	3
Tatworth..	99	91	84	188	1
Wambrook	17	14	14	29½	—
Whitestaunton	24	22	16	35½	—
School total	1,436	1,094	591	1,256	9
Notifications other than above			7	10	3
Total number affected	1,436	1,094	598	1,266	12

Distribution.—Some of the children affected did not take school milk but were found to have a similar supply at home or put it on a rather stodgy milk pudding supplied at the midday meal. No obvious difference in susceptibility could be noticed and there was no sex difference. Fewer older children were ill but this is accounted for by the fact that while the percentage of milk drinkers is about 90% among young children, it is only 50% in older children. The small number of adults is accounted for by the fact that few went to their doctors and the exact number is unknown.

Bacteriology.—All specimens of fæces obtained from persons suffering from symptoms of food poisoning were found to contain *Salm. dublin.* The Salmonella Reference Laboratory confirmed the identification.

Having isolated *Salm. dublin* from the milk of Ladybird it was important to discover how she had become infected. She had calved four days previously and her calf had been put on the herd nursing cow after two days. Specimens from all farm hands were negative. However, it was discovered that one of the milkers who had helped at the calving but who was on holiday during the week of the outbreak, had been infected in a similar outbreak due to the same organism on an adjacent farm in 1947. Repeated fæcal samples showed "nil pathogenic"; his blood reports suggested a past rather than a recent infection. This he was known to have had. In addition his medical practitioner discovered from his records that in September 1950 he was off work for thirteen days with a P.U.O. There was no investigation at that time but his symptoms could have fitted in with a salmonella infection. He did not respond to penicillin treatment and recovered slowly. In spite of the negative findings this man must remain under suspicion.

We looked for a link between this outbreak and the previous one, and first the possibility of a common contaminated water supply was investigated. "Moore" swabs were inserted in the water supply of both farms and all near-by streams and drains. None was positive. The remainder of the herd were examined by the Regional Veterinary Investigation Centre; milk and fæcal samples were all negative. No blood samples were taken. Ladybird's calf was found to be positive although clinically quite well. Subsequently a heifer and two cows developed symptoms and these either died or were slaughtered. The calf was treated and appeared to recover. It may be of significance that all animals affected appeared to acquire the disease in one field used annually for the local Agricultural Show and the possibility of infection persisting at the site of the latrines was considered but a few bacteriological examinations of the soil were unproductive. Another feature of this field may be of more importance: Alone of all those in use on this farm it depends for drinking water upon a brook, the River Ile at Eleighwater, which rises some two miles away and flows from the neighbourhood of the farm which was the source of the same milk-borne outbreak in 1947.

Carriers.—In one boarding school where 29 boys were affected, fæcal samples were taken from them all a month later. None was positive. It was expected that a certain number of secondary cases might occur due to healthy carriers in the day schools and in an effort to detect these "Moore" swabs were inserted in all the drains five weeks after the original outbreak. None was positive. Only one person was known to be still unfit at this time and she finally returned to work symptom-free on December 1. Three consecutive stools were free from *Salm. dublin.*

Schools.—The most serious effects of the outbreak were felt by the school population. Assuming children work a five-day week for forty weeks, it is equivalent to the loss of six years' schooling. If a week-end had not intervened it might have been necessary to close a number of schools.

Pasteurization.—Immediately following the outbreak there was a considerable falling off in the number of children taking milk but the number is slowly increasing and now is only 64 less than before

the supply was pasteurized. The fall is entirely due to parents stating they do not wish their children to take milk and there has not been one complaint by the children about the taste, &c., of the heat-treated milk.

Discussion.—In the various outbreaks in Somerset, particularly those among bovines, it has been noticed how frequently infected milk has failed to cause human infections. A possible reason is that the dose is insufficient where the milk is drunk fresh as usually occurs on a farm. However, it has also been noted, as in the outbreak described, that only one cow need be infected to cause a very large outbreak. Quite often we have found that a particular cow is not clinically ill at first although she may subsequently show all the signs of infection. Calves appear to be much more frequently infected than cows and presumably are more susceptible. At this stage they are of little danger to the public. There is probably much more infection among herds than is realized and it may be that the cows become infected, show no signs and then develop immunity. Whether this is the reason why on occasion only one cow in a herd is found to be infected, I do not know. The Regional Veterinary Investigation Department at Langford have found that antibodies in the blood were unreliable evidence of present infection or carrier state and this may be due to the fact that particular animals have been infected in the past. Field (1948) has shown that water-borne infection is frequent in cows. In Somerset, where recent emphasis has been on piped drinking water for cattle, this risk has probably been masked.

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DISCUSSION ON THE EPIDEMIOLOGY OF ACCIDENTS

Dr. W. P. D. Logan, General Register Office: *Fatal Accidents*

In his memorable Address to this Section in May 1952 our President, Professor Robert Cruickshank, reminded us that the basis of all epidemiological enquiry is the vital statistics analysed by the Registrar-General. With these encouraging words in mind I have approached the preparation of this paper somewhat experimentally, the experiment being to find out how far the routine annual statistical publications of the General Register Office assist in the epidemiological analysis of causes of death. To this end I put myself into the position of the ordinary user of these publications, that is to say I took up the latest volume of medical tables, that for 1950, and worked my way through the successive tables picking out some—but by no means all—of the items relating to fatal accidents that seemed relevant and of interest. The results of this selective survey have been condensed to ten tables which not only illustrate the kind of information that is available to anyone who likes to browse through the official statistics but also gives a broad but, I believe, useful statistical picture of the epidemiology of fatal accidents.

In token recognition, however, that all accidents are not fatal and also that our Department has recently been interesting itself greatly in morbidity statistics as well as mortality statistics, I am including an additional table giving some statistics of accidental injuries resulting in admission to hospital.

Deaths from accidental causes constitute one of the main components of the larger group of deaths from violent causes, other components being deaths by suicide, deaths by homicide and so on. In accordance with the "Sixth Revision" of the International Classification of Diseases, Injuries and Causes of Death, violent causes are classified simultaneously in two ways, first according to the external cause of the violence (given list numbers prefixed by the letter E) and secondly by the nature of the injury (given list numbers prefixed by the letter N). Thus a pedestrian who suffers the misfortune of being accidentally run over by a bus thereby sustaining a fracture of neck of femur would receive the E classification assignment E812 indicating that it was a motor vehicle traffic accident to a pedestrian, and also the N classification assignment N820, fracture of neck of femur. For some years past, coroners have been supplying us with special supplementary information about causes of death from violence in order that this dual classification can be made accurately.

In Table I, showing accidental deaths at different ages, the point to note particularly is that about

TABLE I.—FATAL ACCIDENTS. NUMBERS, RATES PER MILLION AND PROPORTIONATE RATES PER CENT OF ALL CAUSES. BY SEX AND AGE. ENGLAND AND WALES, 1950

	All ages	Under 1	1–4	5–14	15–24	25–44	45–64	65 and over
Males								
Number	8,791	440	418	605	1,182	2,075	1,906	2,165
Rate per million	415	1,232	270	201	417	316	392	1,088
Proportion % of all causes	3·4	3·6	19·0	30·6	34·4	13·6	2·8	1·4
Females								
Number	5,290	300	288	246	175	291	700	3,290
Rate per million	233	880	195	85	60	44	125	1,176
Proportion % of all causes	2·1	3·4	15·3	18·0	6·4	2·3	1·5	1·9