A REVIEW OF SALMONELLOSIS IN SOUTH AFRICA

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Organisms of the salmonella group, which are of world-wide distribution,[1] are encountered as parasitic or disease-producing organisms in most mammals,[1-5] birds,[1-4] reptiles[3,6-10] and fish.[2,11,13,21,40] Some are host specific, e.g. *S. typhi*, *S. paratyphi A*, *B* and *C* and *S. sendai* are found only in man.[12] Others have a certain degree of host specialization,[2] e.g. *S. abortus-ovis* for the sheep, *S. gallinarum* and *S. pullorum* for the fowl, *S. abortus equi* for the horse and *S. dublin* for the ox. Most types, however, appear not to be host specific and it is generally agreed that they are all able to infect man.[1,18]

The organisms may infect man by direct contact,[1,39] but, as indicated by the ill-defined term 'food-poisoning', they are usually conveyed through contaminated food. Lately, house dust[15,16] and lice[17] have also been incriminated as transmitters of infection.

It is convenient to recognize 4 main clinical entities that may occur individually, simultaneously or consecutively in the course of an infection.[18] They are (1) gastro-enteritis, (2) the 'typhoidal or septic syndrome', (3) focal manifestations and (4) the carrier state. In bigger surveys of salmonellosis other than typhoid fever,[18-20] gastro-enteritis was the main symptom in 66-70% of the cases, the typhoidal syndrome in 8-9%, focal manifestations in 7-8% of the infections, and 15% were classified as healthy carriers. The more important localized disorders were meningitis,[3,11,18,19,22-25] endocarditis and pericarditis,[18,26-29] osteomyelitis,[3,18,30,31] pneumonia and pleurisy,[18,19] urinary-tract infections,[18,32] and abscesses.[3,18,19,24,33,34]

The disease does not spare any age-group but is apparently commonest in children.[20,28,40,79] The clinical picture may range from the mildest conditions, which often remain undiagnosed, to the most fulminating forms, terminating fatally. The total mortality in salmonellosis of man, due to types other than *S. typhi*, was 1·4% in one survey of 2,605 cases,[20] and 4·1% in another of 7,779.[18] It may be argued that the groups under observation were overloaded with severe cases, which would tend to increase the mortality. However, 355 deaths among just over 10,000 cases of confirmed salmonellosis are not to be dismissed lightly.

The prognosis depends on the age of the patient, being more serious in the age-groups under 2 and over 50 years.[10,18,20] Moreover, the site of infection, the general resistance of the host, and the infecting salmonella type, are also important factors.[18] Strains such as *S. cholerae suis*, *S. enteritidis*, *S. dublin* and *S. typhi murium* are usually associated with severer symptoms than other types,[18,19] although they may vary from outbreak to outbreak.

In recent years, there has been a definite increase in the incidence of salmonellosis in England and North and South America.[2,11-13,20,35,36] This tendency has been ascribed to large movements of populations,[12] to increased numbers of meals eaten in canteens, restaurants, etc.,[2,19] to the extensive use of bulk prepared food,[2,13,14] to importation of imperfectly sterilized foodstuffs, e.g. dried egg-powder and frozen egg albumin, and to the rising incidence of salmonellosis in animals.[2] The infection rate of domestic animals seems to be associated with the increasing use of contaminated bone meal and fish meal.[21]

In conclusion, the indications are that salmonellosis is on the increase in some parts of the world. The situation has

become further aggravated by the recent description of drug-resistant salmonella types.[37,38]

From South Africa, comparatively little has been published on salmonellosis other than typhoid fever. Outbreaks of food poisoning caused by salmonella infections were reported by Greenfield *et al.*[55] (1936), Buchanan *et al.*[56] (1939), Gear *et al.*[57] (1942), Lewin *et al.*[58] (1945), Le Riche *et al.*[59] (1953) and Neser *et al.*[60] (1957). The number of persons affected ranged from 4 in the smallest outbreak to 175 in the biggest. The organisms incriminated in the outbreaks were *S. bovis morbificans*,[61] *S. typhi murium*, *S. braenderup*, *S. enteritidis*, *S. dublin*, *S. poona* and *S. newport*.

Kahn[63] (1957) and Kahn *et al.*[64] (1958) drew attention to the frequency of salmonellosis as a cause of diarrhoea in Bantu children during the summer. Stein[65] (1955), also working with Bantu children, pointed out that gastro-enteritis caused by salmonellae carried a graver prognosis than that of undetermined aetiology.

Some rarer manifestations of salmonellosis in South Africa were reported by Bennett *et al.*[24] (3 patients with meningitis and 2 with abscesses) and by Utian[25] (1 case of meningitis).

For the treatment of salmonellosis Kahn *et al.*[64] found chloromycetin to be the drug of choice; however, some strains are resistant to all common antibiotics (Stein *et al.*,[38] 1958).

Products associated with the transmission of salmonellosis in South Africa are milk,[58] raw ice,[56] lettuce,[57] gelatine-and-egg pudding,[59] meat dishes[55,57,58,61,66] and the popular dehydrated meat preparation known as biltong.[60]

Salmonellosis is also known to occur in certain animals and birds in this country. It has been found in cattle,[66-68] horses,[67,69-72] sheep,[67] pigs,[67,73] dogs[74] and cats.[74] Henning[67] isolated salmonellae from pigeons, canaries, geese, ducks, turkeys and fowls.

Apart from these reports, the literature contains the description of a number of 'new' salmonella types originally isolated in South Africa.[41-54]

From this survey of the local literature it appears that there are many gaps in our knowledge on the subject. We are ignorant of the prevalence of salmonellosis in man and animal[62] and of the illness and economic losses attributable to these organisms. Furthermore, information on their occurrence in our common foodstuffs is very scanty and we know but little of the relative importance of the various routes of infection.

The purpose of this communication is to record the salmonella types isolated in South Africa before 1958, as well as to focus attention on salmonellosis, which in the future may assume such proportions as to become a matter of considerable concern.

MATERIAL AND METHODS

The information is extracted partly from the records of the Salmonella Typing Unit of the South African Institute for Medical Research (SAIMR) and partly from publications from other laboratories.

The Typing Unit, established in 1952, receives strains isolated from specimens submitted to the SAIMR. To the best of our knowledge, all these specimens were of human origin; some came from acutely ill patients, convalescents and chronic carriers, and others from apparently healthy food-handlers, whose excreta were examined prophylactically. The number of strains exceeds the number of patients because, in several cases, successive specimens from the same patient yielded a growth of different salmonella organisms.

Pure cultures for typing have also been received from other laboratories on the Witwatersrand. Most, if not all, of them were of human origin, but usually without information about the site of infection. In addition, this survey includes strains which were reported from other laboratories in the Union. Such strains, with the exception of *S. pretoria*[46] and *S. amersfoort*,[43] have been isolated from man.

The organisms, classified according to their biochemical behaviour, were identified by detailed antigenic analysis according to Kauffman's recommendation.[75] Slide agglutination technique was the usual procedure, but in doubtful cases it was checked by the tube agglutination method.

The records of the Typing Unit have been scrutinized from 1952 until the end of 1957. *S. typhi* has been omitted from the present survey, because it merits special consideration and will be dealt with in a forthcoming communication.

RESULTS

All salmonella types encountered in the Union of South Africa up to 1958 are listed in Table I, where they are arranged according to the Kauffmann-White schema.[76] A total of 132

TABLE I. SALMONELLA TYPES ISOLATED IN THE UNION OF SOUTH AFRICA BEFORE 1958

Groups and Types	Source				1957 Total
	Faeces	Urine	Blood and CSF	Culture	
Group A					
S. paratyphi A	8	—	6	15	29
Group B					
S. abortus equi	5	—	—	2	7
S. paratyphi B	6	—	—	—	6
S. wagenia	1	—	—	—	1
S. stanley	1	—	—	—	1
S. duisburg					
S. saint paul					
S. reading					
1941: S. kaapstad	1	—	—	—	1
S. chester	15	—	—	3	18
S. san diego	2	—	—	1	3
S. derby	23	—	2	22	47
S. budapest					
S. typhi murium	57	—	CSF=2	63	122
S. bredeney	—	—	—	1	1
S. heidelberg	—	—	—	1	1
S. stanleyville					
Group C 1					
S. san juan					
S. edinburg					
S. georgia	—	—	—	1	1
S. paratyphi C	1	1	—	—	2
S. cholerae suis					
1937: S. amersfoort	2	—	—	1	3
S. mission					
S. livingstone	—	—	—	1	1
S. braenderup	51	1	8	18	78
S. montevideo	1	—	2	2	5
S. oranienburg	19	—	2	18	39
S. thompson	1	—	—	2	3
S. concord					
S. irumu					
S. colorado	1	—	—	5	6
S. infantis	—	—	—	1	1
S. bareilly	—	—	—	1	1
S. aequatoria					
S. eschweiler					
S. tennessee					
Group C 2					
S. narashino					
S. nagoya					
S. muenchen					
S. manhattan	72	1	1	34	108
S. labadi	12	—	—	19	31
S. newport	4	—	—	8	12
S. kottbus					
S. lindenburg					
S. takoradi					
S. bonariensis	—	—	—	1	1

Groups and Types	Source: Faeces	Urine	Blood and CSF	Culture	1957 Total
S. litchfield					
S. fayed					
1955: S. baragwanath	1	—	1	—	2
1955: S. germiston					
S. bovis morbif	8	—	—	7	15
S. hidalgo					
S. gold coast					
S. tananarive					
S. praha					
S. glostrup					
Group C 3					
S. shipley					
S. virginia					
S. kentucky	2	—	—	—	2
S. amherstiana					
Group D 1					
1941: S. durban					
S. ndolo	—	1	—	—	1
S. eastbourne	7	—	2	6	15
S. israel	—	—	—	1	1
S. enteritidis	—	—	—	1	1
S. pensacola					
S. dublin	5	2	5	10	22
S. seremban					
S. panama					
S. goettingen					
S. victoria					
S. pullorum					
Group D 2					
S. strasbourg	3	—	1	—	4
Group E 1					
S. vejle					
S. muenster					
S. anatum	30	1	1	25	57
S. newlands	—	—	—	1	1
S. meleagridis	—	—	—	1	1
S. london	38	3	—	38	79
1957: S. alexander					
Group E 4					
S. senftenberg					
S. krefeld					
Group F					
S. chandans					
S. chingola	1	—	—	—	1
S. aberdeen	10	—	—	3	13
1941: S. pretoria					
S. tel-hashomer					
Group G 1					
S. ibadan					
S. borbeck					
S. poona	1	—	—	4	5
1956: S. roodepoort					
Group G 2					
S. mishmarhaemek	1	—	—	—	1
S. havana	—	—	—	1	1
1952: S. worcester	—	—	—	2	2
S. nachshomin					
S. cubana					
Group H					
S. florida	1	—	—	—	1
S. albuquerque	1	—	—	1	2
1936: S. onderstepoort					
S. carrau	1	—	—	—	1
S. homosassa					
Group I					
S. hvittingfoss					
S. gamanaria					
S. weston	2	—	—	1	3
S. mobeni					
S. rowbarton					
Group J					
1956: S. hillbrow	—	—	—	1	1
Group K					
S. cerro	3	—	—	2	5
Group L					
S. minnesota	3	—	—	2	5
Group M					
S. kibusi					
S. pomona					
S. umbilo					
Group N					
S. urbana					
S. landau					
S. donna					
Group P					
S. adelaide	75	1	1	63	140
S. alachua	3	—	—	3	6
Group Q					
S. roan	2	—	—	—	2
Group S					
1956: S. springs					
S. rio grande					
1952: S. johannesburg	4	—	—	6	10
S. duval	4	1	—	25	30
1957: S. boksburg					
Group T					
S. waycross	2	—	—	1	3
Group U					
S. uphill					
1957: S. rand					
S. weslaco					
Group X					
1955: S. windhoek					
Group 50					
1957: S. greenside					
Total 132	491	12	34	425	962
Percentage	51·0	1·2	3·5	44·2	

Year attached to a type indicates the date of publication of a strain originally isolated in South Africa.
Classification under 'source' applies to those isolated in 1957.

salmonella types have been identified in the Union (Table I, first column). Of these, 17, indicated by year of description, were originally isolated locally. It is noted that the majority of the types belongs to the somatic groups A-E, with group C as the commonest. In order to ascertain the relative frequency of the types, the total number of identifications of individual types at the SAIMR was tabulated for the calendar year of 1957 (Table I, last column). The types without particulars were identified earlier. During 1957 a total of 962 strains, comprising 59 types, were identified. Some types are rare whereas others, shown in Table II, are commoner. More

TABLE II. RELATIVE FREQUENCY OF THE COMMONER SALMONELLA TYPES DURING 1957

Types	Number	% of total
S. paratyphi A	29	3·0%
S. derby	47	4·9%
S. typhi murium	122	12·8%
S. montevideo	78	8·0%
S. thompson	39	4·1%
S. labadi	108	11·2%
S. newport	31	3·2%
S. dublin	22	2·3%
S. anatum	57	5·9%
S. london	79	8·2%
S. adelaide	140	14·6%
Total: 11	752	78·3%

than 3/4ths of the strains were made up of 11 types. *S. adelaide* was the commonest, followed by *S. typhi murium* and *S. labadi*. These three together constituted more than 33% of the identifications.

As mentioned above, some strains were submitted for identification from laboratories outside the Institute. They are recorded under 'culture' in Table I, and comprised 44·2% of the identifications.

Of 537 strains isolated at the SAIMR, 491 (91·4%) were recovered from faeces, 12 (2·2%) from urine and 34 (6·3%) from blood and cerebrospinal fluid. No particular salmonella type predominated in the few cases of infection of the urinary

system. A variety of organisms was recovered from the blood, *S. montevideo*, *S. paratyphi A* and *S. dublin* being the most frequent. In 1957, *S. typhi murium* was not isolated once from the blood stream, whereas on 2 occasions it was recovered from the cerebrospinal fluid.

The results, given in Table III, show that salmonella infections may be expected to occur throughout the year.

TABLE III. SEASONAL TRENDS IN SALMONELLA RECOVERIES, 1957

Month	*Number of cultures*	*% of total*
January	110	11·4%
February	65	6·8%
March	68	7·1%
April	61	6·3%
May	60	6·2%
June	59	6·1%
July	62	6·4%
August	65	6·8%
September	64	6·7%
October	118	12·3%
November	118	12·3%
December	112	11·7%

From February to September the monthly incidence is steady at 6-7% and from October to January it is equally steady but almost twice as high. There are no signs either of a substantially reduced incidence in mid-winter or of a pronounced peak in late summer.

The trends in incidence of salmonellosis is estimated roughly in Table IV, which gives the number of faecal and urine samples investigated bacteriologically in the SAIMR during 1956 and 1957, as well as the number of recovered

TABLE IV. TRENDS IN INCIDENCE OF SALMONELLOSIS

Year	*Number of investigated faeces and urines*	*Number of recoveries*	*Percentage positive*
1956	18,754	338	1·8%
1957	12,560	503	4·0%

salmonellae. The number of investigations in 1957 has decreased by 33% as compared to 1956, probably owing to the opening of a number of hospital laboratories on the Witwatersrand. Nevertheless, more salmonellae were recovered in 1957 than in the previous year. The increase in the percentage of positive specimens is highly significant (chi-square=140, i.e. the probability of the difference being due to chance is infinitely small). The bacteriological technique has remained almost unchanged; the higher infection rate of specimens therefore suggests an increased morbidity in the population.

DISCUSSION

In some respects the findings of this survey differ from those of most other workers. Firstly, *S. typhi murium*, usually the prevailing type in human pathology,[3,4,11,13,19,20,23,77] was outnumbered by *S. adelaide*. Secondly, two strains, *S. adelaide* and *S. labadi* occurred so frequently, that, on reviewing the situation, one is inclined to think that they have caused outbreaks of epidemic proportions. A similar situation, due to *S. reading*, was recently reported in America.[78] Thirdly, the highly virulent strains *S. paratyphi C* and *S. cholerae suis* appear to be rare in South Africa. Finally, the seasonal variation in salmonellosis has not followed the common pattern characterized by a pronounced peak in late summer.[18,79] In contrast, a steady high level in early summer months followed by a sharp decline in mid-summer has been observed. It is possible that a study over a longer period of time may modify the graph of the seasonal distribution.

In other respects the observations are in close agreement with the findings elsewhere. In particular, evidence of increased salmonella morbidity[20] is also found in South Africa. This raises the problem of the measures to be adopted to prevent the propagation of infection, and following that, to decide if such measures are compatible with a simplification of the sero-typing of the strains.

Savage[2] (1956), reviewing the problem of salmonella food-poisoning in England, suggested a method of reducing the incidence of salmonellosis, as follows:

1. Detailed investigation of all outbreaks to ascertain more accurately the extent of the problem. This includes compulsory notification, which was introduced in England in 1938 and has been in operation in the states of Massachusetts and New York for some time.[18] The advantage and necessity of immediate notification was stressed.
2. Detailed investigation of animal reservoirs of salmonellae, particularly with regard to the extent of the infection and the mode of spread.
3. Reduction of the risk of food infection from human carriers of salmonellae.
4. Improvement of standards of hygiene in establishments preparing and serving food.
5. Hygienic control of bulk food preparations.
6. Steps to reduce risks of salmonella infections from egg products.

These suggestions, designed to combat the salmonellosis in England, are equally applicable in South Africa.

Accurate salmonella typing is an involved and costly procedure, and most laboratories would welcome its simplification. One method would be to identify the somatic antigen only and thus classify the organisms according to group antigen. Table V summarizes our results of salmonella

TABLE V. SALMONELLA TYPES IDENTIFIED DURING 1957. CLASSIFIED BY THEIR SOMATIC ANTIGENS ACCORDING TO KAUFFMANN AND EDWARDS[80]

Group	*Number*	*% of total*
A	29	3·0%
B	208	21·6%
C (C1-C3)	311	32·4%
D (D1, D2)	44	4·6%
E (E1-E4)	138	14·4%
11 (F)	14	1·5%
13 (G1, G2)	9	0·9%
14 (H)	4	0·4%
16 (I)	3	0·3%
17 (J)	1	0·1%
18 (K)	5	0·5%
21 (L)	5	0·5%
35 (P)	146	15·2%
38 (Q)	2	0·2%
40 (S)	40	4·2%
41 (T)	3	0·3%

grouping for 1957, had this method been adopted. 76% of our strains belonged to Groups A-E, which is in marked contrast to the results of Edwards *et al.*[1] and MacCready *et al.*,[20] who found that more than 98% of their strains were in those groups. It appears, therefore, that in South Africa a wider range of somatic antisera would be required for a similar percentage of diagnoses.

Another approach was made by Kauffmann and Edwards,[80] who suggested 'a revised simplified Kauffmann-White schema'. The main advantage is, that related H antigens are combined in antigenic complexes with a special designation. It reduces the number of H sera required, does away with many single-factor sera and permits the worker to determine the approximate antigenic structure of numerous salmonella types.

Naturally, a simplified technique does not give the same amount of information as a detailed analysis; there is no short cut if a complete identification is required.

The choice of a serological technique depends on the laboratory facilities available as well as on the information desired by the doctor in charge and by the epidemiologist.

The doctor's main aim is to establish the nature of the infection, to assess the prognosis, and to estimate the number of bacteriological investigations that will be required during and after convalescence. For practical purposes these requirements could be met by grouping the salmonella organisms. In addition it might be advantageous to type the few strains usually associated with septicaemia and/or high mortality (*S. paratyphi A*, *S. paratyphi B*, *S. cholera suis*, *S. enteritidis* and *S. panama*[18]), as well as *S. typhi murium* and one or two of the locally prevailing strains. Such a system would require a limited number of somatic sera and 8-10 flagellar sera.

The epidemiologist, being concerned with the number of outbreaks, the route of infection, and the tracing of reservoirs in nature, will require nothing less than complete identification. In fact, besides complete antigenic analysis, he may wish to subdivide certain types further according to their bacteriophage sensitivity.

SUMMARY

Recent literature on salmonellosis is reviewed and the current concept of the problem outlined. In scrutinizing the South African literature on the subject, particular attention is drawn to our inadequate knowledge of the distribution of the infection in man and animal in South Africa, as well as to our ignorance of human morbidity and mortality attributable to salmonellosis.

The present study reveals that up to 1958 a total of 132 different salmonella types other than *S. typhi* were encountered in South Africa. In 1957, the 3 commonest strains were *S. adelaide* (14·6%), *S. typhi murium* (12·8%) and *S. labadi* (11·2%). The incidence of salmonellosis was twice as high in summer as in winter, but the seasonal decline in incidence did not coincide with the arrival of the cold weather.

It is particularly noteworthy that the proportion of specimens of faeces and urines yielding a growth of salmonella organisms has increased from 1% in 1956 to 4% in 1957. It is probable that this reflects an increased incidence of salmonellosis in the population.

The introduction of a simplified laboratory method of typing the salmonella organisms is discussed and the opinion expressed that the results of this simplified technique provide an adequate indication for treatment. If, however, notification of salmonellosis is made compulsory, complete identification of the organisms will be essential.

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