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A review of outbreaks of infectious disease in schools in England and Wales 1979–88

C. JOSEPH[1], N. NOAH[2], J. WHITE[1] AND T. HOSKINS[3]

[1] *Public Health Laboratory Service, Communicable Disease Surveillance Centre, 61 Colindale Avenue, London NW9 5EQ*
[2] *Kings College School of Medicine and Dentistry, Bessemer Road, London SE5 9PJ*
[3] *Christs Hospital, Horsham, Sussex*

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SUMMARY

In this review of 66 outbreaks of infectious disease in schools in England and Wales between 1979–88, 27 were reported from independent and 39 from maintained schools. Altogether, over 8000 children and nearly 500 adults were affected. Most of the outbreaks investigated were due to gastrointestinal infections which affected about 5000 children; respiratory infections affected a further 2000 children. Fifty-two children and seven adults were admitted to hospital and one child with measles died. Vaccination policies and use of immunoglobulin for control and prevention of outbreaks in schools have been discussed.

INTRODUCTION

The prevention and control of infectious disease outbreaks in schools are important not only because of the number of children at risk but also because of the potential for spread of infection into families and the wider community. Moreover, outbreaks of infection in such communities may lead to serious disruption of children's education and the curtailment of school activities. Details made available of 66 school outbreaks to the Communicable Disease Surveillance Centre between 1979 and 1988 are analysed in this paper and policies for prophylaxis, for example immunoglobulin and vaccination are described.

SOURCES OF INFORMATION

Information on outbreaks in schools between 1979 and 1988 was obtained from reports of investigations in which the Public Health Laboratory Service (PHLS) Communicable Disease Surveillance Centre (CDSC) had been asked to assist [1] and Communicable Disease Report (CDR) inserts (Table 1). In addition, information was collected on outbreaks reported by the Medical Officers of Schools Association (MOSA) weekly surveillance reporting scheme to CDSC [2].

The MOSA/CDSC scheme

The Medical Officers of Schools Association, founded in 1884, represents doctors who have responsibility for preventing and controlling infectious diseases in

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independent boarding schools [3]. While many school doctors have systematically collected their own data on children's sickness, a voluntary weekly reporting scheme to CDSC was established in 1979, originally for the rapid detection of cases of influenza in a national sample of boarding school children and then adapted for other infectious diseases. By 1989, a total of 59 schools were participating in this surveillance scheme. The data derived from the scheme is heavily biased towards children in the 13–18 year age group, attending schools in South East England.

RESULTS

Between 1979 and 1988 CDSC assisted in, or otherwise received information on, 66 outbreaks in schools. In addition to these reports, 98 outbreaks of respiratory infection, 83 of gastrointestinal disease and 20 viral and other outbreaks were recorded from the MOSA weekly returns to CDSC in children who boarded at independent schools (Table 1). The 66 reviewed outbreaks affected almost 8500 children and over 450 adults (Table 2).

Respiratory infections

Influenza

Altogether, 8 investigated outbreaks of influenza were reported from 10 schools, 7 of which were independent boarding schools, 1 a maintained residential school and 2 primary schools. Five outbreaks were caused by influenza A virus, two by influenza B virus and in one, part of a community outbreak, both A and B viruses circulated. Attack rates in each of the schools varied from 23% (275/1196) to 63% (38/60). Where it was possible to obtain attack rates by age, they were higher in younger children than older children.

Influenza vaccine had been offered each year to the children in five boarding schools but appeared to confer little protection; attack rates were higher in the vaccinated than the unvaccinated children in three of the schools (Table 3). In the remaining schools which did not routinely vaccinate, overall attack rates in the outbreaks that were investigated were similar to those found in the 'vaccinated' schools.

There were no admissions to hospital although reported complications included 33 ear infections, 4 lower respiratory infections (1 with pneumonia), 2 mild cases of acute nephritis and 1 case each of urticaria and post-influenzal depression.

Other respiratory infections

Seven other respiratory outbreaks were investigated, six in independent boarding schools and one in a maintained residential approved school. Four outbreaks were of group A streptococcal infection and affected about one third of the children. One was an explosive outbreak in which 45% (34/76) of the boys and 43% (17/40) of the staff in a boys' residential school were affected within 1 week. In the other three, ongoing episodes of infection were described which continued from one school term to the next, in spite of school holidays. Two of the schools experienced outbreaks over two terms, while a third continued over five terms from February 1980 through to the summer term of 1981. Initial treatment with antibiotics of those with symptoms failed to control the outbreaks. All three schools took nose and throat swabs from all pupils and gave antibiotic treatment to children found to have positive cultures. Follow-up swabs showed one or two

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Table 1. *Method of ascertainment of 66 outbreaks included in review in England and Wales 1979–88*

Disease group	Type of school	CDSC/CDR	MOSA*
Respiratory	Maintained	3	—
	Independent	6	6
Gastrointestinal	Maintained	20	—
	Independent	6	5
Viral infections	Maintained	9	—
	Independent	1	1
Other infections	Maintained	7	—
	Independent	—	2
Total	Maintained	39	—
	Independent	13	14
Total outbreaks		52	14

* A total of 201 outbreaks were reported from the MOSA/CDSC surveillance scheme during the period 1979–88. These comprised: respiratory, 98; gastrointestinal, 83; viral infections, 16; other infections, 4.

Table 2. *Summary of 66 outbreaks reviewed from schools in England and Wales 1979–88*

Disease group	Number of outbreaks	Number affected		No. admitted to hospital		Deaths, children
		Children	Adults	Children	Adults	
Respiratory						
Influenza	8	1596	62	—	—	—
Other respiratory	7	359	34	1	—	—
Gastrointestinal						
Campylobacter	9	3600	114	19	4	—
Hepatitis A	8	175	34	—	1	—
Shigella	5	814*	51	7	1	—
Food poisoning	5	155	17	—	—	—
Viral GI	3	398	24+	—	—	—
Other GI	2	233	16	—	—	—
Viral infections						
Measles	6	447	—	10	—	1
Rubella	1	39	—	—	—	—
Other	4	304	19	—	—	—
Other infections	8	309	84	15	1	—
Total	66	8429	455	52	7	1

* Includes 650 children and adults combined.

treatment failures in each of the three schools but further treatment with antibiotics eradicated the infection and terminated the outbreaks.

One outbreak of what was originally thought to be psittacosis in an independent boarding school was investigated in detail [4]. Twenty boys from a school population of 325, 2 teachers, 1 kitchen worker and 1 of the investigators became ill between May and July 1980. No avian source of infection could be found and sera examined some years later showed that the outbreak was caused by *Chlamydia pneumoniae* strain TWAR [5].

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Table 3. *Influenza vaccine efficacy in five school outbreaks*

No. of children in school	No. of cases	Attack rate in vaccinated (%)	Attack rate in unvaccinated (%)	Vaccine efficacy* (%)
1272	338	25	34	25 (7, 40†)
1196	275	20	34	42 (28, 53)
478	112	24	22	−7 (−69, 32)
149	49	35	31	−12 (−78, 30)
470	182	39	37	−5 (−42, 23)

* Vaccine efficacy = $\frac{\text{attack rate in unvaccinated} - \text{attack rate in vaccinated}}{\text{attack rate in unvaccinated}}$.
† 95 % confidence intervals, lower and upper.

Two further respiratory outbreaks in independent boarding schools were investigated. In one, parainfluenza virus type 1 was isolated from 15 of 35 ill boys. In the other 75 boys were admitted to the school sanatorium over a period of 9 weeks with symptoms of fever and severe sore throat, and adenovirus type 7b was isolated from throat swabs from four of the boys. The outbreak ceased when the school term ended.

Gastrointestinal infections

Campylobacter

Nine outbreaks of campylobacter infection were investigated. Seven were reported from independent boarding schools and two from maintained schools. Altogether around 3600 children and 114 adults were affected, with 19 children and 4 adults admitted to hospital.

The vehicle of infection was contaminated or unpasteurized milk in five outbreaks. One school which used unpasteurized milk from its own farm had two outbreaks in the same year and illness was significantly associated with the consumption of milk in the second outbreak [6]. In another school which had two outbreaks, the first was caused by contaminated water and in the second, unpasteurized milk inadvertently sent to the school on one occasion was suspected but not proven as the vehicle of infection. A fourth outbreak also occurred at a school which had its own farm from which it obtained pasteurized milk but it was believed that either raw milk was sent to the school by mistake or that the output pipe (which diverted milk into the pasteurized or raw milk storage tanks) was contaminated [7]. One outbreak affected children in several maintained infant and primary schools through the distribution of free school milk in the Luton and Dunstable area in 1979, and gave rise to around 2500 infections in children, the largest milk associated outbreak of campylobacter so far recorded in the UK [8]. Water was associated with campylobacter outbreaks in three schools. One school used a private bore hole supply in addition to mains water and it was shown that the highest attack rates in the school were amongst those who drank water supplied from the bore hole from which *Campylobacter* sp. was isolated [9]. The two other outbreaks occurred following disruption of the schools' water supplies.

The source of infection was not proven in one outbreak although milk infected by birds who pecked at the milk bottle tops and case-to-case spread from an index case were both suspected.

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Hepatitis A

Eight outbreaks of viral hepatitis, which affected 175 children and 34 adults took place in maintained schools. One of them was in a day school for children with a mental handicap and the other in a mixed boarding and day school for children with learning difficulties.

Three outbreaks were considered to be point source in origin followed by case-to-case transmission, four were person-to-person spread and in one the mode of transmission was not determined. The vehicle of infection was identified in one; these were iced buns which the index case had helped to make in the school cookery class. Thirty-nine cases of hepatitis resulted from this exercise and were followed by a further 58 secondary cases in the community (Table 4).

Immunoglobulin was used to control five outbreaks. In one outbreak in 1988 salivary antibody testing for evidence of immunity to hepatitis A was used, as described by Parry and Mortimer [10, 11]. Eight per cent (12/156) of children in the infant school, 46% (5/11) in the junior school, 46% (6/13) of staff and 50% (12/24) of family contacts were found to be immune. This investigation allowed for selective administration of immunoglobulin to those who were susceptible.

Shigella sonnei

Five outbreaks of *S. sonnei* involved ten maintained primary or infant schools, and affected over 850 persons of whom at least 164 were school children and 51 were adults. Seven children and one adult (from three of the outbreaks) were admitted to hospital. In all outbreaks, cases also occurred in families and contacts of the children, often with spread of the infection from one school to another over a period of several weeks.

Management of the outbreaks involved both the implementation of strict hygiene measures and the exclusion of symptomatic and asymptomatic siblings and/or carriers from school until they were symptom free or had three negative stool specimens. One outbreak in 1982–3, which began in a day nursery and spread to a local primary school, experienced a second wave of cases when an asymptomatic excreter returned to nursery school before she was clear of infection. This outbreak, together with another in 1984–5, was part of a widespread increase in cases in the community where investigative procedures involved the sampling of over 3000 faecal specimens by the two local public health laboratories. Both outbreaks lasted for about 6 months, the latter involving four schools where 650 children and adults were affected.

Bacterial food poisoning

Altogether five outbreaks in seven schools were investigated. In 1988 *Salmonella enteritidis* phage type 4 affected 21 girls from an independent boarding school. A cohort study failed to identify the vehicle of infection. Two outbreaks were caused by *Clostridium perfringens*; in the first, 32 children and 15 adults in three maintained schools developed gastrointestinal symptoms following a lunch of cold pork and salad which had been prepared in one of the school's kitchens. In the second, 27 children from a maintained school for handicapped children developed diarrhoea after eating a special low carbohydrate diet meal of steak and kidney

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Table 4. *Summary of school outbreaks of hepatitis A*

Year	Type of school	No. affected: Children	No. affected: Adults	Age of children (years)	Type of outbreak	Duration of outbreak (months)	Immunoglobulin prophylaxis
1981	Mentally handicapped	3	4	6–7	Person-to-person	3	All children and staff
1982	Educationally subnormal	5	3	Unknown	Point source and person-to-person	1	All children and staff
1983	Primary	18	3	6–12	Point source	5	None
1983	Infant and junior	27	—	4–11	Person-to-person	12	Children in nursery class
1984	Primary	15*	—	7–11	Point source and person-to-person	2	Family of secondary cases
1986	Primary	75	22	0–14†	Point source and person-to-person	3	None
1988	Junior	7	2	3–8	Person-to-person	2	None
1988	Infant and junior	25	—	4–11	Person-to-person	4	One infant class

* Seven cases in point source outbreak.
† Thirty-nine cases aged 8–11 years in point source outbreak.

stew. The other children in the school had the remaining meat made into a pie which was baked in the oven and none of them were ill. In an outbreak of staphylococcal food poisoning 5 boys in a maintained residential school ate some hot dog sausages from a jar which had previously been opened 4 days earlier and stored in a dormitory wardrobe. *Staphylococcus aureus* was isolated from 2 of 4 stool specimens and although the empty jar was recovered it failed to yield the same organism since it had been thrown out of the window and washed by rain. In the fifth outbreak, 70 children and 2 teachers from a maintained primary school were affected by a 'school poison scare' which lasted for about 48 h. The school lunch on the first day of the outbreak was initially suspected but no pathogenic organisms were found in the foods sent for microbiological examination and six children who were ill had not eaten it. However, 3 of 15 stool specimens from pupils and 1 from a kitchen assistant grew *S. aureus* on enrichment media. No source of infection was found.

Viral gastroenteritis

Three outbreaks of winter vomiting disease were reported from independent boarding schools and affected approximately 385 children and 25 staff. In one, a kitchen staff worker developed acute vomiting during the night but carried out normal breakfast duties the following morning before taking sick leave. That same day another school party came to the school to participate in a netball match which was followed by afternoon tea. Twenty-four hours later, 48 children and staff from the host school and 12 children from the visiting school developed profuse vomiting. Small round virus particles were found in the stool sample from the index case but from no other samples. It was postulated that the virus may have passed from the index case onto the crockery and cutlery during the washing and drying process at breakfast; these same utensils were then used for the tea which was taken by the two schools that afternoon. A similar type of outbreak occurred at another independent boarding school where a new kitchen staff member experienced a bout of vomiting 24 h before cases began to appear in the school. Approximately 200 boys and 8 staff were affected but no bacterial or viral pathogens were identified from the specimens sent for microbiological investigation. The third outbreak affected 67 boys and 13 staff and one boy was admitted to hospital for 3 days. The source of infection was probably a boy who returned to school following an episode of illness at home. Once introduced into the school the infection spread by serial propagation amongst the boys and staff over a period of 11 days. Faecal specimens submitted for microbiological examination were negative for bacterial organisms but small round structured virus was found in one specimen, consistent with the diagnosis of winter vomiting disease.

Other gastroenteritis

A large outbreak of *Yersinia enterocolitica* infection, one of the first to be reported in the UK, occurred in an independent boarding school. One hundred and nine of 184 boys aged 11–18 years and 7 of 34 staff were ill with abdominal pain or diarrhoea over the winter and spring terms of 1979–80. *Yersinia enterocolitica* 0 antigen group 3, biotype 4, was isolated from faecal specimens from 10 boys, and antibodies to *Y. enterocolitica* 0:3 were detected in 34 boys and 2 staff. A cohort

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study of the school population showed an association between illness and contact with animals in the school Rural Studies Unit, a small farm run by the pupils under the direction of teaching staff. Contact with pigs was independently associated with gastrointestinal illness. Two boys were admitted to hospital during the outbreak; one underwent emergency abdominal surgery.

An outbreak of gastroenteritis of unknown aetiology occurred in a maintained primary school and affected 20% (124/607) children and 9 of 27 staff. Following a case-control study at the school, illness could not be associated with the consumption of any particular food or drinking water and all faecal specimens were negative for bacterial and viral pathogens. It was thought that this common source outbreak may have been due to temporary contamination of the school's water supply.

Viral exanthems

Measles

Six outbreaks of measles in schools were investigated. Four outbreaks took place in maintained infant or primary schools, one in an independent preparatory school and one in two adjacent maintained secondary schools. A total of 447 children were affected from a school population of around 6500. At least ten children were admitted to hospital in a large outbreak in 1987 which involved several schools in a Welsh community where the measles vaccination uptake rate was low [12]. One death from measles occurred in 1988.

All investigations sought information on vaccine efficacy and on the proportion of unvaccinated susceptible children at risk in each outbreak. The total number of children with no known past history of measles or vaccination was estimated to be 58% (range 13–78%).

Rubella

One outbreak of rubella in an independent mixed boarding school was investigated in 1985. Only boys in the senior school were affected, and 9% (39/415) developed symptoms over a period of 5 weeks. Blood samples from three out of four boys affected showed serological evidence of recent infection. The 56 girls in the school, all of whom were aged 16 years or more, had a history of vaccination against rubella. None of the female staff became ill although their immunization histories were unknown.

Erythema infectiosum

In three outbreaks of erythema infectiosum (Fifth disease) 229 children aged 4–11 years were affected, with an overall attack rate of 23% (range 10–38%). Thirty-eight siblings and 19 parents were also affected. In the largest outbreak, which affected 162 children in one maintained primary school the diagnosis was confirmed virologically in 36 children [13]; this was the first outbreak to show the association between parvovirus and erythema infectiosum.

Other exanthems

An outbreak of 'mild illness with rash' was investigated in a primary school where 11% (37/330) children were affected, 13 of them within a 3-day period, with a rubelliform rash and no prodromal symptoms. No viral agent was isolated and

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many cases were too mild, short-lived and non-specific to enable a diagnosis to be made.

Other infections

Streptobacillary fever

An outbreak of streptobacillary fever occurred in a girls' independent boarding and day school in 1983 and affected 43% (304/700) children and staff [14]. The outbreak was initially thought to be associated with the consumption of raw milk but detailed epidemiological investigations showed that spring water infected by rats was the most likely vehicle of infection. Mains water was supplemented by a spring. Just before the outbreak digging work had been carried out around the sewage system and this, together with inclement weather may have disturbed the local rat population, resulting in contamination of the spring water. *Streptobacillus moniliformis* was isolated from six cases in the school admitted to outside hospitals but was not cultured from samples of water (or from rats), probably because contamination had ceased by the time the outbreak was investigated. The attack rate of infection amongst boarders was 54% compared with 20% for day girls.

Meningococcal meningitis

An outbreak of meningococcal infection occurred in a maintained comprehensive school when four teenage pupils were admitted to hospital over one weekend with a clinical diagnosis of meningitis. The pupils were in different classes at the school and although they lived in the same small town did not meet socially. *Neisseria meningitidis* group C was isolated from the CSF of the first three cases, the fourth had clinical signs of meningitis and a haemorragic skin rash. Prophylactic rifampicin was given to a total of 360 close contacts of the pupils and was followed by the offer of meningococcal A+C vaccine to every pupil in the school. All but two of the 1032 pupils received the vaccine. No prophylactic rifampicin was given to any of the staff at the school. No further cases from the school were reported.

Tuberculosis

Of four outbreaks of tuberculosis three took place in maintained infant or primary schools and one in a comprehensive school. In the first outbreak, 46 out of a school population of 215 children aged 6–11 years received anti-tuberculosis treatment following the discovery of smear positive pulmonary disease in a teacher [15]. Twenty-three children had strongly positive tuberculin tests and abnormal chest radiographs; 2 had tuberculous meningitis; 3 developed a primary complex after BCG vaccination; and the remaining 18 had strongly positive tuberculin tests only. Fourteen out of 118 children given BCG vaccination developed an accelerated reaction. The school classrooms were open plan and most of the infected children were in the class of the index case or the adjacent class.

In the second outbreak, the index case was a comprehensive school teacher who had smear positive pulmonary disease. A 12-year-old pupil, who was initially tuberculin negative, subsequently developed respiratory symptoms and a primary tuberculous complex, and a second member of staff was found to have smear negative pulmonary disease. In the third outbreak, eight cases of tuberculosis were reported in children from one infant school, as well as a further case of

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primary tuberculosis in a preschool child contact found after screening. Nine other children, seven of them from the same school, were also found to be Heaf positive and were prescribed anti-tuberculosis treatment. The index case in this outbreak was thought to be the mother of one of the cases in the infants school. It was concluded that she infected her son, husband and probably two other children in the school with whom she had close contact, but there was insufficient evidence to identify whether she or her son had been the source of infection in the other cases in the school. The fourth outbreak occurred in a primary school where, following a diagnosis of smear positive pulmonary tuberculosis in a teacher, investigations revealed nine children with tuberculous infection all of whom were prescribed anti-tuberculosis treatment [16].

Conjunctivitis

Two unusual outbreaks of conjunctivitis in maintained residential schools were investigated. In the first in 1981, 50% (22/24) of girls were affected and *Moraxella lacunata* was isolated from 19 with symptoms and from none without symptoms. The sharing of eye make-up by the girls was thought to be associated with infection as was the use of communal towels.

The second occurred in Wales in 1985 where 13% (19/143) of boys reported conjunctival symptoms. This outbreak was caused by an untypable *Streptococcus pneumoniae* but extensive investigations could not identify the mode of spread although person-to-person was the most likely route.

DISCUSSION

The outbreaks reviewed in this paper are not derived from a conventional formalized reporting system or a national epidemiological study and therefore are not necessarily representative of outbreaks in schools in general. Nevertheless, they reflect the range and severity of outbreaks in recent years – and the high attack rates that can occur – within this susceptible population. Outbreaks are recognized as a source of disorganization to school life and a recurring anxiety to both school authorities and parents. The school as an institution is well suited to the production and spread of epidemics since it is populated by few adults and large aggregates of children of an age at which they are highly susceptible to infection and where high levels of intimate contact and variable standards of personal hygiene may exist.

School normally marks the beginning of a child's entry into communal life. The earliest records of outbreaks in schools go back to the 15th century when plague was documented; it led to many deaths among pupils and staff and the closure of schools such as Eton College on several occasions. In the 18th century the most commonly reported outbreaks in schools were of smallpox and scarlet fever, then of measles, diphtheria, typhoid and influenza, the latter first reported in schools in 1743 [17]. The outbreaks featured in this 10-year review reflect the changing pattern of infectious diseases and the emergence of newly recognized diseases such as campylobacter infection and viral gastroenteritis.

This review has elicited several 'firsts' in relation to the epidemiological and microbiological investigation of outbreaks. The outbreak of streptobacillary fever

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in 1983 [14] was the first to be recorded in the UK. The outbreaks of yersiniosis, and campylobacter infection associated with free school milk [8] were the largest of their kind so far reported in the UK. The campylobacter outbreak associated with consumption of bore water [9] was the first in which both epidemiological and microbiological evidence has implicated the water supply as the vehicle of infection. Microbiological 'firsts' include the association of Fifth disease with parvovirus infection in 1983 [13] and the use of salivary testing for hepatitis A in 1988.

Most investigated outbreaks in this review were from schools in the maintained sector. However, when the total number of outbreaks reported through MOSA are included, the majority appear to have been in independent boarding schools (Table 1). The smaller proportion of known outbreaks from day schools reflects either the lack of a reporting scheme within the maintained day school sector or the possibility that boarding schools have a higher risk of outbreaks. A pilot scheme to determine the feasibility of monitoring illness in day school children was conducted by CDSC in 1983. It concluded that a surveillance scheme was not possible then because reasons for absence amongst this group of children depended on information supplied by parents, and required extensive administrative organization which the schools felt unable to provide on a regular basis. The MOSA/CDSC surveillance scheme has demonstrated not only the value of routine surveillance in boarding schools in detecting outbreaks, but also the important contribution made by a medical officer appointed to a school who is able to recognize and deal with any outbreak as soon as it occurs and institute control measures to prevent spread of infection. The close association between children in a boarding school may increase the risk of contracting infection but any observed illness will be treated under the same medical care, giving greater accuracy and consistency of diagnosis in an outbreak.

Although outbreaks have been investigated from both independent and maintained schools, ascertainment bias has resulted in the type of infections recorded tending to come from either one type of school or the other, but not from both. One explanation for this is the different age distributions found in the two sectors with the infections of measles, hepatitis and shigella, for example, mainly reported from children in the infant and junior age groups from maintained schools. Of the independent schools that report through the MOSA/CDSC scheme, 86% are for children in the 13–18 year age group. The increased risk of infection from a lower standard of hygiene in some maintained schools situated in socially deprived areas or the increased risk of exposure to infection associated with living in a closed community for boarders may also explain this observation. For instance, the large number of respiratory infections in the independent boarding schools probably reflects both the interest shown by school medical officers in these infections, and the higher levels of exposure to respiratory infection experienced by closed communities.

The second most commonly reported reason for illness in schools has been found to be upper respiratory tract infection. This review identified 15 investigated outbreaks which were due either to influenza or to other respiratory infections. In addition almost 100 outbreaks were reported through the MOSA/CDSC surveillance scheme. Annual school vaccination programmes against influenza

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now appear to be adopted less enthusiastically than in the 1960s and 1970s [18–20] and the most recent MOSA guidelines note that opinions remain divided on their continued use [21]. A survey in 1966 showed that only 11% of schools where vaccination was carried out experienced a serious influenza outbreak compared with 50% of schools that did not vaccinate its pupils [18]. However, Hoskins and colleagues in 1979, following studies into three separate outbreaks of influenza A in a large independent boarding school, concluded that annual revaccination with inactivated influenza A vaccine conferred no long term advantage [22]. The joint MOSA PHLS study of 1980–5 [23, 24] found that response to vaccine was related to the previous experience of the individual and that comparisons of vaccinated with unvaccinated children did not necessarily show any benefit from vaccine.

The Department of Health's annual recommendation on influenza vaccine stated in 1977 that the vaccine could be offered with advantage to children in residential schools. However, in 1983 it expressed doubt as to whether annual revaccination gave a high level of protection and in 1987 it concluded that it was not firmly established that repeated vaccination was efficacious for this group of the population [25]. Vaccination appeared to confer little or no protection in the outbreaks reviewed here and may possibly have delayed children acquiring natural immunity. The finding that attack rates from respiratory infection decreased with age could be due to natural immunity taking place or to younger children being more strictly supervised and therefore excluded from school more often than older children, or to dormitory arrangements within boarding schools which gave older children more opportunity for single bedrooms and thus less exposure to droplet spread of infection.

The greatest number of gastrointestinal outbreaks in this review were due to campylobacter infection. All were thought to be associated with either contaminated milk or water and reflected the finding that where the food source was known or suspected, milk was the most common vehicle of infection in unpublished outbreak reports to CDSC between 1984 and 1987. Closed or semi-closed communities such as boarding schools that obtain their milk from local farms or from their own dairy herds are obviously vulnerable to outbreaks of gastroenteritis if any contamination of the milk occurs. Small on-site pasteurization plants which cater for milk not reserved for bulk tank collection increase the risk of infection to the children when problems arise, such as the breakdown of the pasteurization process, the accidental mixing of the two kinds of milk or the inadvertent delivery of unpasteurized milk to schools. Two of the schools which had experienced outbreaks of campylobacter infection had small dairy farms in their grounds; in one the outbreak may have been prevented if pasteurization had not been carried out on site and in the other if the recommendations on milk supplies to schools in the MOSA handbook had been followed [26].

The number of outbreaks caused by contaminated drinking water was surprisingly high. Disruption of water supplies and/or the mixing of mains and spring or bore hole water clearly carries with it the risk of introducing contamination into the system, and like those outbreaks caused by unpasteurized milk, most could have been prevented if good practice in the treatment and storage of water in schools had been carried out.

In one of these outbreaks, of a rare infection of *Streptobacillus moniliformis*

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caused by the organism's excretion in rat's urine, two highly likely vehicles of infection were present. These were unpasteurized milk and contaminated spring water, and careful epidemiological investigation was required before it was possible to implicate one of them. The infection itself was characterized by septicaemia and arthritis, and it was fortunate that none of the pupils developed endocarditis, a known complication of this infection. This outbreak was the first to be recorded outside the USA [14, 27]. Although unpasteurized milk was not shown to be the cause of the outbreak it was noted that the school changed its supply to pasteurized milk.

All the reported outbreaks of hepatitis were in children who attended maintained infant and primary schools. Children between the ages of 0–9 years accounted for 20% (over 11000 cases) of the annual notifications of infective jaundice to the Office of Population, Censuses and Surveys (OPCS) in the years 1979–88 [28]. However outbreaks in schools other than point source appear to be difficult to recognize and difficult to investigate, particularly when serial transmission of the virus takes place over a long period which includes school holidays [29]. In only one point source outbreak was the vehicle of infection – iced buns, determined. This outbreak might have been avoided if the prepared foods from the children's cookery class had not been so widely distributed or if better hygiene had been practised in the classroom kitchen.

With most of the investigated outbreaks of hepatitis shown to be spread by person-to-person contact, personal hygiene and school toilet facilities were critical factors in preventing further infection in a susceptible population. However, in only three of these outbreaks were the toilet facilities observed to be less than adequate. Despite the comment in 1982 which followed a school outbreak in Birmingham that 'schools are becoming dirty and dangerous places' [30], with spending cuts by educational authorities and shortage of funds leading to a fall in hygiene standards, does not appear to have increased the number of outbreaks of hepatitis reported to CDSC. What does appear to be an important factor in the risk of outbreaks occurring in the future is that the present generation of school children have grown up in a period of improved standards of hygiene in the general population and a low incidence of disease [31]. This may have resulted in limited opportunity for them to acquire immunity at an early age as was indicated in one investigated outbreak by the high number of children found to be susceptible when their hepatitis antibody status was tested.

There were differences of opinion as to whether immunoglobulin should have been given in the hepatitis outbreaks. In one investigated outbreak it was not given because it was felt that the end of term would prevent further close contacts within the school; in another it was not thought to be of any help in that particular situation, and in a third the supply of immunoglobulin was believed to be scarce. Prevention of infection is dependent on stopping faecal-oral transmission and Benenson recommends immunoglobulin when an outbreak constitutes a high risk of faecal-oral spread such as might occur in schools for those with mental or physical handicaps or among groups of very young children [32]. In one outbreak reviewed here the collection of salivary samples from very young children proved to be a speedy and straightforward exercise which gave valuable information on antibody status in the risk groups concerned. The information gained from

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salivary testing, if it were to become a routine procedure in outbreaks, should form the basis for control measures and identifying the extent of the outbreak and the degree of secondary spread, as well as preventing the unnecessary administration of immunoglobulin to those found to be immune to infection [10, 11]. It should result in a more discerning use of immunoglobulin in future outbreaks.

The outbreaks of measles in schools highlighted the variable immunization rates in different parts of the country, with the outbreak in Wales affecting a large number of school children in an area with vaccine coverage well below the national average [12]. Legal enforcement of vaccination against measles before school entry is not necessary in England and Wales according to Noah [33]. We believe that an efficient administration system supported by motivated and informed medical and paramedical staff who involve parents in the vaccine campaign may be sufficient for the containment of measles. This method has been shown to be highly successful in some of the Scandinavian countries [33]. In the UK, measles coverage has now risen to 85% following the successful introduction of measles/mumps/rubells (MMR) vaccine (PHLS CDSC, unpublished data).

Although it is likely that the most serious school outbreaks were reported to CDSC, they nevertheless illustrate the potential for spread of infection in this group of the population. Many outbreaks were preventable. The large number of outbreaks of measles including the only reported death clearly indicates a need for us to maintain our efforts to encourage measles vaccination. Four outbreaks of tuberculosis involving 76 patients requiring treatment were also reported.

The important role played by the school doctors of the 19th century in improving the sanitation, diet, hours of study and the environmental conditions for children in schools is reflected in the high standards of hygiene found in schools of today. Local public health officials are looked to, in conjunction with educational authorities, for maintaining this high standard of hygiene, particularly through early reporting of outbreaks and the implementation of control measures. The valuable information derived from routine surveillance of infectious diseases in schools participating in the MOSA/CDSC scheme has been well demonstrated in this review since without it, many of the outbreaks would not have been detected. The results in this paper suggest that Medical Officers for Environmental Health/Consultants in Communicable Disease Control could quite properly place local schools under closer surveillance. A widening of this surveillance to include more schoolchildren in the younger age groups and also more children from day schools should lead to earlier detection and better control of outbreaks as they arise in the future. Finally, public health officials may need to consider their own policies on the use of vaccines and immunoglobulin for the prevention and control of outbreaks of infectious diseases in schools.

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