We examined some epidemiological features of the viruses associated with gastrointestinal illness, using national data reported by electron microscopists in the United Kingdom. During the 3 years analyzed (1985–1987), a total of 1,993 positive detections of astroviruses, caliciviruses, coronaviruses, and SRSVs were reported. In 1 year of this period, 8,210 rotaviruses were reported. More than 90% of the astroviruses and caliciviruses were detected in children under 5 years of age, while coronaviruses and SRSVs were detected in adults as well as children. Detections of astroviruses increased in the winter and were infrequent during the summer, a seasonal pattern similar to that observed for rotaviruses. There was some variability between reporting regions in rates of detection of fecal viruses. We have attempted to identify the reasons for this. We make suggestions for improving the detection of human fecal viruses, and we recognize the need for continued surveillance of these agents.

KEY WORDS: astrovirus, calicivirus, classification

INTRODUCTION

Viruses are recognized as frequent causes of sporadic diarrhea in young children and of outbreaks of diarrhea and vomiting in patients of all ages. Those implicated include rotaviruses, adenoviruses, astroviruses, caliciviruses, small round featureless viruses (SRVs), small round structured viruses (SRSVs), and coronaviruses. The SRSVs are a morphological group that includes those viruses most frequently associated with outbreaks: the Norwalk virus and other similar viruses [Caul and Appleton, 1982; Kapikian and Chanock, 1990]. The routine technique for diagnosing these infections is electron microscopy (EM), but the capital cost and technical difficulties have limited the availability of EM to comparatively few diagnostic laboratories. Alternative tests for two viruses (group A rotaviruses and adenoviruses of types 40 and 41) are now available, but EM remains the only catchall technique at present. Not surprisingly, epidemiologic data on most of these viruses are scanty and no national data have been published hitherto.

In the United Kingdom, the laboratories that form the Public Health Laboratory Service (PHLS) are distributed through England and Wales and, augmented by University and National Health Service laboratories in England, Northern Ireland, and Wales, report their positive fecal virus findings weekly to the Communicable Disease Surveillance Centre (CDSC) at Colindale, London. We have analyzed the reports to CDSC, which do not include results from Scotland, for the period 1985–1987, to identify any apparent epidemiological trends. Data on rotaviruses, astroviruses, caliciviruses, SRSVs, and coronaviruses have been included in the analysis. The compilation of these data, resulting from more than 50,000 EM observations annually, allowed a unique opportunity to examine aspects of the epidemiology of viral agents of gastroenteritis on a large scale. Observations from the U.K.
experience have formed the basis for a system about to be introduced in North America [Lew et al., 1990]. Information on the epidemiology of individual viruses could focus future investigations to identify specific risk groups of time, place, and person.

MATERIALS AND METHODS

Source of the Data

The data were compiled from the weekly reports to CDSC for the period January 1, 1985 through December 31, 1987. The specimens were stools from sporadic cases of gastrointestinal illness and from common-source outbreaks. There was no selection by age. The laboratories used a standardized nomenclature based on morphology (Fig. 1) to identify enteric viruses. Small round fecal viruses present particular problems of identification and were classified as astrovirus, calicivirus, or SRSV when compatible morphology was present (Table I). These viruses were distinguishable from other small round viruses, present in human fecal samples, which lacked identifiable surface morphology and were termed small round featureless viruses (SRVs). The featureless viruses have not been monitored in the U.K. reporting system. The PHLS EM Committee monitored the accuracy of the reports by reviewing micrographs submitted by the laboratories and by offering help and advice when it was sought. The same committee has an advisory role in the annual distribution of coded reference specimens provided by the PHLS as part of a national scheme (NEQAS).

Analysis was based on positive results, irrespective of whether they were from sporadic cases or outbreaks. The data are the mean of 3 years of reports (1985–1987), with the exception of the weekly data for SRVs, which are the average of reports from only 2 years (1986–1987). For comparative purposes, rotavirus detections were analyzed for a single season from July 1986 to June 1987. It is important to note that a proportion of rotaviruses will have been detected by other techniques, such as enzyme-linked immunosorbent assay (ELISA), latex agglutination, and polyacrylamide gel analysis, as well as by EM. Information on adenovirus detections was not compiled because specific identification of enteric serotypes (40 and 41) was not available.

Seasonal Distribution of Cases

Rotavirus detections in the United Kingdom were highest in the late winter and lowest in the late summer (Fig. 2), a pattern observed in many other temperate climates [Cook et al., 1990]. By comparison, astrovirus detections followed the same general pattern of winter peaks and summer troughs, but with greater scatter because of fewer detections. This pattern was observed in each of the 3 years analyzed (data not shown), although the week of maximum astrovirus detections varied from one year to another. The largest calicivirus peaks occurred during the winter, but peaks of summer activity were also detected, and the numbers were too small to produce a consistent pattern from year to year (data not shown). SRVs and coronavirus detections showed no distinct seasonal patterns.

Age Distribution of Cases

More than 90% of astroviruses and caliciviruses were detected in children under 5 years of age (Fig. 3), the majority in children under 1 year of age. By contrast, 40% of the SRVs and coronaviruses were detected in patients and >15 years of age.

Regional Detection Frequencies

The data were compiled at CDSC by standard National Health Service Regions. As information on the number of specimens examined was not available, incidence rates for the various agents could not be calculated. However, we have attempted to make comparisons between regions using their respective rotavirus detections as denominators. The derived figures, expressed as proportional detection rates, are shown in Table II. Differences in these ratios could indicate variability between regions in disease incidence or in the efficiency of detection of these viruses, provided that we assume that both the disease incidence and detection efficiency of rotavirus were relatively constant throughout the country.

For the 3-year period, the four other agents as a group were detected annually at 8.1% the frequency of rotavirus (664 vs. 8210 annual detections, Table II). There was considerable variation (up to 14-fold) in the proportional detection rates between regions. In some regions, individual viruses were detected at two to three times the national average, while in others particular viruses were never reported.

CONCLUSIONS

The first attempt to analyze aspects of national epidemiologic data on the viruses associated with gastrointestinal illness is reported. The data are derived from viruses found in the feces mainly of hospital inpatients. Most specimens were sent to the laboratory at the discretion of the clinician and probably represented a considerable underestimate of the true incidence. No attempt was made to allow for severity of illness, asymptomatic excretion, or variations in interest and technique between laboratories. Astroviruses and caliciviruses have morphological features that permit positive identification, but the distinguishing features of SRVs and coronaviruses are easily damaged, making recognition difficult. These figures therefore represent minimum observations, and only tentative conclusions can be drawn from them.

The proportional detection rates for these viruses varied from one region to another. This may have occurred for several reasons: differences in disease incidence; different research interests; variable commitment to, and facilities for, EM; variable interest and commitment of the clinicians, and the length of the lines of communication. It would therefore be unwise to speculate further. Moreover, it is inappropriate to
Fig. 1. Electron micrographs of enteric viruses. Micrographs of representative samples of the viruses detected in fecal specimens were prepared as a reference collection. All micrographs were printed at the same magnification. Bar = 100 nm.
TABLE I. Classification Scheme for Small Round Fecal Viruses*

| Group                     | Type                      | Surface features | Physical properties* | Hosts and examples                  |
|---------------------------|---------------------------|------------------|----------------------|-------------------------------------|
| Featureless viruses       |                           |                  |                      |                                     |
| Smooth entire edge;       | Enterovirus (SRV)         | 20–30 nm         | BD 1.34 g/cm³        | Human (poliovirus, hepatitis A)     |
| no surface structure      |                           | RNA genome       |                      |                                     |
|                           | Parvovirus (SRV)          | 18–26 nm         | BD 1.38–1.46 g/cm³   | Cat, dog, mink, cattle              |
|                           | Candidate parvoviruses (SRV) | 22–26 nm       | BD 1.38–1.40 g/cm³   | Human (Wollan, Ditchling, cockle, Paramatta) |
| Structured viruses        |                           |                  |                      |                                     |
| Surface structure         | Astrovirus                | 5–6 pointed      | BD 1.36–1.38 g/cm³   | Human (types 1–5), lamb             |
| and/or ragged outline     |                           | surface star     |                      |                                     |
|                           | Calicivirus               | Surface hollows, | BD 1.36–1.39 g/cm³   | Human (UK1–UK4, Sapporo), cattle,   |
|                           |                           | “star-of-David”  |                      | pig, dog                           |
|                           | Small round               | Amorphous surface, | RNA genome            | Human (Norwalk, Snow Mountain,      |
| structured virus (SRSV)   |                           | ragged outline   |                      | Hawaii, Taunton, Montgomery County) |

*Adapted from Caul and Appleton [1982].
*BD, buoyant density in cesium chloride.

Fig. 2. Seasonal distribution of enteric virus detections. Data represent the mean of three years of reports (1985–1987) except for SRSVs (2 years 1986–1987) and rotavirus (1 year 7/85–6/87). The total number of detections reported for each virus is indicated (N).

Fig. 3. Age distribution of enteric virus detections. Data represent the total of 3 years of reports (1985–1987). Those detections for which a patient age was unknown are not included. The total number of detections reported for each virus is indicated (N).
centers showed that although 11 of 375 specimens
shown to detect viruses in EM-negative specimens. A
proportional detection rates in Australia, in a study
particles were observed by direct EM [Matson et al.,
confirmed by immune electron microscopy (IEM), no
A winter increase in astrovirus detections was also
results suggest that antibody-enhanced EM methods
Astrovirus, like rotavirus, occurred more commonly
during the winter months, while calicivirus, SRSV, and
coronavirus did not exhibit obvious seasonal patterns.
A winter increase in astrovirus detections was also
observed in the 6-year Australian study [Grohmann,
1985]. Whether this pattern is related to serotypic
variations in pathogenicity, seasonal differences in
host susceptibility, modes of transmission, or some
other environmental factors remains to be determined.
Astrovirus and calicivirus were found almost exclu-
sively in samples from young children, specifically in
those under 1 year of age. This finding is consistent
with observations that acquisition of antibodies to
these agents occurs in early childhood [Kurtz and Lee,
1978; Grohmann, 1985; Kurtz and Lee, 1987; Nakata
et al., 1988]. By contrast, SRSV and coronavirus were
frequently found in adults as well as children. In the
case of SRSV, the observed age distribution was con-
sistent with these agents being frequently associated
with community outbreaks of gastroenteritis among
adults [Kapikian et al., 1990]. In such outbreaks in the
United Kingdom, it is normal that only a small number
of samples is examined and, of these, only a small
proportion (10–40%) is positive [Caul, 1988]; conse-
quently, there will be considerable underreporting. A
further problem is that many laboratories do not inves-
tigate outbreaks but concentrate on childhood diar-
Rhe. It follows that the age incidence of SRSVs plotted
in Figure 3 should not be overinterpreted.
The analysis demonstrates that a retrospective re-
porting system can provide an indication of the preva-
ence of fecal viruses in symptomatic patients. A more
complete understanding of the true incidence of these
viruses, particularly in asymptomatic excretion, would
require expensive and time-consuming prospective
studies. These should include collection of data to
define the age-specific incidence of infection, with or
without disease, and to establish the common signs and
symptoms associated with infection. Progress in en-
hancing the sensitivity of EM detection of these agents,
particularly of SRSVs, depends on the application of
immune techniques. The collection of paired serum and
stool samples will be essential in establishing stan-
dardized protocols for immune-enhanced detection and
for the development of new assays. Ultimately, more
sensitive diagnostic tests based on immunoassays will
be required for the diagnostic clinical laboratories
whilst molecular techniques such as hybridization
probes or the polymerase chain reaction will be needed
as research tools to permit studies on the etiology of
gastroenteritis.

TABLE II. Proportional Detection of Novel Viral Agents of Gastroenteritis

| Region          | Rotavirus 7/86-6/87 N | Proportional detection ratea for viruses |
|-----------------|-----------------------|-----------------------------------------|
|                 |                       | Astro | Calici | SRSV | Corona | Total |
| Northern        | 293                   | 4.8   | 0.7   | 2.4  | 0.2   | 8.1   |
| Yorkshire       | 1,087                 | 0.0   | 0.0   | 1.2  | 0.3   | 1.5   |
| Trent           | 825                   | 1.3   | 0.5   | 1.2  | 0.4   | 3.4   |
| E. Anglia       | 238                   | 0.0   | 0.8   | 1.1  | 0.0   | 1.9   |
| Thames          | 2,149                 | 3.2   | 1.3   | 2.5  | 0.7   | 7.7   |
| Wessex          | 294                   | 2.6   | 0.1   | 3.9  | 0.0   | 6.6   |
| Oxford          | 268                   | 7.5   | 0.6   | 12.7 | 0.4   | 21.2  |
| S. Western      | 545                   | 6.5   | 1.0   | 11.0 | 2.1   | 20.6  |
| W. Midlands     | 1,197                 | 1.5   | 0.1   | 1.9  | 0.2   | 3.7   |
| Mersey          | 213                   | 4.9   | 0.5   | 8.6  | 1.1   | 15.1  |
| N. Western      | 853                   | 5.5   | 2.8   | 5.3  | 2.3   | 15.9  |
| Wales           | 136                   | 3.4   | 0.2   | 2.5  | 0.0   | 6.1   |
| N. Ireland      | 112                   | 10.1  | 0.0   | 4.5  | 0.0   | 14.6  |
| Overall rate    |                       | 3.0%  | 0.9%  | 3.5% | 0.7%  | 8.1%  |
| Total detectionsb | 8,210                 | 741   | 271   | 863  | 178   | 1,993 |

a Proportional detection rate = mean annual detections × 100/rotavirus detections.
b Single season detections for rotavirus. Total of 3-year detections for novel viral agents.
Data from routine specimens will always be incomplete as compared with detailed prospective surveys. Nevertheless, the results presented here provide some indications of the disease-associated activity of these viruses. Comparison with the data from the newly instituted North American system will prove both interesting and instructive.

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