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Viral pathogens are the most common cause of gastroenteritis in industrialized countries (1,2). Mead et al. have estimated that of the 38.6 million annual cases of gastroenteritis in the United States, 30.8 million (80%) are the result of viral infections (3). Enteric viral pathogens include Rotavirus A, Astrovirus, adenovirus, and Sapovirus, but most viral gastroenteritis infections are caused by Norovirus (formerly Norwalk-like viruses) (1–3). The use of molecular diagnostics including reverse-transcriptase polymerase chain reaction (RT-PCR) and antigen detecting enzyme immunoassays (EIA) (4–20) have changed researchers’ understanding of the epidemiology of human Caliciviridae (including Norovirus and Sapovirus) (21). For example, using RT-PCR assays, Pang et al. showed that caliciviruses were as common a cause of infection as rotaviruses among children <2 years of age (22).

In addition, many reports have established the importance of noroviruses as a cause of outbreaks of food- and waterborne illness (23–28), though estimates of the proportion of infection spread by these modes vary widely: from 14% in England and Wales (29) to <40% in the United States (7). While person-to-person transmission is probably the mode of infection of most cases, food- and waterborne infections may be of particular importance since these outbreaks have the potential to involve large numbers of people and wide geographic areas and, perhaps, to introduce new variants to an area (30).

A research network to study foodborne viruses in Europe was recently funded by the European Union. Through this project, the participant institutes have networked their virologic and epidemiologic surveillance in order to detect transnational outbreaks, elucidate transmission routes, and make international comparisons of the epidemiology of viral gastroenteritis. We chose to study outbreaks rather than community cases because viral gastroenteritis is a very common infection (1); therefore, enumeration of epidemics (or outbreaks) may be more practical and useful since individual cases are poorly reported (31). International comparisons of surveillance data are difficult because criteria for effective surveillance customarily varies across borders (32).

The objective of this survey was to capture information on the structure of outbreak surveillance in each country (including sources of data and definitions employed) and to gain estimates of the frequency of outbreaks, as well as to compare the setting of outbreaks, the importance of foodborne transmission, and the use of characterization techniques. We present surveillance data from viral gastroenteritis outbreaks from 1995 to 2000 collected by participant European countries. These data provide baseline information for future harmonization and comparison efforts.

Methods

A questionnaire was sent by e-mail to the project leaders of the 13 participant institutions (from 10 countries) in the Foodborne Viruses in Europe group. The questionnaire, administered in English, was developed and completed in collaboration with research and medical virologists and epidemiologists working in viral gastroenteritis surveillance. General information on surveillance systems (including sources of data, estimate of national population under surveillance, definition of a viral gastroenteritis outbreak, and number of such outbreaks investigated) was collected for the period 1995–2000. More detailed epidemiologic data (setting, mode of
transmission, and implicated food vehicles) were collected from outbreaks that occurred in 2000. Contributors were sent a summary report and asked to confirm that the data presented accurately represented their surveillance.

Results

Data Sources of Surveillance Systems

One completed survey questionnaire was received from all 10 countries. A range of sources contributed data on viral gastroenteritis outbreaks for European surveillance systems (Table 1), including diagnostic reference laboratories, local public health staff, food inspectorates, and physicians. We derive our data from routine surveillance except for Germany, where systematic national surveillance was not operational during the survey period. German data were collected from laboratories that performed RT-PCR diagnostics in the surveyed period. The same applies to the Netherlands, Finland, and Sweden, although the collaborating centers in these countries run the sole reference laboratory service.

Outbreak Definition and Geographic Coverage of Surveillance Systems

All surveillance systems reported data collected on outbreaks from the whole population of their respective countries except for Italy, where a small geographically convenient sample of approximately 1% of the population was covered by surveillance (Table 2). Both the criteria and the use of outbreak definitions differed among the surveillance systems (Table 2). Some systems collected information only on incidents that met a specific definition; other systems collected information on all incidents and then applied definitions retrospectively for analysis. Some surveillance systems required laboratory confirmation to attribute an outbreak to an enteric viral pathogen.

Table 1. Sources of information of viral gastroenteritis surveillance systems in the Foodborne Viruses in Europe network

<table>
<thead>
<tr>
<th>Country</th>
<th>Diagnostic microbiology laboratory</th>
<th>Food safety inspectorate</th>
<th>Physician/ patient reports</th>
<th>Local/regional public health authority</th>
<th>Type of outbreaks reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Yes</td>
<td>Food/waterborne</td>
</tr>
<tr>
<td>France</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Yes</td>
<td>Food/waterborne</td>
</tr>
<tr>
<td>England and Wales</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Yes</td>
<td>All</td>
</tr>
<tr>
<td>Italy</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Yes</td>
<td>All</td>
</tr>
<tr>
<td>Finland</td>
<td>Yes&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td>All</td>
</tr>
<tr>
<td>Sweden</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>All</td>
</tr>
<tr>
<td>Germany</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Yes&lt;sup&gt;b&lt;/sup&gt;</td>
<td>All</td>
</tr>
<tr>
<td>Slovenia</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Yes</td>
<td>All</td>
</tr>
<tr>
<td>Spain</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Yes</td>
<td>All</td>
</tr>
<tr>
<td>the Netherlands&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Yes</td>
<td>All&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Participant is sole laboratory performing viral testing, and coordination is conducted at National Public Health Laboratory and National Food Administration.

<sup>b</sup>Norovirus became a reported disease in January 2000. From 1997 to 2000, reports from local health departments were collected unsystematically.

<sup>c</sup>Dutch national data were collected from three systems: notification system, food safety inspectorate, and laboratory-based system (from diagnostic microbiology laboratories, local/ regional public health authorities, physician/patient reports, and other institutions in which outbreaks occurred).

<sup>d</sup>Foodborne only for systems 1 and 2.

Among systems requiring laboratory confirmation, a range of stringency existed from at least one positive sample (England and Wales) to half of all stools positive for virus (Finland and the Netherlands).

Outbreaks Investigated

Outbreak reports were available from the entire surveyed period (1995–2000) from a few countries: England and Wales, Slovenia, Spain, the Netherlands, and Sweden. The overall numbers of outbreaks investigated ranged from 2 in Italy to 1,643 in England and Wales (Table 3).

National outbreak reporting rates for each country were calculated by dividing annual outbreaks by national population (Figure 1). Rates in Sweden (9–22 outbreaks/million in population) were markedly higher than in any other country. In most countries, approximately 3–7 outbreaks per million population were ascertained annually. Since 1997, outbreak reporting rates have been increasing in most countries.

Completeness of Basic Epidemiologic Data

Participants were asked how many of the outbreaks reports from the year 2000 included details on first date of onset, last date of onset, number of persons ill, number of persons hospitalized, number of related deaths, and setting of the outbreak. Completeness of these data differed substantially between countries: none of the data were available from Sweden, whereas data were almost 100% complete for all categories in England and Wales, Denmark, and Slovenia (Figure 2).

Setting of Outbreaks

The settings where reported outbreaks occurred differed substantially by country (Figure 3). In England and Wales, Spain, and the Netherlands, most reported outbreaks occurred in hospitals and residential homes (78%, 64%, and 66%, respectively).
respectively), whereas in Denmark, 13 (76%) of 17 reported outbreaks occurred in food outlets. In Denmark, surveillance is done by the Food Safety Inspectorate, which collects reports of suspected foodborne outbreaks only. The Inspectorate is not informed of person-to-person spread outbreaks, which are more commonly seen in residential institutions and hospitals.

In Slovenia, the majority of reported outbreaks occurred in day-care centers (10/14; 71%), and in France, most reported outbreaks occurred in private houses (7/9; 78%). In France, reporting was recommended only for large outbreaks or if oysters, an item commonly consumed in French households, were the suspected vehicle of infection.

### Food and Water as Sources of Outbreaks

Among countries conducting broad-based outbreak surveillance, the following proportions of viral gastroenteritis outbreaks were reported to be associated with food- or waterborne transmission: Finland (24%), the Netherlands (17%), Slovenia (14%), Spain (7%), and England and Wales (7%) (Table 4). Very rarely was laboratory evidence (detection of the same organism in the vehicle and stool specimens) or statistical evidence (case-control or cohort) available that demonstrated the association of the vehicle with illness. During the survey period, Danish and French surveillance almost exclusively focused on outbreaks transmitted through food and water. Therefore, estimates of the proportion of food and water

### Table 2. National coverage and use of clinical definitions for viral gastroenteritis by European surveillance systems

<table>
<thead>
<tr>
<th>Country</th>
<th>National coverage %a</th>
<th>Definition of viral gastroenteritis outbreakb</th>
<th>Laboratory confirmation required</th>
<th>Outbreak definition applied</th>
<th>As entry criteria in database</th>
<th>Retrospectively for analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>100</td>
<td>Kaplan’s, shellfish</td>
<td>Always</td>
<td>Always</td>
<td>Always</td>
<td>Always</td>
</tr>
<tr>
<td>England and Wales</td>
<td>100</td>
<td>General</td>
<td>Yes</td>
<td>Always</td>
<td>Never</td>
<td>Always</td>
</tr>
<tr>
<td>Finland</td>
<td>100</td>
<td>Clinical</td>
<td>Yes</td>
<td>Always</td>
<td>Never</td>
<td>Always</td>
</tr>
<tr>
<td>France</td>
<td>100</td>
<td>Clinical, shellfish</td>
<td>Yes</td>
<td>Always</td>
<td>Never</td>
<td>Always</td>
</tr>
<tr>
<td>Germany</td>
<td>100</td>
<td>Clinical</td>
<td>Yes</td>
<td>Always</td>
<td>Sometimes</td>
<td>Always</td>
</tr>
<tr>
<td>Italy</td>
<td>1</td>
<td>Clinical</td>
<td></td>
<td>Always</td>
<td>Always</td>
<td>Always</td>
</tr>
<tr>
<td>Slovenia</td>
<td>100</td>
<td>Clinical</td>
<td>Yes</td>
<td>Always</td>
<td>Sometimes</td>
<td>Sometimes</td>
</tr>
<tr>
<td>Spain</td>
<td>100</td>
<td>General</td>
<td>Yes</td>
<td>Always</td>
<td>Sometimes</td>
<td>Always</td>
</tr>
<tr>
<td>Sweden</td>
<td>100</td>
<td>Kaplan’s, clinical</td>
<td>Yes</td>
<td>Always</td>
<td>Sometimes</td>
<td>Always</td>
</tr>
<tr>
<td>Netherlands</td>
<td>100</td>
<td>System 1: clinical</td>
<td>Yes</td>
<td>Always</td>
<td>Sometimes</td>
<td>Always</td>
</tr>
</tbody>
</table>

aRefers to geographic coverage by surveillance, not completeness of reporting.
bKaplan’s criteria for recognition of Norovirus outbreaks (33); clinical, clinical criteria (different from Kaplan’s) specifying that cases must be clustered in time and place; general, general definition used for all outbreaks of gastroenteritis with laboratory confirmation required to attribute outbreak to viral pathogen; shellfish, specific criteria used for identifying shellfish outbreaks.

### Table 3. Reported outbreaks of viral gastroenteritis, European surveillance, 1995–2000

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>390</td>
<td>13</td>
<td>1</td>
<td>34</td>
<td>54</td>
<td>227</td>
<td>135</td>
<td>227</td>
<td>450</td>
</tr>
<tr>
<td>England and Wales</td>
<td>64</td>
<td>50</td>
<td>172</td>
<td>603</td>
<td>428</td>
<td>227</td>
<td>135</td>
<td>227</td>
<td>450</td>
</tr>
<tr>
<td>Finland</td>
<td>4</td>
<td>9</td>
<td>7</td>
<td>8</td>
<td>19</td>
<td>28</td>
<td>1 (14)b</td>
<td>5 (71)b</td>
<td>43</td>
</tr>
<tr>
<td>France</td>
<td>1</td>
<td>53</td>
<td>145</td>
<td>58</td>
<td>58</td>
<td>227</td>
<td>227(100)</td>
<td>227</td>
<td>450</td>
</tr>
<tr>
<td>Germany</td>
<td>0</td>
<td>6</td>
<td>8</td>
<td>14</td>
<td>5</td>
<td>14</td>
<td>8 (57)</td>
<td>6 (43)c</td>
<td>45</td>
</tr>
<tr>
<td>Italy</td>
<td>37</td>
<td>24</td>
<td>25</td>
<td>66</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>236</td>
</tr>
<tr>
<td>Slovenia</td>
<td>1</td>
<td>53</td>
<td>145</td>
<td>58</td>
<td>58</td>
<td>227</td>
<td>135</td>
<td>227</td>
<td>450</td>
</tr>
<tr>
<td>Spain</td>
<td>4</td>
<td>9</td>
<td>7</td>
<td>8</td>
<td>19</td>
<td>28</td>
<td>1 (14)b</td>
<td>5 (71)b</td>
<td>43</td>
</tr>
<tr>
<td>Sweden</td>
<td>81</td>
<td>130</td>
<td>130</td>
<td>130</td>
<td>190d</td>
<td>195</td>
<td>190(97)</td>
<td>190</td>
<td>386</td>
</tr>
<tr>
<td>the Netherlands</td>
<td>25</td>
<td>69</td>
<td>54</td>
<td>36</td>
<td>98</td>
<td>59</td>
<td>5 (13)d</td>
<td>8 (57)c</td>
<td>236</td>
</tr>
</tbody>
</table>

aNumber of outbreaks attributed to organism (percentage of year 2000 outbreaks).
bBased on seven laboratory-confirmed viral outbreaks.
cBased on 14 laboratory-confirmed viral outbreaks.
dApproximate figures.
eBased on 38 laboratory-confirmed viral outbreaks.
transmission from these countries cannot be compared to the
general estimates in other countries.

Molecular Characterization Techniques

Different molecular techniques were used by participating
institutes to characterize virus from outbreaks in 2000. Reverse line blot was used in the Netherlands and Spain, and
the heteroduplex mobility assay was used in England and
Wales. Sequence analysis was performed in England and
Wales, Finland, France, Italy, Germany, Spain, and the Nether-
lands; EIA were used in England and Wales, and a microplate
hybridization technique was used in Finland.

Discussion

Viral gastroenteritis infection, typically a self-limiting con-
dition of short duration in humans, is extremely common and
associated with relatively few deaths. Surveillance of out-
breaks of this infection, rather than individual cases, may be
more appropriate. In our review of the surveillance for this
infection in Europe, we found variations in the organizations
conducting surveillance, the surveillance definition of a viral
gastroenteritis outbreak, the populations under surveillance,
and the completeness of descriptive and analytical epidemio-
logic and diagnostic information.

Researchers comparing surveillance information at an
international level should consider the outputs of surveillance,
as well as the influence of methodology and structure of sur-
veillance on these outputs. Surveillance for viral gastroenteri-
tis in Europe is poorly developed; systems vary in their
sources of data, definitions, and use of diagnostic techniques.
These differences are reflected in the wide range of numbers
of outbreaks, population-based rates, and epidemiologic pat-
ters observed across Europe. Nonetheless, our comparison of
this surveillance data was an informative exercise because
international epidemiologic databases of viral gastroenteritis
infections have not been developed. In many of the countries
included in the Foodborne Viruses in Europe network, viral
gastroenteritis has not been considered a priority, and these
countries do not have a well-developed surveillance system.
This inventory of surveillance data will aid in the developmen-
t of a more consistent and complete surveillance across Europe.

These data clearly show that both the absolute number and
the population-based rates of viral gastroenteritis outbreaks
differ substantially between European surveillance systems.
From 1995 to 2000, 1,643 outbreaks of viral gastroenteritis
were investigated by the Public Health Laboratory Service in
England and Wales, but the outbreak rates (number of out-
breaks/population) were highest in Sweden for every surveyed
year. Some variation in these figures occurred because a num-
ber of the surveillance systems required laboratory confirma-
tion while others did not (Table 2). However, the criteria
suggested by Kaplan et al. to recognize an outbreak of viral
etiology is widely used and is generally accepted as an effec-
tive clinical tool in the absence of diagnostic information (33).
Interestingly, surveillance systems with the most stringent out-
break criteria, including laboratory confirmation of outbreaks
(England and Wales, Finland, and Sweden) ascertained the
most outbreaks, likely because surveillance in these countries
is more developed and integrated better with reporting bodies.

However, even the surveillance systems with the highest
figures greatly underascertain viral gastroenteritis. A study of
infectious intestinal disease in England and Wales estimated
that only 1/300–1,500 cases of Norovirus gastroenteritis are
reported to national surveillance (34). For a case to be ascer-
tained by national surveillance, patients must be examined by their primary-care doctor, a specimen must be taken and submitted for laboratory testing, the test must be positive (the amount of false negatives will depend on the diagnostic technique), and the surveillance unit must be notified. Ascertaining outbreaks requires an additional step in which investigators must recognize epidemiologic links between cases. While this chain of events will differ from country to country, the principle of underascertainment affects all surveillance. However, outbreak recognition and investigation will, through case finding, lead to better ascertainment of persons affected in outbreaks.

Although most surveillance systems may be designed for national coverage, reports were incomplete to a varying degree. Ascertained outbreaks varied geographically and were incomplete, as demonstrated by the large variation in reported outbreaks (Table 3).

This survey found that the great majority of European viral outbreaks could be attributed to Norovirus. In Denmark, England and Wales, Finland, France, and Sweden, >95% of nonbacterial outbreaks were attributed to noroviruses as were 84% of outbreaks in the Netherlands. The relative number of infections from noroviruses was lower in Slovenia (43%) and Spain (57%), although these estimates are based on a small number of outbreaks (n=14 for both). These figures are consistent with previous reports that Norovirus could be detected in 91% of all nonbacterial infectious intestinal disease outbreaks in the Netherlands (9) and 89% of such outbreaks in Sweden (35). Similarly, Fankhauser et al. found Norovirus responsible for 96% of nonbacterial outbreaks in the United States (7).

Estimates of the importance of foodborne transmission also varied widely in this survey. Foods were implicated as the vehicle of transmission in 16 (94%) of 17 outbreaks in Denmark and 28 (100%) of 28 outbreaks in France because surveillance systems in these countries were designed to detect foodborne disease. In countries with more general outbreak data, estimates of foodborne transmission were lower: 7 (17%) of 41 in the Netherlands, 14 (24%) of 58 in Finland, and 20 (7%) of 290 in England and Wales, although laboratory and statistical evidence of association with food or water was scant.

The settings of outbreaks also reflected the proportion of reported outbreaks that were ascertained to be foodborne. For example, in Denmark, 75% of all reported outbreaks were set in food outlets. In Spain, the Netherlands, and England and Wales, most reported outbreaks occurred in residential homes and hospitals, with only a small fraction occurring in food outlets.

In Finland, the National Public Health Laboratory is the only facility in the country testing for Norovirus and, therefore, is aware of all such investigations. Most other surveil-

### Table 4. Foodborne transmission and supporting evidence of implicated food vehicles, European surveillance, 2000

<table>
<thead>
<tr>
<th>Country</th>
<th>Total outbreaks</th>
<th>Food/waterborne outbreaks (%)</th>
<th>Laboratorya</th>
<th>Statisticalb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>17</td>
<td>16 (94)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>England and Wales</td>
<td>290</td>
<td>20 (7)</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Finland</td>
<td>58</td>
<td>14 (24)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>France</td>
<td>28</td>
<td>28 (100)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Germany</td>
<td>227</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>2</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>14</td>
<td>2 (14)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Spain</td>
<td>14</td>
<td>1 (7)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Sweden</td>
<td>190</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>the Netherlands</td>
<td>41</td>
<td>7 (17)</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

aSame organism found in stool specimen and food vehicle.
bStatistically significant result from cohort or case-control study.
Timely feedback of surveillance data to participants is an essential step in the cycle of continued improvement of a surveillance system (41) that we have made possible through this European Union–funded network. In addition to describing the current state of viral gastroenteritis surveillance in Europe, this report will act as a baseline to interpret prospective outcomes of the Foodborne Viruses in Europe network.

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Mr. Lopman is an epidemiologist at the Gastrointestinal Diseases Division of the Public Health Laboratory Communicable Disease Surveillance Centre. He coordinates the epidemiologic surveillance for the Foodborne Viruses in Europe consortium.

References

RESEARCH


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Address for correspondence: Ben Lopman, Gastrointestinal Diseases Division, Communicable Disease Surveillance Centre, 61 Colindale Avenue, London, England NW9 5EQ; fax: +44 208 200 7868; e-mail: blopman@phls.org.uk

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