Antimicrobial Resistance of Diarrheagenic Escherichia coli
Isolated from Children under the Age of 5 Years
from Ifakara, Tanzania

JORDI VILA,1* MARTHA VARGAS,1 CLIMENT CASALS,1 HONORATO URASSA,2
HASSAN MSHINDA,2 DAVID SCHELLEMBERG,2 AND JOAQUIM GASCON1

Departament de Microbiologia, Hospital Clinic, IDIBAPS (Institut d’Investigacions Biomèdiques August Pi i Sunyer),
Barcelona 08036, Spain, 1 and Ifakara Health Research and Development Centre, National Institute
for Medical Research, Ifakara, Tanzania2

Received 15 June 1999/Returned for modification 16 August 1999/Accepted 2 October 1999

Diarrhea caused by multidrug-resistant bacteria is an important public health problem among children in
developing countries. The prevalence and antimicrobial susceptibility of diarrheagenic Escherichia coli in 346
children under 5 years of age in Ifakara, Tanzania, were studied. Thirty-eight percent of the cases of diarrhea
were due to multiresistant enteroenterotoxigenic E. coli, enteropathogenic E. coli, enteroaggregative E. coli, Strains
of all three E. coli categories showed high-level resistance to ampicillin, tetracycline, co-trimoxazole, and
chloramphenicol but were highly susceptible to quinolones. Guidelines for appropriate use of antibiotics in
developing countries need updating.

Diarrhea caused by multidrug-resistant bacteria has been recognized as an important public health problem among children in
developing countries and is a research priority of the diarrheal disease control program of the World Health Orga-
nization. Among these bacteria, strains of the different diarrheagenic categories of Escherichia coli, such as enterotoxi-
genic E. coli (ETEC), enterohemorrhagic E. coli (EHEC), enteropathogenic E. coli (EPEC), enteroaggregative E. coli, and
enteroaggregative E. coli (EAggEC), are among the most important causes of acute enteritis and subsequent morbidity and
mortality in children in developing countries (4). Knowledge of local antimicrobial therapy patterns is important in selecting
the appropriate therapy, since even if microbiology laboratory facilities are available, which is not the case in most of the
developing countries, susceptibilities will generally not be known until 72 h after the sample is processed. Acute enteritis is a widespread health problem in these countries and is an important cause of mortality among infants and young chil-
dren. In Ifakara, Tanzania, children with acute diarrhea are treated by oral rehydration plus administration of an antibiotic
(currently co-trimoxazole). Therefore, since many patients with enteritis are treated empirically with antibiotics, it is im-
portant to know the antimicrobial resistance patterns of the most prevalent bacteria causing this syndrome.

The main objective of this study was to analyze the prevalence of diarrheagenic E. coli as a cause of diarrhea in children under the age of 5 years in Ifakara, Tanzania, as well as to study the susceptibilities of these isolates to six antimicrobial
agents.

Stool specimens from 346 children under 5 years of age from Ifakara, Tanzania, who presented with acute diarrhea were
cultured for E. coli and other enteropathogens by conventional methods in the microbiology laboratory of the Ifakara Center
(from April to June 1998). The identified strains were kept on conservation agar. Detection of the virulence factors of E. coli
strains and susceptibility testing were performed in the clinical

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* Corresponding author. Mailing address: Laboratori de Microbiologia, Hospital Clinic, Villarroel 170, 08036 Barcelona, Spain. Phone: 34.93.2275522. Fax: 34.93.2275454. E-mail: vila@medicina.ub.es.
TABLE 1. Antimicrobial susceptibilities of different diarrheagenic \( E. \) coli isolates from children under 5 years of age in Ifakara, Tanzania

<table>
<thead>
<tr>
<th>Antimicrobial agent</th>
<th>MICs for EAggEC (( n = 65 ))</th>
<th>MICs for ETEC (( n = 44 ))</th>
<th>MICs for EPEC (( n = 21 ))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIC(_{50})</td>
<td>MIC(_{90})</td>
<td>No. of resistant strains (%)</td>
</tr>
<tr>
<td>Ampicillin</td>
<td>&gt;256</td>
<td>&gt;256</td>
<td>54 (83.1%)</td>
</tr>
<tr>
<td>Chloramphenicol</td>
<td>&gt;256</td>
<td>&gt;256</td>
<td>37 (57%)</td>
</tr>
<tr>
<td>Tetracycline</td>
<td>&gt;256</td>
<td>&gt;256</td>
<td>57 (87.7%)</td>
</tr>
<tr>
<td>Co-trimoxazole</td>
<td>&gt;32</td>
<td>&gt;32</td>
<td>59 (90.8%)</td>
</tr>
<tr>
<td>Nalidixic acid</td>
<td>6</td>
<td>12</td>
<td>1 (1.5%)</td>
</tr>
<tr>
<td>Ciprofloxacin</td>
<td>0.008</td>
<td>0.012</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

* \( n \), total number of clinical isolates tested.

Results for the antimicrobial susceptibility testing of the different categories of diarrheagenic \( E. \) coli strains are shown in Table 1. For all three categories of diarrheagenic \( E. \) coli, the MICs of ampicillin, tetracycline, and co-trimoxazole at which 50% of the isolates tested were inhibited (MIC\(_{50}\)) were >256 \( \mu g/ml \). Chloramphenicol showed moderate activity, with resistance ranging from 25 to 57%; the MIC\(_{50}\) of chloramphenicol were 4 \( \mu g/ml \) for ETEC and EPEC and >256 \( \mu g/ml \) for EAggEC. Nalidixic acid and ciprofloxacin had very good activity against these microorganisms; however, one EAggEC strain and one ST-producing ETEC strain showed resistance to nalidixic acid, with MICs of 32 and 256 \( \mu g/ml \), respectively. Recently, Sang et al. (8) described four cases of diarrhea caused by multidrug-resistant EAggEC in Kenyan children. It was therefore reasonable to predict that this multiresistance pattern might emerge in other developing countries where classical antibiotics (ampicillin, tetracycline, and trimethoprim-sulfamethoxazole) have been widely used. It has been shown that the treatment of diarrhea caused by ETEC with antibiotics, specifically co-trimoxazole, decreases the duration and intensity of the diarrhea (1). However, in our study, ETEC exhibited high-level resistance to this antimicrobial agent. According to the antibiogram, different resistance patterns were defined (Table 2) in the three categories of diarrheagenic \( E. \) coli, with Amp\(^r\) Cm\(^r\) Te\(^r\) Sxt\(^r\) NaI\(^r\) Cip\(^r\) and Amp\(^r\) Cm\(^r\) Te\(^r\) Sxt\(^r\) NaI\(^r\) Cip\(^r\) being the two most prevalent multiresistance patterns.

Acute or chronic enteritis due to the different categories of \( E. \) coli, mainly ETEC and EAggEC, is an emerging problem in many parts of the world (4). It has been estimated that 9.2 million deaths in the developing world have been caused by infectious diseases, and diarrheal diseases are the fourth most prevalent cause (3). Most mild diarrhea cases are successfully managed with oral rehydration therapy. Only for more severe or persistent diarrhea cases should antimicrobial treatment be added. Ampicillin and cotrimoxazole have been recommended by the World Health Organization. Local information about antimicrobial resistance should be used in clinical management, and treatment guidelines should be updated (10). In this sense, ampicillin and co-trimoxazole should be excluded. One alternative for enteritis treatment is the use of quinolones. However, they are not recommended for children. Moreover, it should be taken into consideration that in spite of the minimal use of quinolones in Tanzania, we have detected nalidixic acid-resistant \( E. \) coli strains. If quinolones are used as a first-line treatment for enteritis in these countries, where the use of antibiotics is not regulated, a rapid emergence of quinolone resistance will likely occur. Rifaximin is a nonabsorbable antimicrobial agent which has been shown to be effective as a treatment for severe episodes of bacterial diarrhea in children in developed countries (2). However, studies to assess the role of this antimicrobial agent in the treatment of ETEC or EAggEC infections in children from developing countries are needed.

This work was supported in part by grant SAF97/0091 from Plan Nacional I+D, Spain, and by the Spanish Agency for International Co-operation (AECI-1042).

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2. Frisari, L., V. Viggiano, and M. Pelagalli. 1997. An open controlled study of two non-absorbable antibiotics for the oral treatment of paediatric infectious studies in developing countries (4). Several studies have also shown the importance of EAggEC and EPEC as a cause of diarrhea in children (5). In our study, only one EHEC strain, producing verotoxin-2, was isolated. This result is in agreement with previous studies in which EHEC strains were not found (4). Overall, 38% of diarrhea cases in children under 5 years of age are due to multiresistant diarrheagenic \( E. \) coli, with ETEC, EAggEC, and EPEC strains being the most prevalent.

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