Helicobacter pylori is currently recognized as one of the most common chronic bacterial infections worldwide (6). While the majority of infections are asymptomatic (12, 13), the association of H. pylori colonization of the stomach with chronic gastritis, peptic ulcer disease, and gastric malignancies is now well documented in both adults and children (11, 18). Eradication of bacteria is effective in healing peptic ulcers, preventing ulcer relapses, and potentially decreasing the risk of progression to gastric carcinoma (7, 9, 16). Current practice dictates treatment of symptomatic individuals with a regimen containing two antimicrobial agents along with a proton pump inhibitor (18). For successful eradication of bacteria, it is imperative that the clinician be aware of the current antimicrobial susceptibility profiles of isolates within the region. Therefore, this study was initiated to determine antimicrobial susceptibility patterns among H. pylori isolates recovered from children in Egypt.

Children aged 2 to 17 years requiring endoscopy for evaluation of their gastrointestinal complaints were enrolled in this study. Prior to endoscopy, written informed consent was obtained from the parent of the study subject allowing their child to be enrolled. Children who had taken antimicrobials, antacids, H2 blockers, proton pump inhibitors, or bismuth subsalicylate within the 4 weeks prior to endoscopy were excluded from the study. Similarly, children with a history of infection with H. pylori, a known bleeding disorder, or previous endoscopy were also excluded from the study. At the time of endoscopy, a gastric antral biopsy sample was obtained for culture and stored in normal saline on ice until delivered to the laboratory within 2 to 3 h of collection. The biopsy sample was ground to a fine suspension using a sterile, disposable plastic pestle and inoculated onto Columbia agar (Campy-Pak Systems; Becton Dickinson, BBL, Cockeysville, Md.) plates enriched with 5% sheep blood. Plates were allowed to dry for 15 min at room temperature prior to addition of E-test strip.

After 5 days of incubation, the MICs were determined as the point where the elliptical zone of complete inhibition of all bacterial growth, including hazes and isolated colonies, intersected the MIC scale on the strip. When growth occurred along the entire strip, the MIC was reported as greater than the highest value on the reading scale. Alternatively, when the inhibition ellipse was below the strip and did not intersect it, the MIC was reported as less than the lowest value on the reading scale. Antimicrobial susceptibility testing results are presented in Table 1. High-level resistance to metronidazole was defined as an MIC of ≥8 \( \mu \text{g/ml} \), while resistance to erythromycin, clarithromycin, azithromycin, ciprofloxacin, ampicillin, and metronidazole was tested by using antimicrobial impregnated strips (E-test; AB Biodisk, Solna, Sweden). H. pylori isolates were thawed, inoculated onto Columbia agar, and incubated as outlined above. After incubation, bacteria were harvested, suspended in sterile saline to McFarland standard 3 per the manufacturer’s instructions, and then inoculated onto Columbia agar plates enriched with 5% sheep blood. Plates were allowed to dry for 15 min at room temperature prior to addition of E-test strip.

Between June 2002 and February 2003, 104 children (58 males and 46 females; mean age, 7 years 2 months; range, 2 to 17 years) were enrolled in the study, and H. pylori was isolated from 48 of the patients. The antimicrobial susceptibility testing results are presented in Table 1. High-level resistance to metronidazole was present in all 48 H. pylori isolates. In contrast, 44 of the 48 isolates were susceptible to all other antimicrobial agents tested. Of the remaining four isolates, one was resistant to ciprofloxacin (MIC of >256 \( \mu \text{g/ml} \)), another was resistant to ampicillin (MIC of >256 \( \mu \text{g/ml} \)), and two were resistant to the macrolides (erythromycin, clarithromycin, and azithromycin) tested. With the exception of metronidazole, the MIC of each of the antimicrobials tested was within a narrow range, and most were

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The resistance MICs of the antimicrobial agents were as follows: 

Additional studies have demonstrated that the antimicrobial resistance patterns for *H. pylori* isolates tested in the present study are consistent with other studies from the region and the world, as well as previous research in Egypt (3, 10, 14, 20). The resistance rates over 20% have been reported in some areas of the world (15, 19), so it was surprising that only one isolate was resistant to this agent. However, prior studies in the region have found similar low levels of resistance to clarithromycin (17). While the reason for the low level of resistance is not certain, it may be partly due to clarithromycin being available in Egypt for 18 months at the time the present study was initiated. Further surveillance will be needed to determine if resistance to clarithromycin increases within the region in the future.

In conclusion, this study emphasizes that resistance rates of *H. pylori* isolates differ considerably from one geographical region to another. In vitro data would suggest that treatment regimens incorporating antimicrobials other than metronidazole would be effective in eradicating *H. pylori* in Egypt. Nonetheless, in vivo results will need to be carefully monitored to ensure treatment is effective. Continued surveillance to allow for the early detection of development of antimicrobial resistance is critical and will need to be an ongoing endeavor.

We thank Abdelhakam Hamad for outstanding bacterial work and the members of the endoscopy unit at Abu El-Reesh Children’s Hospital, Cairo, Egypt, and the parents and children who made this study possible. We thank John Sanders and Marshall Monteville for critically reviewing the manuscript.

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The study protocol was approved by the NAMRU-3 Institutional Review Board (protocol 31910) in compliance with all federal regulations governing the protection of human subjects.

### REFERENCES


### TABLE 1. MICs and resistance rates for *H. pylori* isolates recovered from 48 study children

<table>
<thead>
<tr>
<th>E-test MIC (µg/ml)</th>
<th>AM</th>
<th>EM</th>
<th>CH</th>
<th>AZ</th>
<th>CI</th>
<th>MZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.016</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>0.016–&lt;0.094</td>
<td>39</td>
<td>61</td>
<td>31</td>
<td>65</td>
<td>31</td>
<td>24</td>
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<tr>
<td>0.094–&lt;0.5</td>
<td>6</td>
<td>13</td>
<td>11</td>
<td>23</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>0.5–&lt;1.0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1.0–&lt;4.0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>4.0–&lt;32</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>≥32</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Total resistant (no. of isolates [%])

- AM: 2 (4)
- EM: 2 (4)
- CH: 2 (4)
- AZ: 2 (4)
- CI: 2 (4)
- MZ: 2 (4)

- Resistance rates of *H. pylori* isolates to ampicillin (AM), erythromycin (ER), clarithromycin (CH), azithromycin (AZ), ciprofloxacin (CI), and metronidazole (MZ).

The resistance MICs of the antimicrobial agents were as follows: ≥0.5 µg/ml for AM; ≥1 µg/ml for EM, CH, AZ, and CI; and ≥8 µg/ml for MZ.


