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Research article

Declining prevalence of *Helicobacter pylori* infection in Jordanian children, report from developing country

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ABSTRACT

Introduction: *Helicobacter pylori* (*H. pylori*) is a Gram-negative bacteria that is harbored in the stomach and linked to chronic gastritis, peptic ulcer disease, and gastric malignancy. Most *Helicobacter* infections are acquired during early infancy. This study aimed to establish the prevalence of *H. pylori* infection in Jordanian children using the ^{13}C-urea breath test.

Materials and methods: We prospectively enrolled children between the ages of 4 and 17 years from April 2019 to July 2019. Enrolled children were patients with nongastrointestinal complaints at the pediatric clinics of two hospitals and at community centers caring for healthy children in Irbid, Jordan. Questionnaires obtaining data on sociodemographics, clinical symptomatology, and hygienic risk factors were completed. Recruited children underwent a urea breath test (UBT).

Results: Of 340 children who were recruited, 328 (96.5%) were included in the final analysis. The mean age (±standard deviation) was 9.56 (±3.98) years (range, 4.0–17 years), and 168 (51.2%) were males. Only 48 children (14.6%) tested positive. There were no gender differences. Living in an urban area and a family history of previous *H. pylori* infection were risk factors for the acquisition of infection ($P = 0.007$ and 0.001, respectively). Although gastrointestinal symptoms were more common in *H. pylori*-infected children, only hiccups and constipation were statistically significant ($P = 0.035$ and 0.038, respectively).

Conclusion: *H. pylori* infects at least 15% of Jordanian children, suggesting a significant drop in infection rates in this group. Larger-scale studies combined with clinical evaluations will be important for further understanding the reasons for the observed decrease in *H. pylori* infections in Jordanian children.

1. Introduction

Helicobacter pylori (*H. pylori*) is a Gram-negative microaerophilic bacillus bacterium that infects the stomach epithelium [1]. *H. pylori* organisms possess specialized characteristics that allow them to withstand the very acidic environment of the stomach. For example, flagella facilitate *H. pylori* mobility to the mucus layer at the surface of the gastric mucosa, contributing to bacterial colonization, inflammation, and immune evasion [2]. In addition, *H. pylori* produces urease, an enzyme that promotes bacterial colonization and is used in the clinic as a biomarker of *H. pylori* infection as part of the rapid urease test [2]. *H. pylori* infection contributes to many gastroduodenal diseases, including peptic ulcers (gastric and duodenal), chronic gastritis, gastric mucosa-associated lymphoid tissue lymphoma, and gastric cancer [3]. Although much is known about the association of *H. pylori* infection with gastrointestinal symptoms in adults, its role in children is less clear [4, 5, 6, 7]. Several studies have shown that the worldwide prevalence of *H. pylori* infection is high, and some have estimated that 50% or more of the world's

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population is infected [7, 8]; moreover, the infection rate/prevalence may reach as high as 70% in developing countries [7]. *H. pylori* infection is largely acquired at an early age and persists to adulthood, as spontaneous clearance is unusual [9]. Factors such as age, gender, ethnicity, and a variety of socioeconomic indicators are associated with the prevalence of *H. pylori* infection [10, 11, 12, 13]. In addition to overcrowded settings, low socioeconomic status is one of the main factors that puts children at risk of acquiring the infection [14, 15]. This association is evident in those living in developing countries, whereas socioeconomic status in developed countries does not have a notable role in *H. pylori* infection [16, 17]. Risk of infection by *H. pylori* reflects exposure during the early years of life [18]; the exact route of transmission is still unknown, despite multiple attempts to uncover the mechanism [19]. Because crowding is a main risk factor for infection and *H. pylori* infection occurs mainly within families, it has been hypothesized that person-to-person spread is the most likely mode of transmission [20]. Fecal-oral, oral-oral, and gastro-oral transmission routes are also probable, particularly since *H. pylori* can be isolated from feces, saliva, and vomitus respectively [21, 22, 23]. Given the role of *H. pylori* infection in gastrointestinal disease, a precise diagnosis of *H. pylori* infection is critical for treating various gastrointestinal symptoms and preventing serious complications [24].

Diagnostic testing for *H. pylori* can be either invasive (requiring endoscopy) or non-invasive. Non-invasive testing itself can be either active or passive [3]. An example of the latter is serology testing for antibodies against *H. pylori*. A positive result can indicate a previously eradicated infection or an existent one but cannot differentiate between the two; this can lead to a higher false positive rate [25]. Use of serology for diagnosis is therefore not recommended in areas where infection is known to be common or for the diagnosis of children [26]. Examples of active testing for *H. pylori* include the urea breath test (UBT) and stool antigen test [19], both of which are helpful for initial diagnosis and for evidence of eradication. The UBT has a sensitivity and specificity of over 90%, although these results may be inaccurate in patients taking certain medications (proton pump inhibitors or antibiotics) or in those who have undergone previous gastric surgeries [27].

The only study measuring the prevalence of *H. pylori* infection among schoolchildren in Northern Jordan using serology was performed in 2006 [28]. This study found a concomitant overall seroprevalence rate of 55.5% and concluded that the prevalence of *H. pylori* infection in children was high. A study in Iraq within the same time period estimated the seroprevalence of *H. pylori* infection at 27% in young Iraqi children, reaching 58% in children between 2 and 18 years of age [29]. A study from Saudia Arabia reported that *H. pylori* infected almost one-third of Saudi children under the age of 10 years [30]. A recent study from Egypt reported the overall rate of *H. pylori* infection in symptomatic children who visited a gastroenterology clinic to be 64.6%. This study depended on the detection of *H. pylori* antigen in stool [31]. In Lebanon, Naous et al. reported that almost one-fifth of Lebanese children harbor *H. pylori*, which was evident by the detection of bacterial antigen in stool [32].

A new nationwide study of *H. pylori* infection in healthy Jordanian adults by Obeidat and Roess [33] reported a seroprevalence of 89%. Despite this high rate, Jordan is considered a low-risk area for gastric cancer, with an age-standardized rate (ASR) of gastric malignancies at 3.9 per 100,000 population [34]. As serological testing is unable to distinguish between active infection and previous exposure, we performed the present study using the UBT. Our goal was to establish a better estimate of the prevalence of *H. pylori* infection in children living in North Jordan and identify risk factors for infection.

2. Materials and methods

2.1. Patients

We prospectively enrolled children between the ages of 4 and 17 years from April 2019 to July 2019. Enrolled patients were attendees at pediatric clinics at King Abdullah University Hospital and Princess Rahma Teaching Hospital and at community centers caring for healthy children in Irbid, Jordan. Irbid is the main agricultural city in North Jordan with a population of approximately 1,770,158 citizens living in 9 counties and 18 municipalities. It is uniquely characterized by a mixture of urban and rural sub-communities, which were represented by the study participants. Children were included following parental consent.

2.2. Inclusion criteria

1. Children between 4 and 17 years of age
2. Children not currently on medications
3. Children presenting with nongastrointestinal complaints
4. Children who agreed to participate in the study

2.3. Exclusion criteria

1. Children who refused to drink the reagent
2. Children who are currently on medications that might affect the results of the test (acid suppressant therapy, antibiotics, etc.)
3. Children presenting with gastrointestinal complaints
4. Children with a history of a previous abdominal surgery
5. Children with developmental issues preventing them from comprehending the test
6. Children younger than 4 years of age
7. Children/parents who refused to participate

Participating parents and children were interviewed. Participants were asked to fill out a questionnaire about the child's age, sex, family size, housing (size and drinking water source), income, level of education, and the medical history of the family and child. Information regarding the eating habits of the child and hygiene-related behaviors were also collected. Parents willing to know the results of their child's test were asked to provide their contact number (Figure 1).

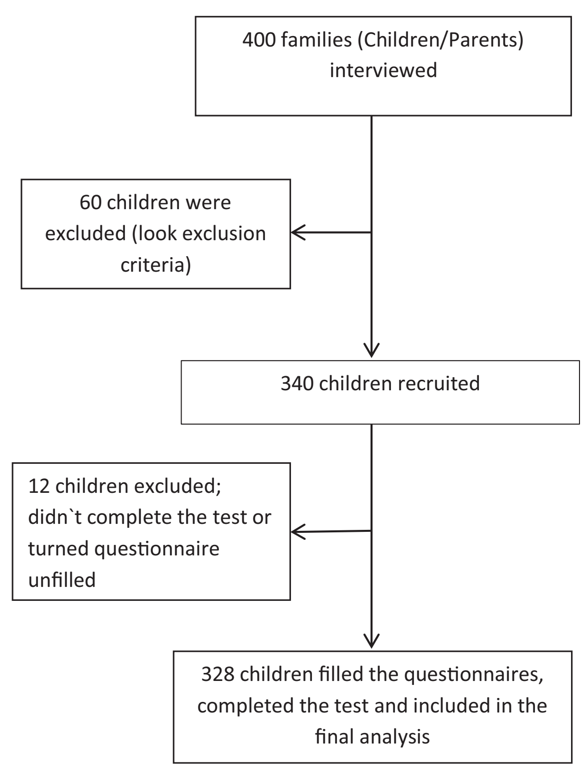

Figure 1. Study recruitment process.

Table 1. Prevalence of sociodemographics and familial and hygienic risk factors, according to the results of the ^{13}-C urea breath test.

Predictor of infection	Negative -ve		Positive + ve		*P* value
	Frequency	Percentage 95% CI	Frequency	Percentage 95% CI	
Age					
4–5	48	17.1 (16.0–18.8)	8	16.7 (6.6–26.8)	NS†
6–11	124	44.3 (42.1–46.5)	25	52.1 (38.5–65.7)	
12–17	108	38.6 (36.4–40.8)	15	31.3 (18.7–43.9)	
Gender					
Male	142	50.9 (48.6–53.2)	26	54.2 40.7–68.4)	NS†
Female	137	49.1 (46.8–51.4)	22	45.8 (32.3–59.3)	
School					
No School	33	12 (10.4–13.6)	5	10.4 (2.1–18.7)	NS†
Public	138	50.2 (47.8–52.6)	26	54.2 (40.7–67.7)	
Private	52	18.9 (17.0–20.8)	13	27.1 (15.0–39.2)	
UNRWA	52	18.9 (17.0–20.8)	4	8.3 (0.8–15.8)	
Grade					
Primary	172	70.8 (67.9–73.7)	35	77.8 (66.0–89.6)	NS†
Secondary	71	29.2 (26.3–32.1)	10	22.2 (10.4–34.0)	
City					
Urban Area	154	55 (53.2–57.6)	38	79.2 (68.2–90.2)	0.007
Rural Area	126	44.6 (42.4–46.8)	10	20.8 (9.8–31.8)	
Water Source					
Filtered + Bottled Water	190	67.9 (65.8–70.1)	27	56.3 (42.8–69.8)	NS†
Municipal + Well Water	90	32.1 (30.0–34.2)	21	43.8 (30.3–57.3)	
Monthly Financial Income					
>700 US $	165	58.9 (56.7–61.1)	32	66.7 (53.9–79.5)	NS†
>700 US $	115	41 (38.9–43.3)	16	33.4 (20.6–46.2)	
Mother Educational Level					
School	152	54.3 (52.1–56.6)	22	45.8 (32.3–59.3)	NS†
Post School	128	45.7 (43.4–48.0)	26	54.2 (40.7–67.7)	
Father Educational Level					
School	167	59.6 (57.4–61.8)	32	66.7 (53.9–79.5)	NS†
Post School	113	40.4 (38.2–42.6)	16	33.3 (20.5–46.1)	
Any Smoker at Home					
No	107	38.2 (36.0–40.4)	16	33.3 (20.5–46.1)	NS†
Yes	173	61.8 (59.6–64.0)	32	66.7 (53.9–79.5)	
Family History:					
Heartburn					
No	176	62.9 (60.7–65.1)	27	56.3 (42.8–69.8)	NS†
Yes	104	37.1 (34.9–39.3)	21	43.8 (30.3–57.3)	

(*continued on next page*)

Table 1 (*continued*)

Predictor of infection	Negative -ve		Positive + ve		*P* value
	Frequency	Percentage 95% CI	Frequency	Percentage 95% CI	
Chronic Stomach Pain					
No	176	62.9 (60.7–65.1)	26	54.2 (40.8–67.8)	NS†
Yes	104	37.1 (34.9–39.3)	22	45.8 (32.3–59.3)	
H. pylori/Tt with Triple Therapy in Family Member					
No	248	88.6 (87.2–90.0)	33	68.8 (56.2–81.4)	0.001
Yes	32	11.4 (10.0–12.8)	15	31.2 (18.6–43.8)	
Gastric/Intestinal Ulcer					
No	245	87.5 (86.0–90.0)	41	85.4 (75.8–95.0)	NS†
Yes	35	12.5 (11.0–14.0)	7	14.6 (5.0–24.2)	
Gastric Cancer					
No	265	94.6 (93.6–99.9)	47	97.9 (94.0–101.8)	NS†
Yes	15	5.4 (0.1–0.7)	1	2.1 (1.8–6.0)	
Intestinal Cancer					
No	279	99.6 (98.6–99.4)	48	100 (99.9–100.0)	NS†
Yes	1	0.4 (0.1–0.7)	0	0 (–0.01–0.01)	
Hygienic Habits					
Buying Food from Hawkers around Home/School					
No	110	45.5 (42.3–48.7)	21	47.7 (33.4–62.0)	NS†
Yes	132	54.5 (51.2–57.7)	23	52.3 (34.0–66.6)	
Using School Toilets					
No	124	52.3 (48.9–55.7)	11	28.2 (14.3–42.1)	0.004
Yes	113	47.7 (44.3–51.1)	28	71.8 (57.9–85.7)	
Drinking Tap Water at School					
No	207	87.7 (85.5–89.9)	34	87.2 (76.9–97.5)	NS†
Yes	29	12.3 (10.1–14.5)	5	12.8 (2.5–23.1)	
Hands Washed after Coming Back Home (Back from School)					
No	36	14.7 (12.4–17.0)	14	31.8 (18.4–45.2)	0.008
Yes	209	85.3 (83.0–87.6)	30	68.2 (54.8–81.6)	
Hands Washed before Meal					
No	60	21.7 (19.8–23.6)	7	14.6 (5.0–24.2)	NS†
Yes	217	78.3 (76.4–80.2)	41	85.4 (75.8–95.0)	
Hands Washed after Meal					
No	20	7.2 (6.0–8.4)	5	10.4 (2.1–18.7)	NS†
Yes	256	92.8 (91.6–94.0)	43	89.6 (81.3–98.0)	
Hands Washed after Using Toilet					
No	17	6.1 (5.0–7.2)	6	12.8 (3.6–22.0)	NS†
Yes	260	93.9 (92.5–94.8)	41	87.2 (78.0–96.4)	

(*continued on next page*)

Table 1 (*continued*)

Predictor of infection	Negative -ve		Positive + ve		*P* value
	Frequency	Percentage 95% CI	Frequency	Percentage 95% CI	
Hands Washed after Contact with Animals					
No	63	24.8 (22.3–27.3)	12	28.6 (15.3–41.9)	NS†
Yes	191	75.2 (72.3–77.7)	30	71.4 (58.1–84.7)	
Sharing Cup/Dish/Towel					
No	111	40.2 (37.9–42.5)	18	37.5 (24.3–50.7)	NS†
Yes	165	59.8 (57.5–62.1)	30	62.5 (49.3–75.7)	
Eating in One Dish with Family					
No	96	34.7 (37.9–42.5)	18	37.5 (24.3–50.7)	NS†
Yes	181	65.3 (63.1–67.5)	30	62.5 (49.3–75.7)	

Numbers might not add up due to some missing data.
†NS, not statistically significant.

2.4. Urea breath test

Recruited children were asked to undergo a UBT. Study participants were first asked to provide a baseline sample of exhaled air at 0 min (test bag). Patients were then asked to drink 75 mg of a ^{13}C-labeled urea substrate (mixed with water according to the manufacturer's recommendations). Thirty minutes later, patients filled a bag with exhaled air. The two samples were then processed simultaneously using a $^{12/13}$-CO_2 breath test analyzer (IR-Force 2000, Beijing Richen-force and Technology Co., LTD, Chaoyang District, Beijing, P.R. China). The test was considered positive if the delta over the baseline value was >4.0%. The test was run by a trained member of the research team.

2.5. Statistics

Data were entered into a spreadsheet. Statistical analyses were performed using appropriate software. For categorical variables, data were presented as frequency distributions; for continuous variables, data were presented as mean ± standard error of the mean. A significance level of 0.05% was used. To assess associations between categorical variables, a Pearson χ2 test was used, whereas for continuous normally distributed variables, a Student's t-test and ANOVA were used. Stepwise linear regression analysis was performed to include the important independent variable only. Risk factors that were significant in the univariate analysis were used in the multiple logistic regression models. All tests were considered statistically significant at *P* values less than 0.05.

2.6. Ethical approval

This study was approved by the institutional review board of the Jordan University of Science and Technology (no. 36/117/2018) and the ethics committee of MOH (no. MOH REC 1900049).

3. Results

Of the 340 children recruited for the study, 328 (96.5%) were included in the final analysis. Twelve children were excluded due to either submitting an incomplete questionnaire or not completing the test. The average age was 9.561 ± 3. 955 years and 168 (51.2%) were males (Table 1). Based on UBTs, we determined that the prevalence of *H. pylori* infection in this cohort was 14.6% (48/328). Although males were more commonly affected compared with females (54.2% vs. 45.8%), this trend was not statistically significant (Table 1).

3.1. Risk factors

We found that residing in the urban side of the governorate was associated with higher rates of *H. pylori* infection compared with non-urban areas (79.2% vs. 20.8%; P = 0.007). A family history of *H. pylori* infection or previous treatment for *H. pylori* infection within the family was a risk factor for acquiring the infection (P = 0.001). Parental education levels, family history of chronic gastrointestinal symptoms, or gastric cancers were not associated with increased risk of *H. pylori* infection in our cohort. Additionally, we found that the source of drinking water was not a statistically significant risk factor (Table 1). Personal hygiene, using the school washroom, and not washing hands upon arriving home from school were also risk factors for *H. pylori* infection (P = 0.004 and 0.008, respectively) (Table 1).

3.2. Symptomatology

Although heartburn, epigastric pain, recurrent chest pain, early satiety, and halitosis were reported more frequently by children infected with *H. pylori* in this study, these symptoms did not reach statistical significance. However, excessive hiccups and constipation were significantly more common in infected children (P = 0.038 and 0.041, respectively). Finally, reported atopic manifestations were not significantly negatively associated with *H. pylori* infection in children in this study (Table 2).

4. Discussion

H. pylori is an important pathogen with an established association with gastritis, peptic ulcer disease, and gastric malignancy [3]. Initial *H. pylori* infection likely occurs during early childhood, with the bacteria inhabiting the stomach [13]. The UBT is an accurate test for detection of *H. pylori* infection with high specificity and sensitivity. Importantly, compared to serology testing, the UBT has a higher specificity, and particularly in children, the non-invasive aspect of the test is more appealing [35].

This is the first study from Jordan that assesses the most well-known risk factors of *H. pylori* infection in children using the UBT as the testing modality. Our results demonstrate that the prevalence of *H. pylori* infection in this cohort is 14.6%. This number is much lower than previous estimates at 55% from 13 years ago [28], as well as what is reported from neighboring countries [29, 30, 31] and developing countries [36, 37, 38, 39]. We believe the differences between our results and those of previous reports from Jordan are multifactorial. First,

Table 2. Comparison of symptoms' prevalence according to *H. pylori* infection status.

Predictor of infection	Negative -ve		Positive + ve		*P* value
	Frequency	Percentage 95% CI	Frequency	Percentage 95% CI	
Heart Burn					
No	262	93.6 (92.5–94.7)	44	91.7 (84.2–99.2)	NS†
Yes	18	6.4 (5.3–7.5)	4	8.3 (0.8–15.8)	
Epigastric Pain					
No	221	78.9 (77.1–80.7)	35	72.9 (60.8–85.0)	NS†
Yes	59	21.1 (19.3–23.0)	13	27.1 (15.0–39.2)	
Recurrent Chest Pain					
No	264	94.3 (93.3–95.3)	44	91.7 (84.2–99.2)	NS†
Yes	16	5.7 (4.7–6.7)	4	8.3 (0.8–15.8)	
Flatulence					
No	237	84.6 (83.0–86.2)	45	93.8 (87.2–100.4)	NS†
Yes	43	15.4 (13.8–17.0)	3	6.3 (–0.3–9.7)	
Nausea					
No	255	91.1 (89.8–92.4)	46	95.8 (90.3–101.3)	NS†
Yes	25	8.9 (7.6–10.2)	2	4.2 (–1.3–9.7)	
Epigastric Satiety					
No	213	76.1 (74.2–78.1)	35	72.9 (60.8–85.0)	NS†
Yes	67	23.9 (22.0–25.8)	13	27.1 (15.0–39.2)	
Vomiting					
No	267	95.4 (94.5–96.3)	47	97.9 (94.0–101.8)	NS†
Yes	13	4.6 (3.7–5.5)	1	2.1 (–1.8–6.0)	
Halitosis					
No	225	80.4 (78.6–82.2)	34	70.8 (58.4–83.2)	NS†
Yes	55	19.6 (17.8–21.4)	14	29.2 (16.8–41.6)	
Sore Throat					
No	233	83.2 (81.5–84.9)	39	81.3 (70.7–91.9)	NS†
Yes	47	16.8 (15.1–18.5)	9	18.8 (8.2–24.4)	
Chronic Cough					
No	259	92.5 (91.3–93.7)	46	95.8 (90.3–101.3)	NS†
Yes	21	7.5 (6.3–8.7)	2	4.2 (–1.3–9.7)	
Excessive Hiccup					
No	270	96.4 (95.6–97.2)	43	89.6 (81.3–98.0)	NS†
Yes	10	3.6 (2.8–4.4)	5	10.4 (2.1–18.7)	
Recurrent Bronchitis					
No	258	92.1 (90.9–93.3)	43	89.6 (81.3–98.0)	NS†
Yes	22	7.9 (9.7–9.1)	5	10.4 (2.1–18.7)	

(*continued on next page*)

Table 2 (*continued*)

Predictor of infection	Negative -ve		Positive + ve		*P* value
	Frequency	Percentage 95% CI	Frequency	Percentage 95% CI	
Recurrent Burp					
No	267	95.4 (90.9–93.3)	47	97.9 (94.0–101.8)	NS†
Yes	13	4.6 (6.7–9.1)	1	2.1 (–1.8–6.0)	
Constipation					
No	264	94.3 (93.3–95.3)	41	85.4 (75.8–95.0)	0.035
Yes	16	5.7(5.2–7.4)	7	14.6 (5.0–24.2)	
Diarrhea					
No	272	97.1 (96.3–97.9)	47	97.3 (92.9–101.7)	NS†
Yes	8	2.9 (2.1–3.7)	1	2.7 (–1.8–6.4)	
Allergy Eye/Skin					
No	254	90.7(89.4–92.0)	45	93.8 (87.2–100.4)	NS†
Yes	26	9.3(8.0–10.6)	3	6.3 (–0.3–13.0)	
Allergy/Asthma					
No	261	93.2 (92.1–94.3)	45	93.8 (87.2–100.4)	NS†
Yes	19	6.8 (5.7–7.9)	3	6.3 (–0.3–12.9)	

Numbers may not add up due to missing data.
NS†, not statistically significant.

the method of detection was different; Bani Hani et al. [28] used serological testing, whereas our study used the UBT, which is more specific for *H. pylori* infection. In a recent systematic review by Hooi and colleagues [40], a drop in the reported rates of *H. pylori* infections—regardless of the diagnostic methodology—was observed in developed and some developing countries. The authors concluded that this was due to improved sanitation and hygienic practices. In Jordan, we believe the sanitation conditions have improved significantly over the last decade. Currently, 97 % of the Jordanian population has access to safely managed sanitation services, whereas 99% have access to safely managed drinking water [41]. This effect was not seen in the adult population [34], which is expected, as most *H. pylori* infections are acquired during childhood. We expect that such an effect will require a longer duration of study.

Moreover, there is widespread use of unprescribed antibiotics in Jordan. Almaayta and colleagues [42] reported that of 202 pharmacies visited, 150 dispensed antibiotics without a prescription, mainly for the treatment of sore throat, urinary symptoms, and diarrhea. Another study reported that one third of antibiotics dispensed at local pharmacies were unprescribed [43]. A cross-sectional study from Irbid done by Yusef and colleagues reported that almost 40% of the participants who received antibiotics did not have a prescription [44]. Although patients receiving antibiotics were excluded from our study, previous exposure to antibiotics could have led to increased clearance or suppression of *H. pylori*, resulting in a negative UBT and lowering the observed prevalence. Although the questionnaire asked about the recent use of antibiotics, no differences were found between infected and uninfected children. This finding might reflect a recall bias as well as uncertainty about the specific antibiotic used, as we didn't ask specifically about the type of antibiotics. On the other hand, the strict exclusion of children presenting with gastrointestinal symptoms might also contribute to the low prevalence of *H. pylori* in our study population.

It is believed that the risk factors for childhood infection with *H. pylori* vary among distinct populations. Identified risk factors in some populations may not be risk factors for others of a different ethnicity or living in different household conditions or locations [18]. Overall, socioeconomic status is the main risk factor in developing countries [18].

H. pylori infection was more common in children from families with a lower economic status, and the infection rate decreased with increased family income; however, it did not reach statistical significance ($P > 0.05$). This is consistent with a new report on the seroprevalence of *H. pylori* in Jordanian adults, in whom higher rates of positive infection were associated with lower income; these results also did not reach statistical significance [33].

The association of male or female sex with *H. pylori* infection is debated. A systematic review by Zamani et al. [8] found there were no differences in *H. pylori* infection between males and females. In contrast, Ibrahim and colleagues [45] reported a male predominance. In addition to the two seroprevalence studies from Jordan [28, 33], our study also showed male predominance, but this observation was not statistically significant.

Parental education level and number of siblings were reported as risk factors for *H. pylori* infection by previous groups [46]. Our study did not confirm this relationship, consistent with previous studies by Chi et al. [16] and Roma et al. [17] in Taiwanese and Greek children, respectively. Additionally, unhygienic behavior, including not washing hands after school and eating unwashed fruits and vegetables, were risk factors for *H. pylori* infection, consistent with recent reports from Poland [47]. On the other hand, living in an urban area was a risk factor for the acquisition of *H. pylori* infection in our study. This finding is consistent with those of previous reports from Vietnam [48], Nepal [49], and Mexico [50].

Attempts to establish the exact route of *H. pylori* transmission have not been conclusive. It has been hypothesized that person-to-person spread as well as fecal-oral, oral-oral, and gastro-oral are the likely modes of transmission. In our study, the drinking water source was not associated with increased risk of infection with *H. pylori,* which was also reported by the recent nationwide seroprevalence study from Jordan [33]. These results likely reflect improvements in sanitation and wide accessibility to clean water [41].

Manifestations of *H. pylori* infection in children have been debated [4, 5, 6, 7, 49]. In our cohort, we found no association between the majority of gastrointestinal symptoms and being infected with *H. pylori*. Although a weak correlation was previously reported in Polish children [51], our findings were limited by the fact that recall bias cannot be excluded, as no proper medical evaluation was performed and medical records were not reviewed. On the other hand, our selection criteria of excluding patients presenting primarily with gastrointestinal complaints might further suppress this correlation, if present. The association of constipation with *H. pylori* infection may reflect a common presence rather than a real association.

This study is the first of its type in our population and the first to report a significant decline in the prevalence of *H. pylori* in children of a developing country. However, it carries inherent weaknesses: the study participants were not evaluated medically, infections were not confirmed by further testing, and the study results might have been affected by recall bias. A future study that includes a larger number of children is needed to confirm our results.

Declarations

Author contribution statement

E. Altamimi: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

N. Alsharkhat: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

A. AlJawarneh, A. Assi, S. Alawneh and M. Al-Ahmad: Performed the experiments; Contributed reagents, materials, analysis tools or data.

M. Hamad: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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