Association between *Helicobacter pylori* and end-stage renal disease: A meta-analysis

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Abstract

**AIM**

To investigate the prevalence and association of *Helicobacter pylori* (*H. pylori*) with end-stage renal disease (ESRD).

**METHODS**

A comprehensive literature search was completed from inception until October 2016. Studies that reported prevalence, relative risks, odd ratios, hazard ratios or standardized incidence ratio of *H. pylori* among ESRD patients were included. Participants without *H. pylori* were used as comparators to assess the association between *H. pylori* infection and ESRD. Pooled risk ratios and 95%CI was calculated using a random-effect model. Adjusted point estimates from each study were combined by the generic inverse variance method of DerSimonian and Laird.
RESULTS
Of 4546 relevant studies, thirty-seven observational studies met all inclusion criteria. Thirty-five cross-sectional studies were included in the analyses to assess the prevalence and association of H. pylori with ESRD. The estimated prevalence of H. pylori among ESRD patients was 44% (95%CI: 40%-49%). The pooled RR of H. pylori in patients with ESRD was 0.77 (95%CI: 0.59-1.00) when compared with the patients without ESRD. Subgroup analysis showed significantly reduced risk of H. pylori in adult ESRD patients with pooled RR of 0.71 (95%CI: 0.55-0.94). The data on the risk of ESRD in patients with H. pylori were limited. Two cohort studies were included to assess the risk of ESRD in patients with H. pylori. The pooled risk RR of ESRD in patients with H. pylori was 0.61 (95%CI: 0.03-12.20).

CONCLUSION
The estimated prevalence of H. pylori in ESRD patients is 44%. Our meta-analysis demonstrates a decreased risk of H. pylori in adult ESRD patients.

Key words: Helicobacter pylori; Kidney failure; Renal disease; Renal insufficiency; End stage kidney disease; Meta-analysis

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Core tip: Helicobacter pylori (H. pylori) is the most common chronic bacterial infection in gastrointestinal tract of humans. The prevalence and association of H. pylori with end-stage renal disease (ESRD), however, are still unclear. To further investigate this potential relationship, we conducted this systematic review and meta-analysis of observational studies reporting the association between H. pylori infection and ESRD and prevalence in ESRD patients. We found an estimated prevalence of H. pylori in ESRD patients of 44%. In addition, our meta-analysis demonstrates a 0.71-fold decreased risk of H. pylori in adult ESRD patients.

Wijarnpreecha K, Thongprayoon C, Nissaisorakarn P, Lekuthai N, Jaruvongvanich V, Nakka K, Rajapakse R, Cheungpasitporn W. Association between Helicobacter pylori and end-stage renal disease: A meta-analysis. World J Gastroenterol 2017; 23(8): 1497-1506 Available from: URL: http://www.wjgnet.com/1007-9327/full/v23/i8/1497.htm DOI: http://dx.doi.org/10.3748/wjg.v23.i8.1497

INTRODUCTION
Helicobacter pylori (H. pylori) is the most common chronic bacterial infection in the gastrointestinal tract of humans[1]. It has been estimated that the prevalence of H. pylori infection is up to thirty percent in adult aged 18 to 30 years and to fifty percent in those older than 60 years old[2]. Many studies demonstrated that H. pylori infection is associated with a peptic and duodenal ulcer, chronic gastritis, and gastric cancer[3,4]. Recently, epidemiologic studies have demonstrated associations between H. pylori infection and extra-gastrointestinal organ involvements including coronary artery disease, dyslipidemia, insulin resistance, and hematologic disorders[5-7].

End-stage renal disease (ESRD) is a common and serious chronic disease worldwide that continues to increase in prevalence by approximately 21000 cases per year in the United States[8]. Although there is no visible evidence demonstrated that H. pylori infection is directly associated with renal disease, patients with ESRD usually have gastrointestinal problems such as gastritis, dyspeptic symptoms or ulcers[9-11]. Interestingly, recent investigations have demonstrated an association between H. pylori infection and ESRD[12-14]. In addition, an increase in renal resistance index due to systemic inflammation state H. pylori infection was also described[15-18]. However, many studies reported the conflict data regarding the association between H. pylori infection in ESRD and also the prevalence of H. pylori infection in ESRD patients[19-42]. Thus, we conducted the systematic review and meta-analysis that summarized all available evidence to determine the prevalence of H. pylori infection among ESRD patients and the association between H. pylori infection and ESRD.

MATERIALS AND METHODS

Literature search
Three investigators (Wijarnpreecha K, Thongprayoon C and Cheungpasitporn W) independently reviewed published studies indexed in MEDLINE and EMBASE database from their inception to October 2016 using the search strategy that included the terms for “Helicobacter”, “hemodialysis”, and “renal disease” as described in Item S1 in online Supplementary Data 1. A search for additional articles utilizing references from included studies was also performed. There was no confinement on language in the literature search.

We conducted this systematic review following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis statement.

Selection criteria
The inclusion criteria were: (1) observational studies appraising the association between H. pylori and ESRD and prevalence in hemodialysis; (2) prevalence, odds ratios, relative risks, or hazard ratios with 95%CI were presented; and (3) individuals without H. pylori were used as comparators in cohort studies while individuals without ESRD were used as comparators in the cross-sectional and case-control studies. Wijarnpreecha K, Thongprayoon C and Cheungpasitporn W individually examined the titles and abstracts of the studies. After
the first phase, the full text of the included studies was subsequently examined to ascertain if they met the inclusion criteria. Discrepancies were also settled by discussion with all investigators.

**Data abstraction**

A structured data collection form was utilized to obtain the data from included studies including title of the study, year of publication, country where the study was conducted, name of the first author, demographic of subjects, method used to diagnose H. pylori, prevalence of H. pylori, effect estimates (hazard ratios, odds ratios, relative risks) with 95%CI, and factors adjusted in the multivariate analysis. To ensure the certainty, this data extraction process was reviewed by all investigators.

The quality of each study was individually appraised by each investigator. We utilized the validated Newcastle-Ottawa quality assessment scale for cohort and case-control studies[43] and modified Newcastle-Ottawa scale[44] for the cross-sectional study. The prevalence of H. pylori among ESRD patients

Thirty-five cross-sectional studies were included in the analyses to assess the prevalence and association of H. pylori with ESRD. The estimated prevalence of H. pylori among ESRD patients was 44% (95%CI: 40%-49%, \(I^2 = 80\%\)), as demonstrated in Figure 2. Subgroup analysis was also performed on thirty-two studies\[12,13,16,19-23,25-28,30,42,49-51,53-56\] that provided prevalence on adult subjects and three studies\[24,29,52\] that provided prevalence on pediatric patients and showed estimated prevalences of H. pylori among adult ESRD patients of 44% (95%CI: 39%-49%, \(I^2\)
Table 1  Main characteristics of the cross-sectional studies included in this meta-analysis

| Study                  | Country          | Year | Study sample | H. pylori testing | H. pylori prevalence (%) | OR                | Study quality |
|------------------------|------------------|------|--------------|-------------------|--------------------------|-------------------|---------------|
| Offerhaus et al[36]    | The Netherland   | 1989 | Dialysis     | Antibody          | 22/50 (44%)              | 0.96 (0.42-2.22)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 0           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Shousha et al[55]      | United Kingdom   | 1990 | Dialysis     | Histology         | 12/50 (24%)              | 0.43 (0.20-0.90)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 0           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Loffeld et al[34]      | The Netherland   | 1991 | HD           | Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Davenport et al[22]    | United Kingdom   | 1991 | HD           | Antibody          | 27/76 (36%)              | 1.29 (0.75-2.22)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Ala-Kaila et al[16]    | Finland          | 1991 | HD           | Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Gladziwa et al[27]     | Germany          | 1993 | HD           | Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Giachino et al[25]     | Italy            | 1994 | HD           | Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| De Vecchi et al[29]    | Italy            | 1995 | HD and PD    | Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Jaspersen et al[31]    | Germany          | 1995 | HD           | Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Seyrek et al[39]       | Turkey           | 1996 | HD           | Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Krawczyk et al[33]     | Poland           | 1996 | HD           | Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Orgür et al[32]        | Turkey           | 1997 | HD           | Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Hruby et al[42]        | Poland           | 1997 | HD           | Antibody, culture | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Yildiz et al[43]       | Turkey           | 1999 | HD           | Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Fabrizi et al[44]      | United States    | 1999 | HD           | Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Tamura et al[45]       | Japan            | 1999 | HD and PD    | Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Güç et al[46]          | Turkey           | 1999 | HD           | Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Araki et al[47]        | Japan            | 1999 | HD and PD    | Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Karari et al[48]       | Kenya            | 2000 | CRF (HD - 36%)| Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
| Nakajima et al[49]     | Japan            | 2002 | HD           | Antibody          | 13/30 (43%)              | 1.24 (0.58-2.64)  | S 3           |
|                        |                  |      |              |                   |                          |                   | C 1           |
|                        |                  |      |              |                   |                          |                   | O 2           |
The association between \textit{H. pylori} and ESRD

We found a marginal but not significantly decreased risk of \textit{H. pylori} infection in overall ESRD subjects compared with non-ESRD subjects\cite{12,13,16,19-42,49-56} with pooled RR of 0.77 (95%CI: 0.59-1.00, \(I^2 = 79\%\)) (Figure 3). Subgroup analysis based on ageing as described above, we found a significant decreased risk of \textit{H. pylori} infection among adult ESRD patients\cite{12,13,16,19-23,25-28,30-42,49-51,53-56} with pooled RR of 0.71 (95%CI: 0.55-0.94, \(I^2 = 79\%\)) compared with non-ESRD patients (Supplementary Figure 3). Nevertheless, we did not find a significant association between \textit{H. pylori} infection and ESRD among ESRD children\cite{24,29,52}, pooled RR = 1.93 (95%CI: 0.55-6.82, \(I^2 = 77\%\)), (Supplementary Figure 4).

The data on the risk of ESRD in patients with \textit{H. pylori} were limited. Two cohort\cite{14,48} studies were included to assess the risk of ESRD in patients with \textit{H. pylori}. The pooled risk RR of ESRD in patients with \textit{H. pylori} was 0.61 (95%CI: 0.03-12.20).

Evaluation for publication bias

A funnel plot assessing publication bias for the association between \textit{H. pylori} infection in overall ESRD subjects was demonstrated in Figure 4. The funnel plot of the association between \textit{H. pylori} infection in overall ESRD subjects was symmetric and suggested no publication bias.

DISCUSSION

In this meta-analysis summarizing all presently

\begin{table}
\centering
\begin{tabular}{ |l|l|l|l|l|l|l|l|l|l|l|l|}
\hline
\textbf{Tsukada et al}\cite{41} & Japan & 2003 & HD & Histology & 9/36 (25\%) & 0.28 (0.02-3.82) & S 3 & C 2 & O 2 & S 3 & C 2 & O 2 \\
\textbf{Olmos et al}\cite{37} & Argentina & 2003 & HD & Antibody & 44/93 (47\%) & 0.62 (0.35-1.11) & S 3 & C 2 & O 2 & S 3 & C 2 & O 2 \\
\textbf{Nakajima et al}\cite{54} & Japan & 2004 & HD & Antibody & 51/138 (37\%) & 0.35 (0.22-0.58) & S 3 & C 1 & O 2 & S 3 & C 1 & O 2 \\
\textbf{Nardone et al}\cite{35} & Italy & 2005 & HD & Urease test, histology, urea breath test and stool antigen & 7/11 (64\%) & 3.04 (0.82-11.13) & S 3 & C 0 & O 2 & S 3 & C 0 & O 2 \\
\textbf{Blusievicz et al}\cite{35} & Poland & 2005 & HD & Urease, histology & 19/30 (63\%) & 0.71 (0.24-2.07) & S 3 & C 0 & O 2 & S 3 & C 0 & O 2 \\
\textbf{Khedmat et al}\cite{54} & Iran & 2007 & HD & Urease test & 46/73 (63\%) & 3.20 (1.88-5.44) & S 3 & C 0 & O 2 & S 3 & C 0 & O 2 \\
\textbf{Kazaee et al}\cite{41} & Iran & 2008 & HD - children & Urease test, and histology & 16/24 (67\%) & 8.00 (2.19-29.25) & S 3 & C 0 & O 2 & S 3 & C 0 & O 2 \\
\textbf{Gioè et al}\cite{26} & Italy & 2008 & HD & Urease test, and histology & 75/142 (53\%) & 1.39 (0.86-2.23) & S 3 & C 0 & O 2 & S 3 & C 0 & O 2 \\
\textbf{Abdulrahman et al}\cite{41} & Saudi Arabia & 2008 & ESRD & Histology & 16/40 (40\%) & 0.22 (0.09-0.56) & S 3 & C 1 & O 2 & S 3 & C 1 & O 2 \\
\textbf{Asl et al}\cite{41} & Iran & 2009 & HD & Histology & 23/40 (58\%) & 2.81 (1.13-6.99) & S 3 & C 1 & O 2 & S 3 & C 1 & O 2 \\
\textbf{Sugimoto et al}\cite{54} & Japan & 2009 & HD & Antibody & 262/539 (49\%) & 0.26 (0.19-0.35) & S 3 & C 0 & O 2 & S 3 & C 0 & O 2 \\
\textbf{Chang et al}\cite{21} & South Korea & 2010 & HD & Urease test and histology & 12/33 (36\%) & 0.30 (0.12-0.74) & S 3 & C 0 & O 2 & S 3 & C 0 & O 2 \\
\textbf{Hooman et al}\cite{29} & Iran & 2011 & HD - children & Histology & 19/68 (28\%) & 1.59 (0.65-3.92) & S 3 & C 0 & O 2 & S 3 & C 0 & O 2 \\
\textbf{Genc et al}\cite{24} & Turkey & 2013 & HD and PD - children & Antibody & 17/33 (52\%) & 0.69 (0.26-1.83) & S 3 & C 1 & O 2 & S 3 & C 1 & O 2 \\
\textbf{Chang et al}\cite{20} & Taiwan & 2014 & ESRD & Urease test and histology & 81/144 (56\%) & 0.54 (0.38-0.77) & S 4 & C 2 & O 3 & S 4 & C 2 & O 3 \\
\hline
\end{tabular}
\caption{H. \textit{pylori}: Helicobacter \textit{pylori}; HD: Hemodialysis; PD: Peritoneal dialysis.}
\end{table}
Table 2 Main characteristics of the cohort studies included in this meta-analysis

| Study                        | Country      | Study design             | Year | Study sample | H. pylori testing | ESRD definition                          | Adjusted HR | Confounder adjustment | Quality assessment (Newcastle-Ottawa scale) |
|------------------------------|--------------|--------------------------|------|--------------|-------------------|-------------------------------------------|-------------|-----------------------|-------------------------------------------|
| Offerhaus et al              | Hong Kong    | Cohort study             | 2004 | Type 2 diabetic patients with clinical proteinuria and renal insufficiency | Antibody | Doubling of baseline serum creatinine concentration or need for dialysis or serum creatinine ≥ 500 μmol/L | 0.12 (0.03, 0.52) | Sex, H. pylori status, serum creatinine, hemoglobin, systolic blood pressure, ACE inhibitors, Hepatitis B surface antigen status | Selection: 3 Comorbid: 3 Outcome: 3 |
| Shousha et al                | Taiwan       | Cohort study             | 2015 | H. pylori-infected and non-infected patients without ESRD | Diagnosis of H. pylori infection (ICD-9 041.86) was used from inpatient database of The Taiwan National Health Insurance Research Database | ESRD was identified from Registry for Catastrophic Illness Patient Database | 2.58 (2.33, 2.86) | Age, sex, comorbidity | Selection: 4 Comorbid: 3 Outcome: 3 |
| Loffeld et al                |              |                          |      |              |                   |                                           |             |                       |                                           |
| Davenport et al              |              |                          |      |              |                   |                                           |             |                       |                                           |
| Ala-Kalia et al              |              |                          |      |              |                   |                                           |             |                       |                                           |
| Gladziwa et al               |              |                          |      |              |                   |                                           |             |                       |                                           |
| Giachino et al               |              |                          |      |              |                   |                                           |             |                       |                                           |
| De Vecchi et al              |              |                          |      |              |                   |                                           |             |                       |                                           |
| Jasperesen et al             |              |                          |      |              |                   |                                           |             |                       |                                           |
| Seyrek et al                 |              |                          |      |              |                   |                                           |             |                       |                                           |
| Krawczyk et al               |              |                          |      |              |                   |                                           |             |                       |                                           |
| Ozgur et al                  |              |                          |      |              |                   |                                           |             |                       |                                           |
| Yildiz et al                 |              |                          |      |              |                   |                                           |             |                       |                                           |
| Tamura et al                 |              |                          |      |              |                   |                                           |             |                       |                                           |
| Gur et al                    |              |                          |      |              |                   |                                           |             |                       |                                           |
| Fabrizi et al                |              |                          |      |              |                   |                                           |             |                       |                                           |
| Araki et al                  |              |                          |      |              |                   |                                           |             |                       |                                           |
| Karai et al                  |              |                          |      |              |                   |                                           |             |                       |                                           |
| Nakajima et al (1)           |              |                          |      |              |                   |                                           |             |                       |                                           |
| Tsukada et al                |              |                          |      |              |                   |                                           |             |                       |                                           |
| Olmos et al                  |              |                          |      |              |                   |                                           |             |                       |                                           |
| Nakajima et al (2)           |              |                          |      |              |                   |                                           |             |                       |                                           |
| Nardone et al                |              |                          |      |              |                   |                                           |             |                       |                                           |
| Blusiewicz et al             |              |                          |      |              |                   |                                           |             |                       |                                           |
| Khedmat et al                |              |                          |      |              |                   |                                           |             |                       |                                           |
| Khazaee et al                |              |                          |      |              |                   |                                           |             |                       |                                           |
| Goe et al                    |              |                          |      |              |                   |                                           |             |                       |                                           |
| Hosseini et al               |              |                          |      |              |                   |                                           |             |                       |                                           |
| Sugimoto et al               |              |                          |      |              |                   |                                           |             |                       |                                           |
| Chang et al (1)              |              |                          |      |              |                   |                                           |             |                       |                                           |
| Hooman et al                 |              |                          |      |              |                   |                                           |             |                       |                                           |
| Genc et al                   |              |                          |      |              |                   |                                           |             |                       |                                           |
| Chang et al (2)              |              |                          |      |              |                   |                                           |             |                       |                                           |
| Hruby et al                  |              |                          |      |              |                   |                                           |             |                       |                                           |
| Abdulrahman et al            |              |                          |      |              |                   |                                           |             |                       |                                           |

Overall Q = 174.36, P = 0.00, I² = 80%

Figure 2 Forest plot of overall prevalence of Helicobacter pylori infection among end-stage renal disease patients.

Wijarnpreecha K et al. H. pylori and end-stage renal disease

H. pylori: Helicobacter pylori; HD: Hemodialysis; PD: Peritoneal dialysis; ESRD: End-stage renal disease.
available data on the prevalence of *H. pylori* infection among ESRD patients and the association between *H. pylori* infection and ESRD, we demonstrated an estimated prevalence of *H. pylori* in ESRD patients of 44%. In addition, we found a 0.71-fold decreased risk of *H. pylori* in adult ESRD patients.

Although the precise explanation of reduced risk of *H. pylori* among adult ESRD patients is still unclear, there are several plausible explanations for this association. First, it has been postulated in previous studies that administering antibiotics and antacid more frequently in ESRD patients may contribute to lower the prevalence of *H. pylori* infection27,29. Previous study proposed that ESRD patients may have a lower risk of *H. pylori* infection from routinely used of antacids to prevent renal osteodystrophy by reducing intestinal phosphate absorption20. Second, patients with ESRD have higher levels of inflammatory cytokines including tumor necrotic factor, interleukin-6 and -8 from infiltrative inflammatory cells in gastric mucosa57 and chronic circulatory failure58,59 could lead to gastric mucosal damage and progress to gastric atrophy or atrophic gastritis, increased in gastric pH mucosa, and eventually eradication of *H. pylori* infection50-62.

Although the included studies in this meta-analysis are almost of good quality, there are several limitations to this study that need to be addressed. Firstly, there was a statistical heterogeneity in the completed analysis. Possible sources of this heterogeneity include differences in confounder-adjusted methods (e.g., age, gender, ethnicity and socioeconomic status), different test to detect *H. pylori* infection in each study, various grades of uremia. Secondly, our subgroup analysis revealed significantly decreased the risk of *H. pylori* infection among adult subjects with ESRD but not in children likely due to a limitation in some studies. Although the number of study assessing *H. pylori* infection in children was limited and the insignificant finding in ESRD children could be from the lack of power, further studies are required to determine the role of aging in the underlying pathogenesis of *H. pylori* infection.

Figure 3 Forest plot of the association between *Helicobacter pylori* infection and end-stage renal disease.

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**Table 3**

| Study or subgroup | log[relative risk] | SE | Weight | Risk ratio | Risk ratio | Year |
|------------------|-------------------|----|--------|------------|------------|------|
| Offenhaus et al  | -0.04082          | 0.1020 | 1.65   | 0.99 (0.42, 2.21) | 2000 |
| Shousha et al    | -0.84397          | 0.1447 | 1.24   | 0.43 (0.20, 0.91) | 1990 |
| Ala-Kalla et al  | -0.38566          | 0.1020 | 1.65   | 0.68 (0.17, 2.68) | 1991 |
| Davenport et al  | 0.254642          | 0.1020 | 1.65   | 1.29 (0.75, 2.22) | 1991 |
| Loffeld et al    | 0.211111          | 0.1020 | 1.65   | 1.24 (0.58, 2.65) | 1991 |
| Gladziwa et al   | -0.82098          | 0.1020 | 1.65   | 0.44 (0.19, 1.01) | 1993 |
| Giachino et al   | -0.67334          | 0.1020 | 1.65   | 0.51 (0.20, 1.29) | 1994 |
| De Vecchil et al | -0.94161          | 0.1020 | 1.65   | 0.39 (0.18, 0.83) | 1995 |
| Jaspers et al    | -0.82098          | 0.1020 | 1.65   | 0.44 (0.18, 1.08) | 1995 |
| Seynek et al     | -0.57682          | 0.1020 | 1.65   | 0.56 (0.21, 1.50) | 1996 |
| Krawczyk et al   | -0.07257          | 0.1020 | 1.65   | 0.93 (0.27, 3.20) | 1996 |
| Hruby et al      | -0.38566          | 0.1020 | 1.65   | 0.68 (0.19, 2.44) | 1997 |
| Ozgur et al      | -0.18633          | 0.1020 | 1.65   | 0.83 (0.41, 1.69) | 1997 |
| Fabrizi et al    | 0.10436           | 0.1020 | 1.65   | 1.11 (0.74, 1.66) | 1999 |
| Yildiz et al     | -0.23572          | 0.1020 | 1.65   | 0.79 (0.34, 1.84) | 1999 |
| Araki et al      | -0.79851          | 0.1020 | 1.65   | 0.45 (0.22, 0.92) | 1999 |
| Gur et al        | 0.039221          | 0.1020 | 1.65   | 1.04 (0.45, 2.40) | 1999 |
| Tamura et al     | -0.12783          | 0.1020 | 1.65   | 0.88 (0.40, 1.95) | 1999 |
| Karari et al     | 0.322601          | 0.1020 | 1.65   | 1.38 (0.73, 2.60) | 2000 |
| Nakajima et al   | -1.20397          | 0.0906 | 1.08   | 0.30 (0.11, 0.81) | 2002 |
| Olmos et al      | -0.47804          | 0.0897 | 1.08   | 0.62 (0.35, 1.10) | 2003 |
| Tsukada et al    | -1.27297          | 0.0897 | 1.08   | 0.28 (0.02, 3.87) | 2003 |
| Nakajima et al   | -1.04982          | 0.0897 | 1.08   | 0.35 (0.22, 0.57) | 2004 |
| Nardone et al    | 1.111858          | 0.0906 | 1.08   | 3.04 (0.83, 11.20) | 2005 |
| Bluvsieczk et al | -0.34249          | 0.0897 | 1.08   | 0.71 (0.24, 2.09) | 2006 |
| Kheda et al      | 1.163151          | 0.0906 | 1.08   | 3.20 (1.88, 5.44) | 2007 |
| Khazaee et al    | 2.079442          | 0.0906 | 1.08   | 8.00 (2.19, 29.24) | 2008 |
| Goe et al        | 0.329304          | 0.0906 | 1.08   | 1.39 (0.86, 2.24) | 2008 |
| Abdulrahman et al| -1.51413          | 0.0897 | 1.08   | 0.22 (0.09, 0.55) | 2008 |
| Hosseini et al   | 1.033184          | 0.0897 | 1.08   | 2.81 (1.23, 6.44) | 2009 |
| Sugimoto et al   | -1.34707          | 0.0897 | 1.08   | 0.26 (0.19, 0.35) | 2009 |
| Chang et al      | -1.20337          | 0.0897 | 1.08   | 0.30 (0.12, 0.74) | 2010 |
| Hooman et al     | 0.463734          | 0.0897 | 1.08   | 1.59 (0.65, 3.90) | 2011 |
| Genc et al       | -0.37106          | 0.0897 | 1.08   | 0.69 (0.26, 1.83) | 2012 |
| Chang et al      | -0.61619          | 0.0897 | 1.08   | 0.54 (0.38, 0.77) | 2014 |

Total (95%CI): 100.0% (0.77 (0.59, 1.00))

Heterogeneity: $I^2 = 79%$

Test for overall effect: $Z = 1.95$ (P = 0.05)
among ESRD patients. Lastly, this study is a meta-analysis of observational studies. Thus, our study demonstrated an association, but could not establish causality as unknown confounders could play a role in the association between prevalence of H. pylori among hemodialysis and association between H. pylori and ESRD.

In conclusion, our meta-analysis demonstrated an estimated prevalence of H. pylori in ESRD patients of 44%. In addition, our meta-analysis demonstrates a decreased risk of H. pylori in adult ESRD patients. ESRD could be a potential protective factor for H. pylori infection.

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