



REVIEW

Contaminated water as a source of *Helicobacter pylori* infection: A review



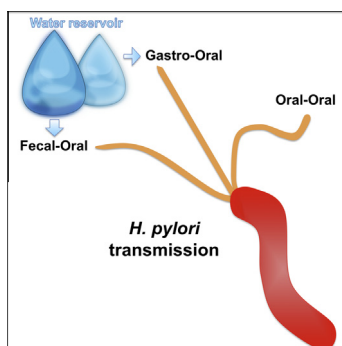
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GRAPHICAL ABSTRACT



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ABSTRACT

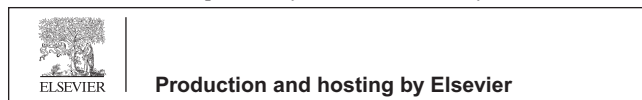
Over the preceding years and to date, the definitive mode of human infection by *Helicobacter pylori* has remained largely unknown and has thus gained the interest of researchers around the world. Numerous studies investigated possible sources of transmission of this emerging carcinogenic pathogen that colonizes > 50% of humans, in many of which contaminated water is mentioned as a major cause. The infection rate is especially higher in developing countries, where contaminated water, combined with social hardships and poor sanitary conditions, plays

Abbreviations: IMS, immunomagnetic separation; PCR, polymerase chain reaction; VBNC, viable-but-non-culturable.

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a key role. Judging from the growing global population and the changing climate, the rate is expected to rise. Here, we sum up the current views of the water transmission hypothesis, and we discuss its implications.

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Introduction

Water crisis and risk of infectious diseases in the developing world

On July 28, 2010, the General Assembly of the United Nations voted to recognize access to clean water and sanitation as a human right (URL: <http://www.un.org/News/Press/docs/2010/ga10967.doc.htm>), a long-awaited decision that had been advocated and endorsed by the scientific community [1]. This recent UN resolution came at a time in which water is

increasingly becoming at the heart of geopolitical and socioeconomic conflicts, notably in the developing world and in particular as a consequence of climate change [2,3].

In developing countries, many communities lack access to a reliable source of clean water (Fig. 1A) or sanitation services (Fig. 1B) [4]. Instead, those communities find themselves having no other choice but to depend on the surrounding sources of continuously flowing water, such as nearby rivers and streams as their sole everyday water source (Fig. 2A). On the other hand, isolated communities living in low-populated deserted geographical areas, located hundreds of miles away from a nearby river branch or stream, are obliged to rely on municipal water wells as their main supply for drinking and irrigation (Fig. 2B). An alarmingly rising number of those individuals suffer from numerous gastrointestinal tract-related problems [5–8], some of which can be directly linked to *Helicobacter pylori* infection, which can result into chronic infection and even cancer [9,10].

When waterborne diseases are discussed, acute infections related to diarrhea and malnutrition (e.g., infections by *Vibrio cholerae*, *Escherichia coli*, and *Salmonella enterica*) often come to the front scene [3,11], but it is less common to consider chronic diseases, such as those resulting from *H. pylori* infection, as water-related public health threats. Still, the increase in *H. pylori*-associated gastrointestinal conditions could only raise an obvious question of whether contaminated water is a route of transmission of this pathogen, being a common factor among the infected patients [12]. This question gains particular importance given the continuously changing pattern of human demography expected to redraw the global map of *H. pylori* epidemiology [13].

In this article, we briefly introduce *H. pylori* and its epidemiology, we review evidence suggesting contaminated water as a source of infection with emphasis on recent evidence confirming viability of the bacteria isolated from water sources, and we discuss the potential implications of this route of transmission on global health and health policies.

Helicobacter pylori and its transmission

H. pylori, a bacterium initially observed in 1893 ([14] cited in [15]), has not been recognized as an infectious agent until 1982—in the seminal work of Nobel Laureates, Warren and Marshall [16–18]. *H. pylori* colonizes various regions of the upper digestive system, mainly the stomach and duodenum, causing stomach and duodenal ulcers and certain stomach cancers [9,19,20]. The infection is surprisingly common, and the bacteria are believed to colonize more than half of the world's population [21].

H. pylori bacteria grow only under microaerophilic conditions on rich media [22]. An interesting feature of these bacteria is their ability to adapt to harsh conditions. They are

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