

The Impact of Educational Campaigns on the Global Dynamics of Cholera Epidemics*

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Abstract In this study, we examine a cholera epidemic model that incorporates educational transmission and delve into the long-term dynamics of the epidemic equilibrium point, particularly in relation to the spread of information about disease transmission. We find that if the basic reproduction number R_0 is less than or equal to 1, the disease is destined to be eradicated, and the unique disease-free equilibrium point becomes globally stable. It is noteworthy that the stability of this disease-free equilibrium is not influenced by the extent of disease education, the variety of infections, or the rate of education. On the other hand, if the basic reproduction number is greater than 1, we study the existence of the endemic equilibrium, and demonstrate that the disease will persist if $\beta_0 > D_0$. To assess the impact of educational campaigns on disease control, we further establish the asymptotic behavior of both infected and susceptible populations in response to educational interventions. Our findings indicate that well-executed educational campaigns can substantially contribute to the management and mitigation of the disease's effects.

Keywords Cholera epidemic model, education communication, asymptotic behavior

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1. Introduction

Cholera is an ancient disease that has caused at least seven global pandemic. According to statistics, 3 to 5 million people worldwide are infected with cholera each year, resulting in over 100000 deaths. This acute intestinal infectious disease is caused by *Vibrio cholera* and is characterized by rapid onset, fast transmission, and widespread occurrence. It can be transmitted to humans through direct contact with infected individuals and indirect contact with contaminated water environments [15, 19]. After ingesting water or food contaminated with *Vibrio cholera*, individuals may experience symptoms within 12 hours to 5 days [10], which can include vomiting and diarrhea. If infected individuals are not treated promptly, cholera can lead to severe dehydration and even death [24]. Cholera remains a sig-

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nificant public health challenge in many parts of the world [20], particularly in areas lacking clean drinking water and underdeveloped sanitation facilities [21]. Various measures have been implemented across different regions to control the spread of cholera infection. Education and media campaigns play a crucial role in preventing the spread of cholera, especially in developing countries that may not have effective healthcare to prevent the spread of cholera. These campaigns can provide essential information to raise individuals awareness about cholera and help individuals to change harmful habits, such as drinking from unclean water sources or consuming contaminated water products; see [3, 5, 17, 22]. Recently, Denu et al. [11] studied a time delayed HIV/AIDS epidemic model with education dissemination and they considered the asymptotic behavior of the endemic equilibrium with respect to the education dissemination. In [12], they further proved the existence of traveling wave solution and spreading speed of a diffusive time-delayed HIV/AIDS epidemic model with information and education campaigns.

In order to understand the impact of control strategies on the spread of cholera infection, various mathematical models have been used to simulate the spread of cholera. Results have indicated that intervention measures are crucial for controlling disease spread [1, 2, 4, 6–8, 13, 16, 19, 23, 28–30]. In this paper, we incorporate information and educational initiatives into the SIR epidemic model to analyze their effects on controlling the transmission of cholera. We assume that the dynamics of cholera involve the interactions among human hosts, bacteria, and the environment, including human-to-human transmission, indirect environmental transmission, and bacterial shedding into the water environment. In our model, we use the compartment $B(t)$ to represent the bacteria concentration in the environment.

Thus, we divide that population with a total size of $N(t)$ at time t into four classes, which are susceptible ($S_0(t)$, $S_1(t)$), infected individuals $I(t)$, and the removed category $R(t)$. The $S_0(t)$ class, also known as the general susceptible group, consists of uninfected individuals who are vulnerable to infection after contacting with infected individuals. In addition, group $S_0(t)$ can directly access information and educational activities related to the disease. We denote by $Z(t)$ the amount of the educational information from the information and education campaigns. The main educational strategies are enhancing people's awareness of cholera and encouraging them to drink purified water to reduce exposure to the cholera virus. As a result of participating in educational campaigns, some individuals in $S_0(t)$ will change their behavior and enter other compartments based on the information they have received. The group $S_1(t)$ represents individuals whose behavior has been changed due to information and educational campaigns. We assume that only through natural death and infection can individuals leave group $S_1(t)$. Furthermore, we assume that the infection between $S_0(t)$ and $Z(t)$ will transfer to $S_1(t)$ at a rate of γ . The compartment $R(t)$ represents the recovery group of infected individuals.

Based on the above discussion, we consider the following system of nonlinear