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Co-Infection Alters the Population Dynamics of Infectious Diseases: Mini-Review

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Novelty:
This brief review provides an analysis of co-infection in natural populations, its nature of interaction and effect among pathogens.

Abstract

Infectious diseases are of significant health importance to human and animal life. Globally, infectious diseases continue to present a great challenge to health with regard to morbidity and mortality. This review seeks to analyse from existing evidence, the altering role of co-infection on the population dynamics of infectious diseases. This paper has implications for research, policy and clinical interventions.

Keywords: Co-Infection, Infectious diseases, Population Dynamics, Mini-Review.

Introduction

For centuries, infectious diseases continue to present a great challenge to health systems worldwide. They correlate with wars and famine and are known to affect human development and existence (Morens et al., 2004). Disease-induced mortality from infectious diseases depends on several factors. These include features of the host, environmental conditions, features of infecting pathogens and pathogen-pathogen interactions in instances where there are co-infections (Thumbi et al., 2014). For several decades, vaccines and antibiotics have brought improvement in the prevention and treatment of several infectious diseases, and even enabled the eradication of diseases such as small pox (Mack, 1972). Nevertheless, several reports of drug resistance and vaccine blocking have been reported all over the world with new diseases emerging and even those that were considered to be under control re-emerging (Morens et al., 2004).

One of the hurdles identified in the treatment or prevention of morbidity and mortality associated with infectious diseases is the fact that existing interventions usually overlook the possibility of different infections affecting one another (Griffiths, 2013; Susi et al., 2015). There is

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currently a growing awareness that most often than not, infections consist of more than one pathogen species (Balmer et al., 2011). Therefore, to effectively tackle infectious diseases, interactions between infectious agents must be considered.

Co-infection in natural populations, interactions and effects

Co-infection is a common occurrence in natural populations (man and other animals) involving parasites of various taxa, transmission routes and pathologies (Kotob et al., 2016; Susi et al., 2015). Research of specific taxa and groups of individuals indicate that co-infection is very extensive and prevalent in areas endemic with diverse parasites (Griffiths, 2013; Thumbi et al., 2014).

An estimated 30 % of infections, which could even be up to 80% in certain human populations are possibly co-infections (Petney et al., 1998). It is simply defined as the concurrent infection of a species by more than a single type of parasite or pathogen (Griffiths, 2013; Kotob et al., 2016). Co-infections may occur when hosts become separately infected by diverse parasites concurrently. Also, it can occur throughout a sequential infection, when interactions among parasite species cause co-occurrence to be possible (Vaumourin et al., 2015).

Several parasites that infect humans usually coexist within an individual host. Typical examples of co-infections in humans include malaria and helminth infections and co-infections that involves human immunodeficiency virus [HIV] (Thumbi et al., 2014). The effects of co-infections on human health are seldom evaluated. Thus, global estimate of people living with co-infections are deficient (King, 2010).

A study conducted in the Ivory Coast discovered that 75% of village folks were severely co-infected with between three (3) and ten (10) intestinal parasite species (Griffiths, 2013; Raso et al., 2004). Out of an estimated 3 billion individuals who have parasitic worms (helminth), one billion people are co-infected with multiple helminth species (Drake & Bundy, 2001). Furthermore, about 10 million persons are co-infected with HIV and tuberculosis (World Health Organization, WHO, 2018) and in 2016, mortality from HIV and Tuberculosis co-infections were over 370,000 people (Narasimhamurthy et al., 2018).

Parasites/pathogens may either act singly or interact with each other and the host using several mechanisms with variable outcomes on the host's health and survival (Thumbi et al., 2014). Interactions that exist between parasites can either be direct or indirect (Griffiths, 2013). Typical examples of direct interactions are viruses infecting bacteria and helminths transmitting bacteria (Flores et al., 2011). For indirect interactions mediated by the host immune response, it can be opportunistic co-infection by common commensal bacteria where the immune system is repressed by another infection (Vaumourin et al., 2015), and trade-offs between diverse parts of the host immune system (Page et al., 2006). An illustration of indirect interaction is competition between malarial parasites for red blood cells (Antia et al., 2008).

Co-infections impact greatly on host-parasite ecology (Griffiths, 2013). The presence of multiple species in the same individual host can bring to bear additional burdens on the host's health (Brogden et al., 2005; Brooker et al., 2007). Therefore, co-infections impact greatly on the course and severity of various diseases of man and other animals (Kotob et al., 2016; Thumbi et al., 2014). With co-infections, the pathogens are genetically different and may cause pathogenic outcome which causes harm to the host in simultaneity with other pathogens (Kotob et al., 2016). They "alter the host's susceptibility to other parasites, infection duration, transmission risks, clinical symptoms and consequently treatment and prevention strategies" (Vaumourin et al., 2015, p.1).

Also, it is possible that interactions between co-occurring parasites or pathogen strains may affect the progress and persistence of disease epidemics, and consequently their population dynamics (Sundberg et al., 2016). These interactions yield various consequences: the load of one or both parasites/pathogens may increase, one or both may be suppressed or one may be increased and the other suppressed (Kotob et al., 2016). In a study by Susi et al. (2015) using Plantago lanceolate infected with two strains of Podosphaera plantaginis, it was observed that co-infected hosts shed more propagules as compared to independently infected hosts. Their findings provided a better comprehension of how co-infection modify disease load across host genotypes. Epidemiological studies that were conducted in Thailand showed that the elimination of helminth co-infections might increase the frequency of cerebral malaria (Nacher, 2004).

Co-infection between Plasmodium spp. and Soil-transmitted helminth infections have been the theme of many researches in humans and animal models. Plasmodium parasites commonly co-occur with geohelminths especially hookworms. Some studies showed that the presence of geohelminths resulted in an increase in severity and incidence of malaria (synergistic interaction) while others observed a reduction in the severity and incidence of malaria (antagonistic interaction) (Thumbi et al., 2014). However, a review by Nacher (2004) suggested that the interaction was synergistic. Therefore, infectious agents play a significant role in regulating the populations of several host species across different ecosystems (Thumbi et al., 2014). Depending on the mechanisms by which the interactions occur, co-infections could result in further harm to the host as compared to the collective outcome of the component, or less harm in comparison to the collective outcome of the component infections (Alizon et al., 2008; Thumbi et al., 2014).

According to theory, co-infections have significant effect on within-and-between-host disease dynamics (Susi et al., 2015). Within-host disease dynamics are predicted to alter under co-infections, an assumption which underlies many theoretical models which projects an increase in virulence when a single host is infected with several strains of a parasite or pathogen. The changes that are predicted to occur in within-host infection dynamics might have extreme repercussions on between-host dynamics as well as epidemiological outcomes since both are proposed to be interconnected (Susi et al., 2015).

Interestingly, results of within-host infection may be mediated by the host's response to infection (Susi et al., 2015). Such immune-mediated interactions can create obstruction on preventative measures such as vaccination (Griffiths, 2013). Some vaccines are reported to be less effective in persons with other infections such as helminthes and HIV, human papillomavirus (Geiger et al., 2011; Pons-Salort et al., 2013). There is also a shift in the prevention and control of helminth infections from single drug treatment to that of an integrated approach as a result of co-infections (WHO, 2018). Again, multiple strain infections of Leishmania infantum and Mycobacterium tuberculosis confound treatment (Balmer & Tanner, 2011).

Conclusion

In conclusion, the dynamics in co-infection will continue to be a topic of research, clinical and policy interest. Parasites/pathogens may act separately or interact with one another through several mechanisms to produce variable outcomes on the host's health and survival. Since these interactions may affect the development and persistence of disease epidemics as well as their population dynamics, there is the need to shift attention to investigating the consequences of co-infections. Hence, prevention strategies and existing interventions must consider the possibility of co-infections in an effort to prevent and control infectious diseases effectively.

Conflicts of interest

The author declares no conflicts of interest.

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