Editorial: Using mathematical models to understand, assess, and mitigate vector-borne diseases

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Editorial on the Research Topic
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vector-borne diseases

Vector-borne diseases are simply known as infectious diseases transmitted by vectors
such as mosquitoes, black flies, fleas, ticks, sandflies, tsetse flies, lice, aquatic snails, and are
caused by different pathogens, including parasites, viruses and bacteria. Examples of these
vector-borne diseases include, but not limited to malaria, Rift Valley fever, dengue, Zika,
monkeypox, yellow fever, onchocerciasis, chikungunya, sandfly fever, schistosomiasis, and
leishmaniasis [1]. The emergence and re-emergence of vector-borne diseases are of great
concern to the public health, as the diseases continue to pose threat to the existence of such
living creatures as humans and animals, claiming lives and constituting overwhelmed health
systems in several countries of the world.

One of the means through which transmission dynamics of infectious diseases can be
understood with a view to suggesting the needed intervention measures for prevention
and control of the diseases in the population is mathematical modeling [see, for examples,
refs. [2–13]]. This Research Topic is, therefore, set out to address the dynamics of
various vector-borne diseases transmitting among human and animal populations using
a variety of mathematical modeling tools. Consequently, six different articles contributed
robustly to this Research Topic through the two participating journals, namely Frontiers in
Applied Mathematics and Statistics (Mathematical Biology) and Frontiers in Public Health
(Infectious Diseases: Epidemiology and Prevention).

The first paper (Madubueze, Chazuka et al.) focused on schistosomiasis, a vector-
borne disease transmitted by aquatic snails and caused by parasite. The authors of the first
manuscript formulated and analyzed a novel mathematical model for schistosomiasis by
considering heterogeneity associated with the host transmission pathways. After establishing
the existence and uniqueness of solutions of the model, the authors computed the basic
reproduction of the schistosomiasis transmission and conducted stability analyses of the
equilibrium states. Latin-hypercube sampling was used to perform the global sensitivity
analysis in order to investigate the most significant parameters in the basic reproduction
number. The impacts of the most sensitive parameters on the disease dynamics were
visualized and it was concluded that decrease in the population of the aquatic snails
could lead to the eradication or reduction of schistosomiasis transmission within the
human population.

The authors of the second paper (Madubueze, Onwubuya et al.) considered another vector-borne disease of public health interest, which is monkeypox. The disease is zoonotic, and it is caused by monkeypox virus of *Orthopoxvirus* genus. The authors presented a deterministic model for the environmental transmission of monkeypox in the presence of quarantine and vaccination. Existence of equilibrium points of the model were established and their stabilities were investigated using comparison theory and Volterra Lyapunov matrix theory. Sensitivity analysis carried out showed that environmental transmission parameters are the major drivers of the monkeypox infection and it was recommended that health practitioners should focus on control strategies targeted at shedding of virus in the environment.

In the third paper (Adeniyi et al.), authors developed a mathematical model to examine the impact of various malaria control and mitigation strategies. Malaria is a notable vector-borne disease caused by parasite of genus *Plasmodium* and transmitted by Anopheles female mosquitoes. The authors of the third manuscript investigated the stability of the steady states of the developed model using Lyapunov function and implicit function theorem after obtaining the basic reproduction number. Data-driven analysis was performed using R-statistical package with MATLAB to fit the developed model to the real data of malaria cases obtained from Benue State in Nigeria. Some sensitive parameters capable of increasing the risk of malaria transmission in the population were identified. The analysis of the model was extended to optimal control theory using Pontryagin's maximum principle. Arising from the analysis, combination of long lasting insecticide treated bednets, treatment and indoor insecticide spray was recommended as the best optimal control intervention for curbing the spread of malaria in endemic areas where resources are scarce.

Leishmaniasis disease caused by parasite and transmitted by infected sandflies was studied by the authors of the fourth paper (Egbelowo et al.). A mathematical model for co-infection of leishmaniasis and tuberculosis was developed. The dynamics of the co-infection model was analyzed and it was shown that the model exhibited backward bifurcation phenomenon when the associated basic reproduction number crossed unity, implying that a stable disease-free equilibrium coexists with a stable endemic equilibrium when the basic reproduction number is less than unity.

In another development, the fifth paper (Adeyemi and Oluyo) concentrated on the transmission dynamics of mastitis which is a vector-borne and zoonotic disease caused by bacteria leading to the inflammation of the mammary gland. The authors obtained the effective reproduction number and showed the stability of both disease-free and endemic equilibria. Sensitivity analysis performed showed that biting rate of flies is the most sensitive parameter that should be targeted by control measures in order to improve the quality and quantity of milk production by cattle for human consumption. The last paper (Fisher et al.) published under this

Research Topic provided a novel specialist hybrid approach, which combines a linear predictive model and a recurrent neural network predictive model trained with asymmetric loss, to accurately forecast malaria prevalence. The authors carried out the analysis on an open-source dataset Containing 22 years of malaria cases reported from the city of Ibadan in southwest Nigeria.

Conclusively, there were 23 authors from different continents of the world who contributed meaningfully toward achieving the aim of this Research Topic. The originality of their studies was premised on the novelty of the developed mathematical models for the transmission of different vector-borne diseases. It is, therefore, hoped that the findings of the Research Topic would help in improving decision-making process regarding efforts to combat the spread of vector-borne diseases.

Author contributions

MN: Writing—review and editing. SO: Writing—original draft.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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