Operations Research and Management of Infectious Diseases

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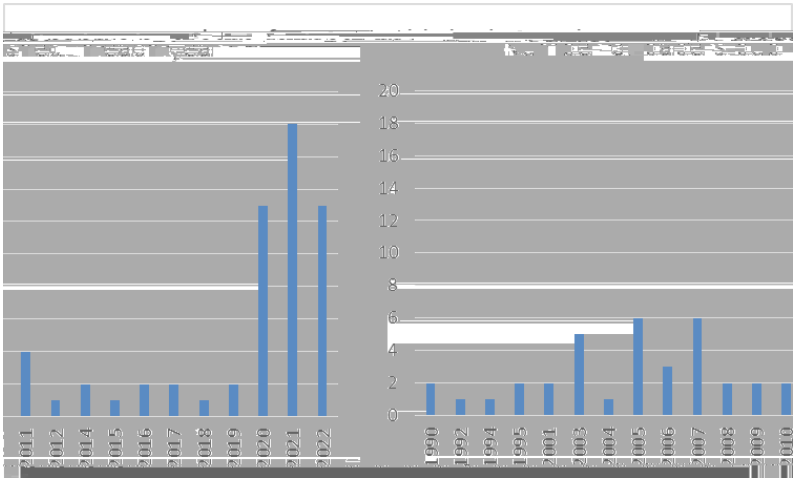
Health care sector and medical science has been dynamically evolving since past 20 years. Emergence of epidemics like SARS, HIV, Malaria and recently covid-19 has resulted in the incorporation of operational research in medical science. The field has experienced a growing presence of operational research techniques to study the

system models, and validated these models using data they collected during full-scale simulations of disease outbreaks. In 2006, derive deterministic epidemiological models for the propagation of a P2P virus through a P2P network. In order to create e ective control measures for the UK foot-and-mouth outbreak of 2001, mathematical models played a crucial role. reviews the numerous modelling exercises that were created throughout the pandemic, outlining the challenges in understanding the data at hand and the suitability of the various assumptions. conducted an expert elicitation process to come up with the design principles, priority issues [7] [Figure 1], and eld experiences that should inform development of an epidemic recovery model. eir results categorise the ndings into the following categories Operating de nitions, Response prioritized, Politics/economics, Distinctive features, and Model considerations. In the year 2007, a study proposed a nurse allocation policy to manage patient out ow during the pandemic in uenza outbreak. (Allocation of resources for the management of disease) e objective of this study was to minimize the number of patients waiting in queue for treatment of the virus alongside maximizing the patient in ow. is model if e ciently applied could prove to be a live saver if applied to bed allocation in hospitals as shortage of beds becomes a major bottleneck in times of rapidly rising infections To do this they made use of ARENA simulation so ware and proposed various combinations for the number of nurses needed with the help of operations research [8].

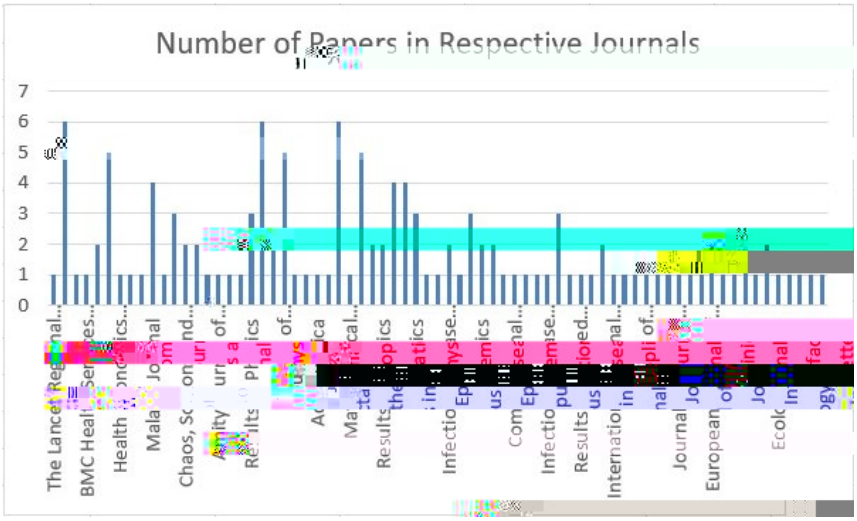
ere have been speci c disease-related researches conducted by many researchers. Some of the examples of such research have been included and described in this review paper.

A model of the transmission of AIDS among the homosexual population in the UK has been developed by (Roberts & Danger eld, 1990) using system dynamics techniques. It is able to represent the e ects while capturing the virological and behavioural characteristics of the pandemic. constructed a unifying, data-guided framework to simulate risk group turnover in deterministic, compartmental transmission models to examine how turnover in uences modelled projections of the tPA of high-risk groups. eir results show that if the models do not capture the projected contribution of high-risk groups, the impact of developing interventions for their needs might be underestimated. Used telephonic survey as a rapid tool for operational research for rabies post-exposure management in South Africa. is "fast and dirty" survey method produced useful data for enhancing a crucial public health programme, and it should be taken into account when evaluating other health programmes, especially if a simple method for validating replies is available [Figure 2].

Research by focused on the control of the vector-borne parasitic disease, lymphatic lariasis, and showed how mathematical models of parasite transmission can possibly provide a scienti c framework for supporting the optimal design of parasite control monitoring



Number of Papers published in each year.



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programmes. e ndings of their research demonstrate how adopting an adaptive management strategy can signi cantly improve the usage of a model-based monitoring framework by facilitating the use of monitoring data to learn about e ective control and allowing future decisions to be changed as we gain experience.

As there is a wide variety of methods and models for the management of infectious diseases have done a review of how the decision makers can choose the best way among the present OR-based methods such as standard cost-e ectiveness analysis, linear and integer programming, simulation, numerical procedures, optimal control methodologies, nonlinear optimization, and heuristic approaches to control epidemics.

Various researchers have developed speci c models such as SIR, SIER, etc for the management of infectious diseases. e paper discusses some models which are of high importance in this eld. developed a novel operational matrix for a susceptible-infected-recovered (SIR) epidemic dynamical system of children's illnesses based on Laguerre wavelets. eir numerical ndings and graphs demonstrate that chaos exists in the positive integer and arbitrary orders of the arbitrary-order SIR epidemic system. e proposed Laguerre wavelet mechanism, according to their argument, is a potential tool for identifying and analysing both linear and nonlinear dynamical systems in the biological and medical sciences. developed a Neurodynamical model of epidemics in social networks, Susceptible–Infected–Removed (SIR) epidemic processes are mechanistically modelled as analogous to the activity propagation in neuronal populations. eir results validate the strategies of social distancing. predict the future course of ongoing susceptible–infected–susceptible (SIS) epidemics on regular, high-dimensional stochastic model of an SIS epidemic on a network is approximated by a lower-dimensional surrogate model. e surrogate model is based on a birth-and-death process, the e ect of the underlying network is described by a parametric model for the birth rates. e numerical e ciency of their model makes it attractive to be used either as a standalone inference and prediction scheme or in conjunction with other inference and/or predictive models. used a nested modelling approach, embedding a within-host viral kinetics model within a population-level Susceptible-Exposed-Infectious-Recovered (SEIR) framework to estimate epidemic growth rates from cross-sectional Ct distributions across three regions in Madagascar. eir results show that public reporting of Ct values could o er an important resource for epidemiological inference in low surveillance settings, enabling forecasts of impending incidence peaks in regions with limited case reports.

A er the Covid-19 pandemic struck the world, there has been evident increase in the usage of operations research in the area of contagious disease. focused their study towards nding ways to slow down the growth of covid-19, they developed a transmission dynamical model and studied the e ect of various parameters of corona virus through the fractional mathematical model. eir ndings show a strong relationship between the contact rate and spreading cases therefore their study con rms the impact of social distancing and lockdowns. proposed a new model on covid-19 pandemic by extending the SIR model, their model distinguishes individuals on the basis of diagnosed and non-diagnosed and predicts that the latter is more engaged in spreading the disease. e model had the following stages of infection susceptible (S), infected (I), diagnosed (D), ailing (A), recognized (R), threatened (T), healed (H) and extinct (E), collectively termed SIDARTHE. e results of the study con rm that social distancing and strict lockdown at the early stages of a pandemic can save lives. Developed two data-based metrics that could be used along with estimation to forecasting better indicators of epidemic growth. e two metrics epidemic rate of change (RC) and a related state-dependent response rate parameter (RP), recursive estimates of which are obtained from dynamic harmonic and dynamic linear regression (DHR and DLR) algorithms. ey further suggested a model to estimate the number of deaths in the net 15 days of the pandemic. ey also suggest that state-dependent parameter (SDP) modelling procedures may provide data-based insight into a nonlinear di erential equation model for epidemics such as COVID-19. proposed 7 mathematical models and also developed 5 new models that supported two waves of infection in a single in uenza season. Finally, in order to determine the processes causing two-wave epidemics, they devised a modelling approach. ey conducted sensitivity analyses on crucial variables in each model and discovered that lowering the fundamental reproduction number or the transmission rate, restricting the addition of susceptible individuals, and restricting the likelihood of replenishment of individuals who are to be reinfected could lower the number of infection waves and the prevalence of clinical attacks. ey also recommended actions aimed at lowering the fundamental reproduction number or transmission rate, limiting the proportion of additional infected persons, and reducing the likelihood of replenishment of those who would be reinfected.

e use of a general System Dynamics infectious disease model to the transmission of a mutant strain of avian in uenza from person to person is discussed in the research work by. e model gives users the option to determine the rate of new infections over time using either the conventional contagious illness model's set "reproductive number" or contact rates for various subpopulations and chance of transmission per contact. e study discusses the outcomes of several approaches. ese ndings point to the potential value of contact tracing, constrained quarantine, and targeted vaccination tactics for containing epidemics, particularly in situations where vaccine supplies may be initially few and the e ectiveness of antiviral medications questionable.

Extensive research has been done for the management of Malaria using Operations research techniques which can be applied to other diseases as well with a little modi cation. us this research paper have included valuable insights and learning from articles and previous papers. e path to controlling infectious diseases is challenging owing to the potential for the diseases to adapt and evolve, volatile environmental conditions, an unstable nancial landscape and behavioural changes in the target populations. e conditions favouring transmission are varied and diverse to the extent that decisions cannot be made on the basis of a single condition and that's why use of Mathematical modelling can guide all stages of malaria elimination and obliteration by interpretating information, measuring uncertainty, and inavian iund ting thestrainon forD(obliteration upportewould adtious dion

of RTS s Malaria vaccine in relation to scaling up other malaria interventions in sub-Saharan Africa.

Methodology

Literature Collection

e existing literature was searched for and relevant papers were identi ed using particular keywords on scholarly search engines such as EBSCO HOST, Science Direct, and Google Scholar. e Literature was also scanned by viewing the research papers available on databases such as Elsevier, Emerald, Springer, and Wiley.

Boundary Identi cation

e search included research papers on “Operations Research and Communicable & Infectious Diseases” during the last 30 years (1992-2022) in order to maintain currency. e research inclusion was limited only to English language full text, peer-reviewed journal articles. Only the papers that mentioned Operations research methodologies like mathematical modelling or other models and simulations used related to Communicable diseases were included.

Data Extraction

e review has downloaded approximately 200 research papers that have been published in various journals during the mentioned timeline. During data extraction, some articles were excluded as they did not adhere to inclusion criteria. For the analysis, a RIS. File was made using the Mendeley Reference Manager and it was various analysis results were obtained by Co-authorship and Co-occurrence maps in Vos Viewer so ware.

Conclusion

Operations Research is now being widely used for management of diseases and speci cally in case of infectious diseases as infectious diseases have been growing at a very fast pace and they pose a great threat to mankind. In this review paper, we have systematically reviewed the literature present on how to improve and support the management of infectious diseases.

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