





COVID-19 Vaccine's Distribution Routes with Bioinspired Metaheuristic Algorithms: Resoluteness

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Abstract—The global emergency of COVID-19 caused by the SARS-CoV-2 virus at the end of 2019, it was without a doubt a critical and historical point for society in general; for instance, the effective development of vaccines, as well as the efficient distribution of them; They were an unprecedented challenge to slow down the spread or mitigate its impact on societies around the world. This article specifies three bio-inspired metaheuristic algorithms (genetic algorithm, particle swarm optimization algorithm, and artificial bee colony algorithm) that were used in the context of the capacitated vehicle routing problem to generate vaccine distribution routes, specifically, COVID-19 vaccine for over 18 years old the first and the second doses applications in Mexico, particularly in the State of Mexico. The quality of the solutions obtained by these algorithms is compared, and the performance of the particle swarm optimization (PSO) algorithm being superior in solution quality. The results show that the construction of vaccine distribution routes applying bio-inspired algorithms determines reliable scenarios that support the decision-making of the personnel dedicated to carrying out this activity.

Link to graphical and video abstracts, and to code:
<https://latam.ieee9.org/index.php/transactions/article/view/8709>

Index Terms—Artificial Bee Colony Algorithm, Bio-inspired, Capacitated Vehicle Routing Problem, Genetic Algorithm, Metaheuristics, Particle Swarm Optimization Algorithm.

I. INTRODUCTION

At the end of 2019, the existence of a virus was announced that would gradually spread worldwide, giving rise to the COVID-19 pandemic (Corona Virus Disease). According to the World Health Organization (WHO), the disease is caused by a virus called SARS-CoV-2 [1].

The evolution of the pandemic was characterized from the next relevant aspects, the implementation of health measures in daily activities, isolation, distribution, and application of vaccines, and finally to recover daily routine. Today it is not possible to precisely determine how SARS-CoV-2 infections began, however, all evidence suggests that the virus has an animal origin which it is not a manipulated or constructed virus [2]. According to Banxico [3], in Mexico, the evolution of the pandemic was divided into three phases [3]: i. The installation of the National Day of Healthy Distance; ii. Non-essential economic activities were suspended; iii. The activities of the construction, mining, transportation, equipment manufacturing

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industries were reestablished. *Phase 1.* It began in February 2020, it is characterized by imported cases, the implementation of mitigation strategies has not yet been considered and ends with the installation of the National Day of Healthy Distance. *Phase 2.* Since March 2020, most cases and transmission were already local, limited to the suspension of in-person classes, mass events, and at the end of March non-essential economic activities were suspended. *Phase 3.* In April 2020 and is characterized by showing faster and more widespread transmission. In this phase, the activities of the construction, mining, transportation, equipment manufacturing industries were reestablished as essential activities if they could comply with health safety protocols. The new normal or the return to daily activities gradually involved changing personal care habits, the way of carrying out daily activities, and the way of communication, among others. The return to normality was carried out in accordance with criteria established by federal and state authorities, such as the usage of face masks, hand washing frequently, and healthy distance they are part of the gradual changes to the new routine [4]. The return to normality was carried out in accordance with criteria established by federal and state authorities, such as the usage of face masks, hand washing frequently, and healthy distance they are part of the gradual changes to the new routine [4].

To deal with the pandemic, the WHO issues the Emergency Use Listing (EUL) procedure. The procedure evaluates the suitability of the creation of medicines and vaccines as quickly as possible, respecting the criteria of safety, efficiency, and quality [5].

This involved a rigorous evaluation of clinical data from experimental trials corresponding to human trials, recruiting groups of volunteers [6]. Likewise, it required thorough analysis of data related to safety, efficiency, quality, and risk management plan by independent experts and WHO teams.

The technical advisory group for the COVID-19 vaccine in Mexico is a group of experts that defines a strategy focused on reducing the number of deaths associated with COVID-19 based on the mortality observed in the country. As a result, 4 prioritization axes were established for the application and distribution of the COVID-19 vaccine in Mexico [7]: 1) Age of individuals; 2) Personal comorbidities; 3) Priority care groups; and 4) Epidemic behavior.

Based on an analysis of population projections from National Council of Population (CONAPO, Consejo Nacional de Población; Mexico) and data from the National Epidemiological Vigilance System (SINAVE, Sistema Nacional de Vigilancia Epidemiológica; Mexico) risk groups and vaccination stages were identified [7]: