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DISCRETE EVENT SIMULATION FOR EVALUATION OF THE PERFORMANCE OF A COVID-19 VACCINE CLINIC

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ABSTRACT

Mass vaccination is one strategy for controlling the spread of SARS-CoV-2 resulting in COVID-19 and for quick deployment of vaccines in places with high transmission rates. Gathering people for vaccination against infectious respiratory diseases in a building can cause concerns regarding safety and public health. Therefore, designing safe vaccine clinics is a priority in current and future pandemics. Designing the COVID-19 vaccine clinic is different from traditional clinics. In this study, discrete event simulation is used to simulate a COVID-19 vaccine clinic to study the balance of resources needed for several sizes of clinics. We assess the time in system (TIS), number in the system (NIS), the maximum number in waiting queues, maximum waiting time in queues, scheduled utilization, alongside considering the COVID-19 safety precautions such as social distancing. This study aims to support health administrators to plan the operation of COVID-19 vaccine clinics efficiently beyond current planning methods.

1 INTRODUCTION

For controlling the pandemic and returning to normal life, a considerable percentage of people will need to get the COVID-19 vaccine to reduce community spread in a fast and safe manner (Asgary et al. 2020). To achieve this goal, planning and deploying mass COVID-19 vaccine clinics is a key effort. In contrast to typical planning methods, simulation of random events can be used to study the impact of design decisions on the COVID-19 vaccine clinic to provide more accurate assessment of system performance. This case study assesses resource planning strategies through discrete event simulations (DES) to model the COVID-19 vaccine clinic to reduce TIS, maximum time and number waiting, and NIS while maintaining a high level of utilization of workers to have more balanced and economic clinics.

2 LITERATURE REVIEW

There is not enough published research about COVID-19 vaccine clinics for mass vaccination since the world has been faced with the COVID-19 disease from beginning the of 2020 (Gianfredi et al. 2021). There are a few research studies for mass vaccination clinics (Beeler et al. 2016, and Asgary et al. 2020), and some research from the decade of 2000 (Asllani et al. 2007). Discrete event simulation has been used for modeling the stochastic nature of operations, the behavior of a system over time with a defined set of processes, and random events of the sites.

3 CASE STUDY AND RESULTS

This study uses the DES to simulate a COVID-19 vaccine clinic under different patient capacities and schedules. We used a six-step process modeled with 6 feet social distancing constraints and estimated processing times (Table 1). For each of control variables, number of patients per day (500, 1000, 2000) and hours per day (8, 10, 12), a set of server capacities were tested for scenario comparison (total scenarios = 100, minimum repetitions = 30, and maximum repetitions = 100). A separate CRN was defined for each variable. A subset of scenarios that completed the service of the last patient within a reasonable amount of time (approx.. 30 min after clinic close) was tested for each control variable. This study assessed the impact of servers' capacities on the average TIS, the NIS, waiting time at each station, the number of waiting patients in the system, observation seats, and server utilization. A range of scenarios with balanced capacities of resources is assessed for each size of clinic. Table 2 shows the optimal number of staff for the stations. The sum of maximum waiting times in queues and the average maximum number of observation seats are shown in Table 2.

Table 1: Processing times (minutes)

Servers	Appointment	Check In	Vaccination	Sticker Giver	Observation	Check Out
Processing Time	Triangular [0.5,1.5,2.5]	Triangular [2,3,4]	Triangular [4,6,9]	Triangular [0.25,0.5,0.75]	Uniform [14,16]	Triangular [0.5,1,1.5]

Table 2: Final decision for capacities

Control Variables		Decision Variables			Response Variables	
No. of Patients	Clinic Hours	App. Check	Clinical Check-In	Vac. Staff	Avg. Max. No. Seats (95% Half Width)	Sum of Max. Waiting Time in Queues (95% Half Width)
500	12	2	3	5	14.37 (0.183)	11.92 (0.00599)
500	10	2	3	6	16.47 (0.213)	12.63 (0.00777)
500	8	2	4	7	19.50 (0.235)	12.68 (0.00594)
1000	12	3	5	10	26.00 (0.219)	11.07 (0.00543)
1000	10	3	6	11	29.77 (0.305)	12.22 (0.00630)
1000	8	4	7	14	36.83 (0.341)	12.05 (0.00499)
2000	12	5	10	19	48.73 (0.438)	10.92 (0.00459)
2000	10	6	12	23	57.87(0.677)	10.04 (0.00345)
2000	8	8	14	28	71.00 (0.480)	10.69 (0.00400)

4 DISCUSSION AND CONCLUSION

According to the results from these scenarios, the capacity of the clinical check-in server has more impact on the TIS and waiting time in queues than the appointment check server. Additionally, assigning the optimal capacity for the appointment check server is critical because more capacity has a negative impact by increasing NIS, TIS, and waiting time in queues, as seen in voting systems during COVID-19. More research is needed to design the COVID-19 vaccine clinics for mass vaccination economically and to ensure patients satisfaction. In the future, the layout of the COVID-19 vaccine clinics, disease progression, and costs should be included as parameters of investigation.

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