Proceedings of the 2021 Winter Simulation Conference
S. Kim, B. Feng, K. Smith, S. Masoud, Z. Zheng, C. Szabo and M. Loper, eds.

MATHEMATICAL MODELING OF NOVEL CORONAVIRUS (SARS-COV-2) INFECTION IN DIALYSIS FACILITIES

Michal Mankowski

King Abdullah University of Science and Technology
Thuwal, 23955, Saudi Arabia

Junaid Qazi
Abdulrahman Housawi

Ministry of Health,
Kingdom of Saudi Arabia
Abdulrahman Bin Abdulaziz St
Riyadh, Saudi Arabia

ABSTRACT

The dialysis patients likely carry an additional risk for contracting (and spreading) the infection to others as they continue necessary treatment at dialysis facilities. They visit dialysis facilities multiple times a week, regardless of curfew and lockdown regimes. In addition, dialysis patients are at a heightened risk for developing complications due to their inherently compromised immune systems. The aim of this simulation study was to evaluate and model the practice patterns, relevant scheduling, and testing scenarios applied to limit the spread of infections among the dialysis patient population along with the associated staff. Using agent-based simulation, we evaluated the attack rate among the targeted population. The simulation proved the importance of applying countermeasures as well as intense testing scenarios. Our study found that using antigens testing may perform better in reducing a spread in weekly and fortnightly time intervals than PCR testing.

1 INTRODUCTION

Since the occurrence of coronavirus disease 2019 (COVID-19), there has been an increasing number of COVID-19 cases throughout the world. Along with the general population, a rising number of dialysis patients has suffered from this devastating problem, especially dialysis patients who have to visit dialysis facilities to get their treatments multiple times a week, despite curfew and lockdown requirements. This frequent mobility poses a challenge to addressing the spread of the infection among this population. More importantly, the dialysis population is inherently immunocompromised and is at risk of developing a severe or fatal disease in such a pandemic.

2 MODELING

To evaluate prevention practices within dialysis facilities, we modeled and simulated the virus spread among 300,000 of the general population with a focus on 5,000 dialysis patients located in three dialysis centers. The results presented in this report were generated using Covasim library, an agent-based model of COVID-19 transmission, within-host progression, and countermeasures that was developed at the Institute for Disease Modeling (IDM). We looked at the three months attack rate among targeted populations.

The appropriate precautions and interventions such as countermeasures (visual screening, contact tracing, non-pharmaceutical interventions) and testing/scheduling scenarios were modeled. Considered testing interventions: 1) gold-standard PCR tests that typically take one or more days to return results, and 2) rapid antigen-based tests with lower sensitivity and a greater chance of false-positive results. We

considered two ‘hybrid’ patients scheduling scenarios, where patients visit the facilities twice (hybrid_2) and thrice (hybrid_3) per week.

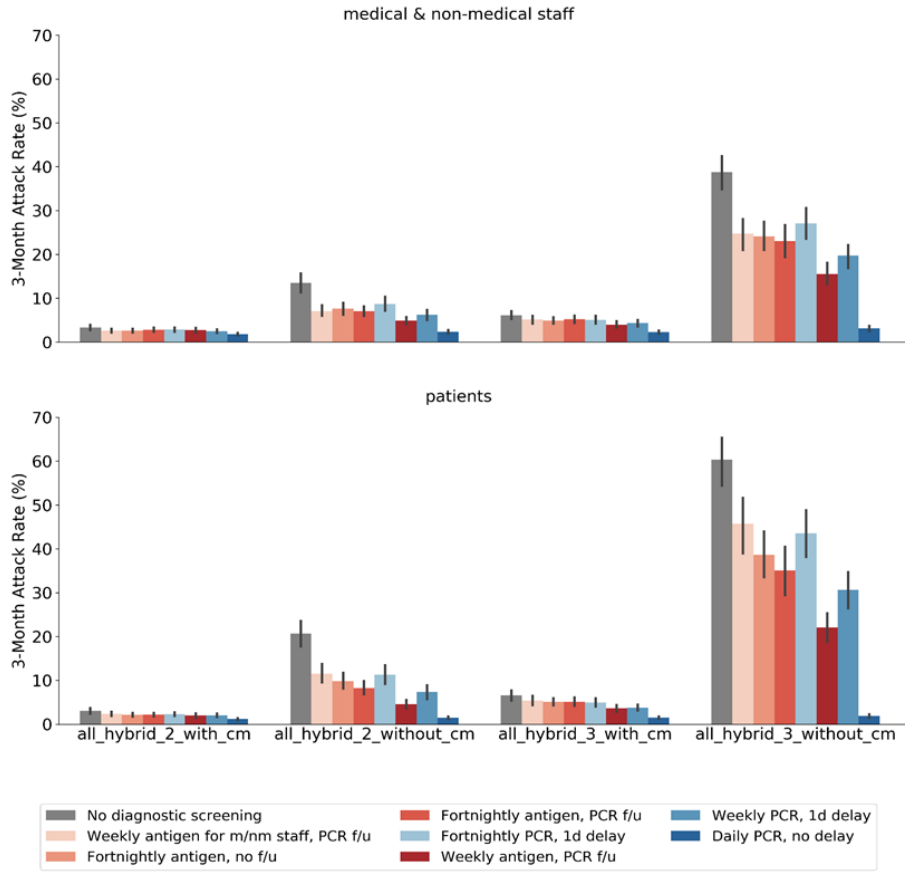

Figure 1: The attract rate for patients and medical/non-medical staff under various population. Scenarios without countermeasures are labeled with ‘without_cm’, while scenarios with countermeasure are labeled with ‘with_cm’.

3 RESULTS AND DISCUSSION

The most successful scheduling scenario was the daily PCR test with same-day results (Fig. 1). A surprising finding was that fortnightly and weekly antigen testing resulted in a lower three month attack rate than fortnightly and weekly PCR testing with 1-day delay for most of the scenarios. We hypostatize that the speed of the antigen test in returning results outbalanced the higher sensitivity of PCR tests. Another factor to consider in this case is that antigen testing has a high false-positive rate resulting in the separation of suspected patients.

The dialysis patients turn to be more at risk of infection than medical/non-medical staff. The reduction of visits per week in the dialysis center reduces the attack rate for patients and medical/non-medical staff.

Future work will involve analysis of the vaccination level and effectiveness among the dialysis population.