PCR and Antigen Testing Approaches to Minimize Infections and Lost Workdays in the Workplace

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INTRODUCTION

As employees return to the workplace in midst of the COVID-19 pandemic, companies need to determine how to best minimize workplace infections, minimize workdays lost to infection, and protect employee safety. Polymerase Chain Reaction (PCR) is considered the gold standard for SARS-CoV-2 detection. Rapid antigen diagnostic tests (RADT) have a faster turn-around-time but have lower sensitivity and equal/slightly lower specificity than PCR. Using a mathematical model, we estimated the frequency of true infections, number of workdays lost, and the costs associated with these testing strategies in a workplace testing scenario.

METHODS

We adapted an existing deterministic compartmental model across multiple workplace transmission scenarios. This revised model includes 5 compartments representing various SARS-CoV-2 states in a workplace population (susceptible, exposed, infected, quarantined and recovered) with assumptions shown in Table 1.

Table 1: Model Assumptions

Model Assumptions	
Workplace size	5000 employees
Time Period	Single quarter (64 workdays)
Initial infections	10 employees
Length of quarantine for positive test	10 days fully unproductive
Sensitivity: PCR / RADT	99% / 58%
Specificity: PCR / RADT	99.5% / 98%
Time to results: PCR / RADT	24 hr / 15 min
Cost of test: PCR / RADT	$35 / $15
PCR pool size	5 samples/pool
Average salary	$83,574/year

We modeled several testing strategies; weekly PCR testing, weekly pooled PCR, weekly and twice-weekly RADT, with and without PCR confirmation of positive RADT. The model looked at disease control and costs associated with each testing strategy. Disease control and costs were modeled across a range of R_0 values ranging from 0.5–2.0.

RESULTS

The ability to detect infections and, thereby, control of spread of disease is directly related to the sensitivity of the testing methodology. Since, the sensitivity of the PCR strategy is higher than RADT, it allows for earlier identification of infected workers and earlier removal from the workforce.

RESULTS (Contd.)

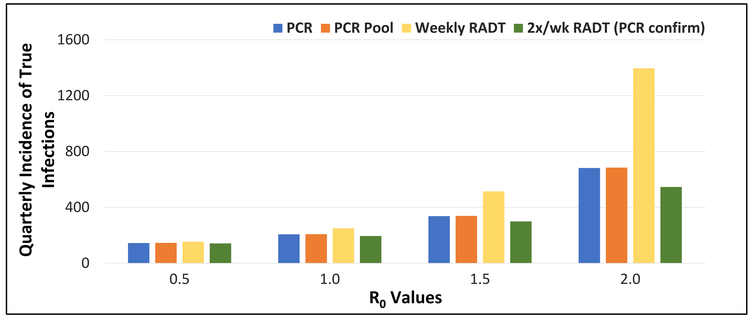

Figure 1: Quarterly incidence of true infections for different testing strategies across different R_0 values

Weekly PCR testing (Standard and Pooling) resulted in low infection rates across all R_0 values. Weekly RADT resulted in more infections than weekly PCR with higher incidence with increasing R_0 values. Twice-weekly RADT followed by PCR confirmation of positive results, improved the sensitivity of the RADT testing strategy and resulted in similar disease control as PCR testing strategies (Fig.1)

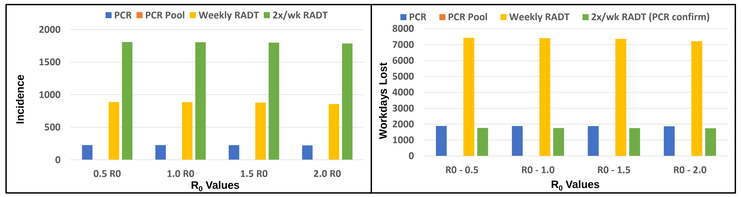

Figure 2. Incidence (A) and workdays lost (B) due to false positive cases for each testing strategy

The rate of false positives is related to the specificity of the testing methodology. There is low incidence of false positives due to high specificity of PCR. In the pooling strategy, due to the high specificity of the PCR method combined with the fact that a positive pool is deconvoluted and individual specimens are retested, there is even lower probability for a false positive. Twice weekly RADT will result in the highest number of false positives. PCR confirmation can mitigate the overall impact, but employees will be required to quarantine until results are conformed by PCR. Unnecessary quarantines may lead to lack of confidence in the testing program. Even at low R_0 values, the slightly lower specificity of RADT results in significantly more false positives than the PCR testing strategies (Fig. 2A). The impact of false positives from the RADT strategies in terms of workdays lost can be mitigated by confirming all positive results with PCR (Fig 2B).

RESULTS (Contd.)

The total costs is composed of two categories; the cost of implementing the testing strategy itself and the economic impact due to lost productivity from workdays lost due to, both, true infections and false positives. The Pooled PCR testing strategy allows for the most cost-effective strategy as far as the implementation is concerned with PCR only and 2x/week RADT being similar in program costs. (Fig. 3A) As far as economic impact is concerned due to true infections and workdays lost, PCR pooling strategy has the least economic impact and weekly RADT testing has the highest economic impact. (Fig. 3B)

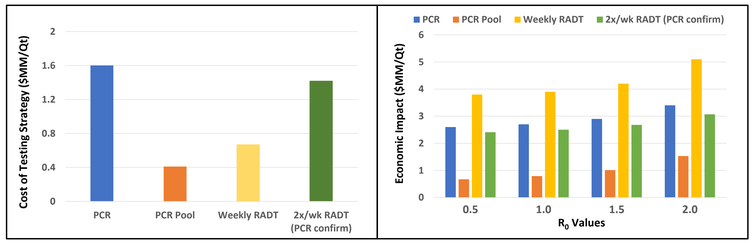

Figure 3: Program costs (A) and economic impact (B) of each testing strategy for workplace testing

CONCLUSIONS

- Weekly PCR pooling testing strategy achieved the best disease control and lowest overall cost to the company compared to the other testing strategies.
- The lower sensitivity of antigen tests can be overcome by more frequent testing.
- Small differences in RADT specificity results in substantially greater number of false positives, especially as testing frequency increases and/or COVID-19 prevalence decreases which can lead to unnecessary workdays lost and lack of confidence in return-to-work strategies.
- False positive RADT can be mitigated with PCR confirmation of positive results.

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