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Evaluation of Testing Frequency and Sampling for Severe Acute Respiratory Syndrome Coronavirus 2 Surveillance Strategies in Long-Term Care Facilities



To the Editor:

Identifying optimal testing strategies for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in long-term care facilities (LTCFs) is a public health priority.¹ Asymptomatic surveillance is necessary to detect asymptomatic and presymptomatic carriers to prevent widespread coronavirus disease 2019 (COVID-19) outbreaks in LTCFs. In the context of test availability, costs, and acceptability constraints, the trade-offs between testing intensity and potential benefits are currently unknown for LTCFs.¹ Unique features of COVID-19 transmission dynamics within LTCFs and communities need to be considered when implementing an optimal surveillance strategy. Using a dynamic model of COVID-19 transmission in a LTCF setting, we estimated the impact of several SARS-CoV-2 surveillance strategies varying in test frequency and sampling on the time to diagnosis and the cumulative number of cases at first diagnosis.

Methods

We developed an agent-based model² of SARS-CoV-2 transmission among (n = 280) residents and staff members of a hypothetical LTCF (Appendix, Supplementary Methods). Briefly, 1

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Table 1
Delay to First Diagnosis, Number of Cumulative Cases at First Diagnosis, and Number of Tests Conducted to Diagnose a First Case, by Testing Strategy, in the Context of a Simulation of a SARS-CoV-2 Outbreak in a LTCF

Testing Strategy*	Delay to First Diagnosis, Mean d (Median, IQR)	Cumulative Cases at First Diagnosis, Mean (Median, IQR)	Number of Tests Conducted, Mean
1. Test 100% every 14 d	7.9 (7.0, 8.0)	13.3 (5.0, 9.0)	218
2. Test 50% every 7 d	6.6 (6.0, 6.0)	7.3 (4.0, 5.0)	192
3. Test 100% every 7 d	4.0 (3.5, 4.0)	3.8 (2.0, 3.0)	278
4. Test 50% twice a wk	3.5 (3.0, 4.0)	3.2 (2.0, 3.0)	260
5. Test 20% on weekdays	3.3 (3.0, 4.0)	2.8 (2.0, 3.0)	251
6. Test 14% daily	3.3 (3.0, 4.0)	2.7 (2.0, 2.0)	252
7. Test 100% twice a wk	1.7 (1.0, 1.0)	1.8 (1.0, 1.0)	372

*All individuals are susceptible at baseline, 1 infectious case is imported randomly in the first 2 weeks of simulation, and the model tracks individual disease status daily until a first case is diagnosed. Results for 1000 iterations.

infectious case is imported into the LTCF during the first 2 weeks of simulation, with all individuals susceptible at baseline. Individual status is tracked daily until a first case is diagnosed. Individuals can acquire SARS-CoV-2 from the community at a daily probability matching the definition of moderate community transmission (50 cases/100,000 people/14 days).³ The daily probability of being infected inside the LTCF varies with the number of infectious individuals, the basic reproductive number ($R_0 = 3$),⁴ and the duration of infectiousness ($D_I = 7$ days).⁵ Individuals test positive for SARS-CoV-2 for 14 days postinfection, with a test sensitivity of 0.9. Seven strategies (S) were modeled with 1000 iterations each, testing: S1. 100% of individuals every 14 days; S2. 50% every 7 days; S3. 100% every 7 days; S4. 50% twice a week; S5. 20% every week-day; S6. 14% every day; and S7. 100% twice a week.

Strategies were evaluated by the number of days to first diagnosis, the cumulative number of infected cases at the time of first diagnosis, and the number of tests used. We conducted sensitivity analyses accounting for uncertainty around model parameter values (Appendix, Supplementary Methods).

Results

Table 1 reports the delay to first diagnosis and cumulative cases by testing strategy. S1 was less optimal than S2 with longer delay to diagnosis (7.9 vs 6.6 days), more cases at first diagnosis (13.3 vs 7.3), and more tests to detect the first case (218 vs 192). Comparing S3 to S2, delay to diagnosis was shortened to 4.0 days and the number of cases decreased to 3.8, using 86 extra tests (25/case averted). S3 to S6 had similar results, with a slight benefit in spreading the tests over 7 days. S7 produced the most favorable clinical outcomes (delay = 1.7 days, cases = 1.8), yet required additional tests (33/case averted compared with S2, 47/case averted compared with S3).

Results of the sensitivity analyses were concordant with our primary scenarios. Incremental benefits associated with more frequent testing increased with the high community importation rate, high infectiousness, and low-test sensitivity scenarios (Appendix, Supplementary Results).

Discussion

Our simulation of 7 SARS-Cov-2 testing strategies varying frequency and sampling suggests that the optimal strategy is informed by the level of community transmission and the basic reproduction number within the LTCF. We recommend testing at least 50% of people weekly in the context of a low probability of infectiousness ($R_0 < 2$), and 100% of people weekly when the probability of transmission is higher ($R_0 = 3$ and community importation rate = $3.6 * 10^{-5}$). Testing 100% of people twice a week may be beneficial when the risk is very high ($R_0 = 5$ or importation rate = $7.14 * 10^{-4}$). Once a case is diagnosed, more comprehensive testing should follow.⁶

R_0 may not be directly quantifiable as it depends on modifiable (handwashing, mask wearing, physical distancing) and

nonmodifiable factors (occupancy, physical crowding). As modifiable factors are less easily intervenable in LTCFs,⁷ more frequent testing may guard against widespread transmission and allow less stringent confinement measures. The differences in number of cases averted between scenarios are clinically significant considering the high fatality rates observed in LTCFs and the challenges to control outbreaks in closed environments.¹ Substantial incremental benefits were associated with increased testing, and the current development of rapid low-cost viral tests⁸ suggests that frequent testing could be cost-effective.

Our recommendations support emerging modeling evidence that testing frequency has a stronger effect on SARS-Cov-2 transmission than test sensitivity^{9,10} and provides further insights in the context of LTCFs. Nevertheless, our simulation begins when a first case is introduced, and a conventional cost-effectiveness analysis should acknowledge that when community transmission is low, more tests will need to be conducted before a first diagnosis.

Conclusions and Implications

With low transmission rates, weekly testing of 50% of residents and staff should be implemented as a minimal surveillance strategy to prevent widespread outbreaks. Weekly testing of 100% of residents and staff provides added benefit in higher infectiousness contexts. These results can be instrumental in developing timely surveillance of SARS-CoV-2 transmission among a population severely impacted by the COVID-19 pandemic.

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Mental Health Impact of SARS-COV-2 Pandemic on Long-Term Care Facility Personnel in Poland



Dear Editor:

The COVID-19 pandemic has had a disproportionate impact on long-term care facility (LTCF) residents worldwide, with 19% to 72% of COVID-19–related deaths occurring in LTCFs.¹ While facing this critical situation, LTCF personnel have to cope with an overwhelming workload, a depletion of adequate personal protection equipment (PPE), and deaths caused by SARS-CoV-2 infections.^{2,3} As of this

writing, there are few scientific studies addressing epidemiologic data and intervention models focused on LTCF and COVID-19. Therefore, the aim of this study was to assess psychological consequences (somatic symptoms, anxiety and insomnia, social dysfunction, and depression) among LTCF employees exposed to the SARS-CoV-2 coronavirus pandemic crisis. In addition, we investigated if factors such as PPE availability, safety guidelines, or access to psychiatric and psychological support at the workplace correlated with the level of psychological distress experienced by personnel.

Data were collected through an anonymous online survey between May 25 and June 25, 2020, among personnel of Polish LTCFs. The survey was accessed 242 times, and 12 participants' responses were rejected for leaving >70% questions unanswered. The response rate was 73.5% (n = 178 completed surveys); participants included LTCF personnel, including managers, administrative and maintenance staff, nurses, medical doctors, medical caregivers, social workers, physiotherapists, occupational therapists, and psychologists.

The survey consisted of 3 sections: (1) the sociodemographic section; (2) the authors' questionnaire with questions related to COVID-19 exposure, working conditions, access to PPE and mental health services; and (3) the General Health Questionnaire (GHQ-28),⁴ which consists of 28 questions scored on a 4-point Likert-type scale, illustrating the frequency of specific psychopathological symptoms such as somatic symptoms, anxiety and insomnia, social dysfunction, and depression experiences over the preceding 4 weeks. Higher GHQ-28 scores indicate higher levels of distress. The study obtained ethical clearance (KB-365/2020) and was performed in accordance with the Declaration of Helsinki.

The statistical analysis was performed with the R for Windows package (version 4.0.2). The normality of data was analyzed using the D'Agostino-Pearson test and visual assessment. Comparisons of qualitative variables were performed using the chi-squared test. Qualitative and quantitative variables were compared using the Mann-Whitney or Kruskal-Wallis test. The level of statistical significance was set at 0.05.

The study findings demonstrate the importance of institutional factors of LTCF on mental health of employees (Table 1). First, LTCF staff who had PPE access at the workplace received lower scores in the GHQ-28 social dysfunction subscale ($P = .018$); especially important were disposable aprons ($P = .02$) and full-body protection suits ($P = .006$). These findings are in accordance with recent studies by Zhang et al⁵ and Maciaszek et al⁶ in which PPE access predicted better physical health and lower distress. Implementation of a mandatory face mask policy in Poland significantly reduced scores on all GHQ-28 subscales in the general population,⁷ indicating the significance of PPE for both physical and mental health.

Second, the results suggest that the availability of workplace safety guidelines reduced anxiety symptoms. Participants whose workplaces had well-developed guidelines scored lower in the GHQ-28 anxiety and insomnia subscale ($P = .031$). It is also in line with the Medicare & Medicaid Services perspective that sets quality and safety standards in the health care system and defined one of its goals as prevention of COVID-19 transmission through issuing guidance and recommendations, providing PPE and testing needs recommendations in LTC facilities, and increasing payment for COVID-19 testing.⁸

Third, working conditions were crucial for the mental health of the respondents, as LTCF shift workers scored higher in the GHQ-28 somatic symptoms subscale ($P = .05$). The feeling that there were too few people in the workplace during the pandemic was related to the greater severity of psychopathological symptoms as evaluated with the GHQ-28 total score ($P = .009$).

Finally, availability of psychological support and care was also a crucial factor associated with better coping with the pandemic situation. Our study presents evidence that people who knew that they

Supplementary Methods

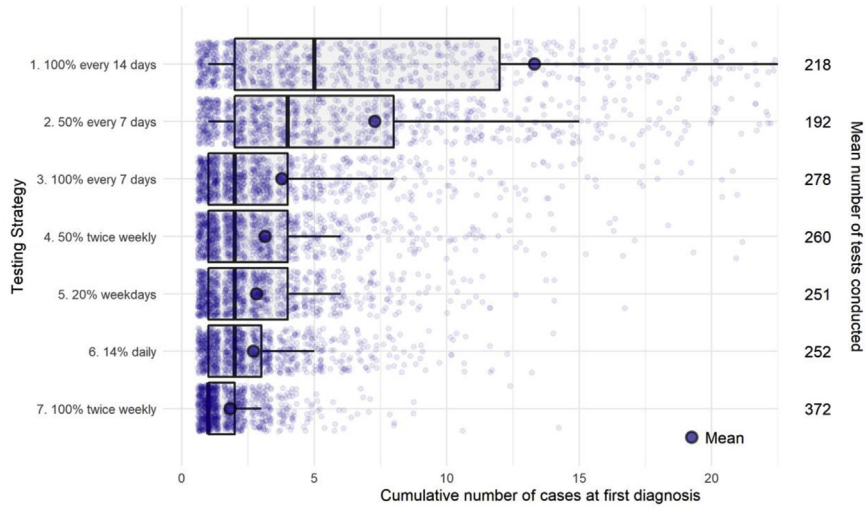
Detailed model structure

We developed a stochastic, agent-based model of SARS-CoV-2 transmission among ($n = 280$) residents and staff members of a hypothetical LTCF. Four disease states are modeled: (1) susceptible to infection; (2) infected – latent phase; (3) infected – infectious phase; and (4) post-infection (recovered or deceased). All individuals are susceptible at baseline, and 1 infectious case of SARS-CoV-2 is randomly imported into the LTCF as an exogenous shock during the first 2 weeks of simulation to seed the outbreak. Individuals are assumed to mix randomly and can acquire SARS-CoV-2 at a daily probability of $p(t) = p_{out}(t) + p_{ins}(t)$, with $p_{out}(t)$ the probability of acquisition from an individual outside of the LTCF (eg, through visitors or staff members in contact with the community), and p_{ins} the probability of acquisition from an individual inside the LTCF. $p_{ins}(t)$ varies as a function of the number of infectious individuals at time t , the basic reproductive number within the LTCF R_0 , and the duration of infectiousness D_I . Following infection, individuals enter a

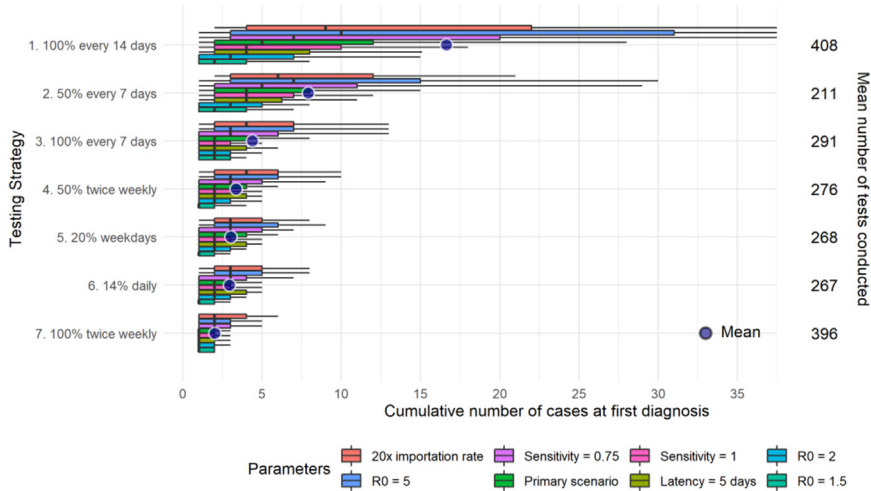
latent phase of duration D_L , followed by an infectious phase of duration D_I , before transitioning to the postinfection phase. The model tracks individual disease status daily (with fixed time steps) until a first case is diagnosed. We assumed that individuals can test positive for SARS-CoV-2 up to 14 days after the day of infection, with sn the sensitivity of the reverse transcription polymerase chain reaction (RT-PCR) test. For each strategy, 1000 iterations were performed. Simulations were run using R version 4.0.0 (R Core Team, Vienna, Austria), and the code is available on <https://github.com/quocdnguyen/test-strategy>.

Sensitivity analyses

Since the probability of acquiring SARS-CoV-2 could vary among LTCFs we compared a range of R_0 values (1.5, 2, and 5) to reflect diverse transmission conditions. In addition, uncertainty subsists around the viral dynamics of SARS-CoV-2 and the sensitivity of viral tests. We, therefore, conducted secondary analyses using varying values for $p_{out}(t)$ ($7.14 * 10^{-4}$, 20 times moderate community transmission), R_0 (1.5, 2, and 5), D_L (5 days), and sn (0.75 and 1.00).



Supplementary Fig. 1. Distributions of cumulative cases at time of first diagnosis by testing strategy for the primary scenarios. The left vertical axis shows 1 of the 7 testing strategies. The horizontal axis (truncated) indicates the cumulative number of cases at first diagnosis for all simulations [boxplot of the distribution (0.1, 0.25, 0.5, 0.75, and 0.9 percentiles) and mean]. Each point represents the result for 1 iteration. The right vertical axis shows the average number of tests conducted to diagnose the first case.



Supplementary Fig. 2. Distributions of cumulative cases at time of first diagnosis by testing strategy for the secondary scenarios (varying importation rate, R0, test sensitivity, and latency). The left vertical axis represents each 1 of the 7 testing strategies. The horizontal axis (truncated) indicates the cumulative number of cases at first diagnosis for all simulations [boxplots of the distribution (0.1, 0.25, 0.5, 0.75, and 0.9 percentiles) and mean]. The right vertical axis shows the average number of tests conducted to diagnose the first case. Each color displays a sensitivity analysis varying one parameter value from the primary scenario.