THE IMPORTANCE OF SCREENING ASYMPTOMATIC PATIENTS ADMITTED TO HEALTHCARE FACILITIES DURING THE COVID-19 PANDEMIC

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SUMMARY

Objectives: Screening of asymptomatic patients upon hospital admission became a key strategy to prevent nosocomial transmission of SARS-CoV-2 during the COVID-19 pandemic, particularly in facilities treating immunocompromised patients. Rapid antigen tests (RATs) were widely used due to their speed, but their reliability in detecting potentially infectious individuals remained debated. In parallel, the role of immunosuppression, especially in solid organ transplant (SOT) recipients, as a risk factor for asymptomatic positivity and prolonged viral shedding raised additional concerns. The aim of the study was to evaluate the diagnostic performance of rapid antigen testing compared to RT-PCR in asymptomatic patients admitted to a high-risk hospital, and the difference in SARS-CoV-2 PCR positivity between asymptomatic patients with and without a history of solid organ transplantation.

Methods: We retrospectively analysed 17,086 paired RAT and RT-PCR tests collected from 11,858 asymptomatic patients admitted to a tertiary care hospital between October 2020 and October 2022. Viral load was assessed via PCR cycle threshold (Ct) values. The sensitivity and specificity of RATs were calculated using PCR as the reference (Ct < 28).

Results: RATs showed a sensitivity of 83.5% and a specificity of 99.3% in detecting patients with high viral loads (Ct < 28). False negatives occurred predominantly in cases with low viral loads (Ct ≥ 28). SARS-CoV-2 PCR positivity was significantly higher in SOT patients (5.4%) than in non-transplant patients (3.2%) ($p < 0.001$), a difference that was consistent across viral variants.

Conclusions: RATs reliably identified the majority of asymptomatic patients with high viral loads who pose a risk of in-hospital transmission. SOT recipients represent a high-risk subgroup for asymptomatic SARS-CoV-2 carriage, underscoring the importance of rigorous admission screening protocols in specialized healthcare settings.

Key words: COVID-19, SARS-CoV-2, antigen test, RT-PCR, transplant patients, asymptomatic infection, hospital screening, cycle threshold value

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INTRODUCTION

Coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has posed extraordinary challenges to healthcare systems worldwide. One of the key concerns throughout the pandemic has been the risk of nosocomial transmission, particularly from asymptomatic carriers who are capable of viral shedding despite the absence of clinical signs (1). This issue is especially critical in tertiary-care settings managing highly vulnerable patient groups, such as recipients of solid organ transplants (SOTs) or individuals undergoing complex cardiac procedures, who are typically exposed to immunosuppressive regimens (2, 3).

To mitigate this risk, many hospitals adopted routine screening protocols for all admissions, including those for elective and emergency interventions. In the Czech Republic, these protocols often incorporated both reverse transcription polymerase chain reaction (RT-PCR) assays and rapid antigen tests (RATs) (4, 5). While RT-PCR remains the gold standard in terms of analytical sensitivity, RATs offer advantages in speed and logistical feasibility, making them attractive tools for point-of-care screening in high-throughput clinical environments (5–8). However, their diagnostic performance in asymptomatic individuals, especially in relation to infectivity as approximated by PCR cycle threshold (Ct) values, has been widely debated (6, 7).

Transplant recipients emerged during the pandemic as a particularly complex population from a virological and epidemiological perspective. Their chronic immunosuppression may modify viral kinetics, leading to prolonged PCR positivity and a higher potential for asymptomatic carriage (1, 3, 9). These factors necessitate careful evaluation of screening strategies tailored specifically for this group (3).

The present study was conducted at the Institute for Clinical and Experimental Medicine (Czech acronym IKEM) in Prague,

a leading high-volume centre for transplantation and cardiovascular medicine. Over a two-year period, asymptomatic patients admitted to the hospital underwent paired RAT and RT-PCR testing at the point of admission. This unique dataset enabled us to evaluate the real-world diagnostic performance of RATs and to compare SARS-CoV-2 positivity rates between transplant and non-transplant patient populations.

Despite declining COVID-19 prevalence in later pandemic stages, routine screening of asymptomatic patients remained critical for preventing nosocomial outbreaks, particularly in transplant and cardiovascular centres treating immunocompromised individuals. Mathematical modelling indicates that test frequency and rapid turnaround time outweigh sensitivity for effective outbreak control in hospital settings (10). Gavurová and Rigelský reported strong public acceptance of repeat asymptomatic testing in Czech and Slovak populations, even during periods of low disease incidence (11). Additionally, population-wide rapid antigen testing campaigns, such as those in Slovakia, were associated with substantial reductions in community prevalence, supporting the implementation of combined RAT-PCR protocols in healthcare environments (12). These findings underscore the importance of sustaining comprehensive admission-screening protocols in high-risk hospital wards, even when community transmission is low.

The primary objective of this study was to determine whether rapid antigen tests could reliably detect asymptomatic COVID-19 patients with high viral loads (Ct < 28) upon hospital admission, thus serving as an effective first-line barrier against nosocomial transmission. The secondary objective was to assess whether the prevalence of PCR positivity was significantly higher among asymptomatic solid organ transplant recipients compared to other admitted patients.

MATERIALS AND METHODS

Study Design and Population

This retrospective observational study was conducted at the Institute for Clinical and Experimental Medicine, a tertiary care hospital in Prague, Czech Republic. We analysed data from 11,858 asymptomatic patients admitted between 1 October 2020 and 1 October 2022. All patients were pre-screened for COVID-19-related symptoms and fever prior to admission.

Upon arrival at the testing centre (located outside the main hospital building), patients underwent simultaneous SARS-CoV-2 testing using both RT-PCR and RAT on nasopharyngeal swabs. Patients with a negative RAT result were admitted immediately; RT-PCR results were typically available within 6–24 hours. During that time, patients remained in designated areas to prevent potential in-hospital transmission.

Clinical and laboratory data were obtained from the hospital's information system. Discriminatory PCR testing for viral variants was available during selected periods with co-circulating strains (March–June 2021 and July 2021–January 2022) and was used for sub-analyses.

Evaluation of Antigen Test Performance

To assess the diagnostic accuracy of RATs in asymptomatic individuals, we analysed 17,086 paired RAT and RT-PCR test results. The PCR cycle threshold value served as a proxy for viral load, with Ct < 28 considered indicative of a high viral load and potential infectiousness. RAT performance was evaluated using RT-PCR as the reference standard.

To better understand how SARS-CoV-2 PCR positivity was defined for subsequent sensitivity analyses, we applied the following classification framework: samples with Ct < 28 were labelled as positive in the most conservative definition, while all samples with Ct ≥ 28 were considered negative (Table 2). Borderline or uncertain results (n = 157) were excluded from binary comparisons unless explicitly reclassified.

Comparison of PCR Positivity in Transplant vs. Non-transplant Patients

To evaluate differences in asymptomatic SARS-CoV-2 carriage, patients were categorized into two groups:

- SOT group: patients with a history of solid organ transplantation (kidney, liver, heart, or pancreas);
- Non-SOT group: all other patients.

PCR positivity rates were compared between these groups. Variant-specific positivity was also analysed when discriminatory PCR data were available.

Statistical Analysis

Descriptive statistics were used to summarize patient characteristics. Continuous variables were reported as means with standard deviations or as medians with interquartile ranges, depending on distribution. Categorical variables were expressed as counts and percentages.

The positivity rate for PCR tests was calculated as the ratio of the number of tests yielding positive results to the total number of tests conducted. RAT sensitivity and specificity were calculated using PCR with Ct < 28 as the reference. Confidence intervals (95% CI) were estimated via bootstrap resampling. Differences in PCR positivity between SOT and non-SOT groups were analysed using Pearson's chi-squared test. All analyses were performed using R software (version 4.3.2). Statistical significance was defined as $p < 0.05$.

RESULTS

Diagnostic Performance of Antigen Tests

A total of 17,204 paired RAT and RT-PCR tests were performed between October 2020 and October 2022 among asymptomatic individuals admitted to IKEM in Prague. These included both solid organ transplant recipients (n = 3,123; 18.2%) and non-transplant patients (n = 14,081; 81.8%). Overall, 614 tests were PCR positive, corresponding to a positivity rate of 3.6%.

Among the tested population, 63.8% were males and 36.2% females across both groups. The median age was 65 years overall, with transplant recipients being notably younger (59 vs. 67 years in non-transplant patients). Testing covered several SARS-CoV-2 variant periods, with the Alpha variant (V1) representing 52.1% of cases, followed by Delta (23.8%), Omicron BA.1 (17.8%), and undetermined variants (6.3%).

Table 1. *Baseline characteristics of asymptomatic patients undergoing paired RAT and RT-PCR testing, overall and by transplant status (N = 17,204)*

Characteristics	Non-SOT patients n = 14,081	SOT patients n = 3,123	All patients
Sex			
Female	5,098 (36.2%)	1,122 (35.9%)	6,220 (36.2%)
Male	8,983 (63.8%)	2,001 (64.1%)	10,984 (63.8%)
Age	67 (53–75)	59 (48–68)	65 (52–74)
Test date	2020-10-16 to 2022-10-01	2020-10-16 to 2022-09-29	2020-10-16 to 2022-10-01
Ct-value	32 (22–36)	27 (21–35)	31 (22–36)
Missing Ct-value	13,177	2,852	16,029
Covid variant			
Alpha	7,487 (53.2%)	1,483 (47.5%)	8,970 (52.1%)
Delta	3,277 (23.3%)	819 (26.2%)	4,096 (23.8%)
Omicron	2,431 (17.3%)	625 (20.0%)	3,056 (17.8%)
Undetermined	886 (6.3%)	196 (6.3%)	1,082 (6.3%)
IKEM			
Employee	667 (4.7%)	1 (0.0%)	668 (3.9%)
Patient	13,414 (95.3%)	3,122 (100.0%)	16,536 (96.1%)

Values are presented as n (%) for categorical variables and median (IQR) for continuous variables.

The Ct value was available in a subset of samples and showed a tendency toward lower median values in transplant patients (27 vs. 32), suggesting potentially higher viral loads in this group. Most individuals tested were patients (96.1%), with a small proportion (3.9%) being hospital staff.

A comprehensive overview of the study population's baseline characteristics, stratified by transplant status and for the overall sample, is presented in Table 1.

Values are presented as n (%) for categorical variables and median (IQR) for continuous variables.

Table 2 summarizes the classification of all test results under different PCR definitions. To enable consistent categorization, we applied additional Ct-based definitions: samples with Ct < 28 were labelled as positive in the most conservative classification. All samples with Ct ≥ 28 were considered negative.

This classification framework was used throughout our downstream analyses of RAT sensitivity and positivity trends.

Among the 17,204 tested individuals, a Ct value from the confirmatory RT-PCR was available in 1,175 samples, all of which were either positive or yielded uncertain results. Figure 1 illustrates the distribution of Ct values, stratified by the corresponding antigen test (RAT) result. A clear shift toward higher Ct values (lower viral loads) was observed in RAT-negative samples. This highlights the known limitation of antigen tests in detecting infections with lower viral loads.

Table 2. *Test result classification under different PCR definitions*

Classification scheme	Negative n (%)	Positive n (%)	Uncertain n (%)
RAT (antigen test)	16,667 (25)	537 (19)	0 (0)
PCR (laboratory-defined)	15,926 (24)	1,121 (40)	157 (100)
PCR (Ct < 28)	16,702 (25)	502 (18)	0 (0)

As shown in Figure 2, RAT positivity decreased progressively with increasing Ct values, illustrating the reduced sensitivity of antigen tests in cases with low viral loads.

We further assessed the sensitivity of the antigen test in subgroups of patients, stratified by SARS-CoV-2 variants (V1, Delta, Omicron).

As shown in Table 3, the overall sensitivity of the antigen test in the full study population (Ct < 28) was 83.5%. In non-SOT patients, sensitivity was 84.1%, while in SOT recipients it was 81.9%; these differences were not statistically significant (all p > 0.05). The test performed best during the Alpha (V1) period (87.9% overall), followed by Omicron BA.1 (82.5%) and Delta (80.4%). The specificity of the antigen test in the overall cohort was 99.3% (95% CI: 99.2–99.4).

The sensitivity did not significantly differ between SOT and non-SOT patients across variants (all p > 0.05).

We also examined whether the likelihood of a positive PCR result differed between immunocompromised (SOT) and non-

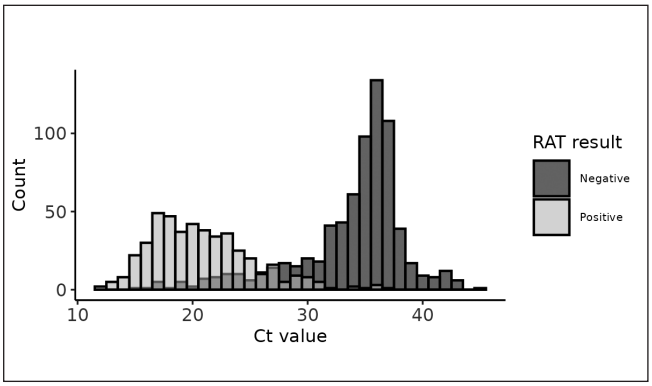

Fig. 1. *Distribution of Ct values among 1,175 RT-PCR–positive or uncertain samples, stratified by the corresponding rapid antigen test result.*

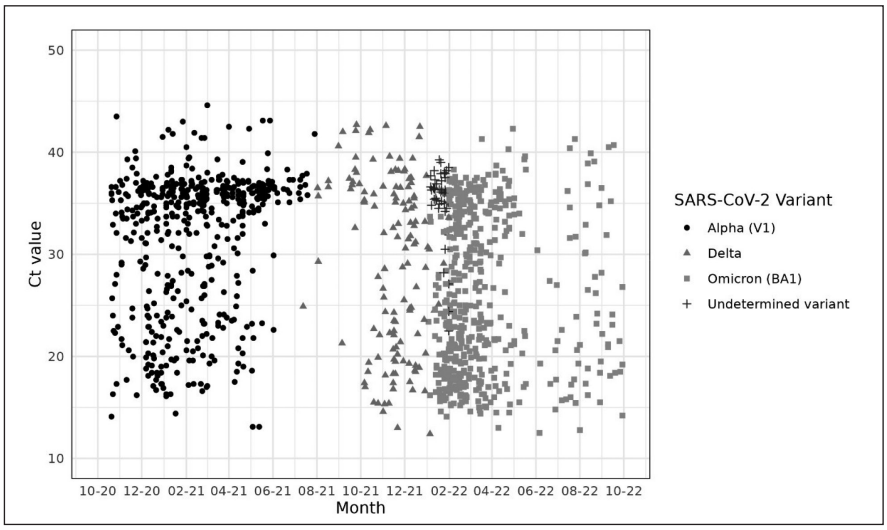

Fig. 2. *Distribution of antigen test results by Ct value across variants.*

Table 3. *Sensitivity of rapid antigen tests (Ct < 28) stratified by SARS-CoV-2 variant and patient group*

Variant	Non-SOT: total/true positivity (%)	SOT: total/true positivity (%)	All patients: total/true positivity (%)	p-value (SOT vs. non-SOT)
All variants	358/301 (84.1)	144/118 (81.9)	502/419 (83.5)	0.60
Alpha (V1)	97/87 (89.7)	43/36 (83.7)	140/123 (87.9)	0.40
Delta	43/35 (81.4)	13/10 (76.9)	56/45 (80.4)	0.70
Omicron BA.1	216/178 (82.4)	87/72 (82.8)	303/250 (82.5)	1.00

The sensitivity did not significantly differ between SOT and non-SOT patients across variants (all $p > 0.05$).

immunocompromised patients. As shown in Table 4, PCR positivity was significantly higher in SOT patients (5.4%) compared to non-SOT patients (3.2%). Pearson's chi-square test confirmed this difference ($\chi^2(1, N = 17{,}204) = 36.988$, $p < 0.001$).

To further explore differences in SARS-CoV-2 infection rates, we stratified PCR positivity by both patient group (SOT vs. non-SOT) and viral variant. As shown in Table 5, positivity rates were consistently higher in SOT patients compared to non-SOT patients. The largest absolute difference was observed during the Omicron (BA.1) wave (16.2% vs. 10.6%), followed by the Alpha variant (3.3% vs. 1.7%). These differences were statistically significant for Alpha and Omicron (both $p < 0.001$), while no significant differences were observed for Delta or undetermined variants. The corresponding visual comparison in Figure 3 highlights that for each variant, the positivity rate was higher among SOT patients, with all points lying below the line of equality.

Each point represents positivity in both groups; points below the diagonal indicate higher positivity in SOT patients.

Table 4. *PCR test results in SOT and non-SOT patients presented as row percentages*

Patient group	Negative	Positive
Non-SOT (n = 14,081)	13,636 (96.8%)	445 (3.2%)
SOT (n = 3,123)	2,954 (94.6%)	169 (5.4%)

Table 5. *PCR positivity rates among transplant (SOT) and non-transplant (non-SOT) patients across SARS-CoV-2 variants*

Variant	Group	PCR negative (n)	PCR positive (n)	Positivity rate (%)	p-value (SOT vs. non-SOT)
Alpha (V1)	Non-SOT	7,358	129	1.7	0.001
	SOT	1,434	49	3.3	
Delta	Non-SOT	3,224	53	1.6	0.29
	SOT	801	18	2.2	
Omicron BA.1	Non-SOT	2,173	258	10.6	0.001
	SOT	524	101	16.2	
Undetermined	Non-SOT	881	5	0.6	1.00
	SOT	195	1	0.5	

Numbers in bold indicate statistically significant values.

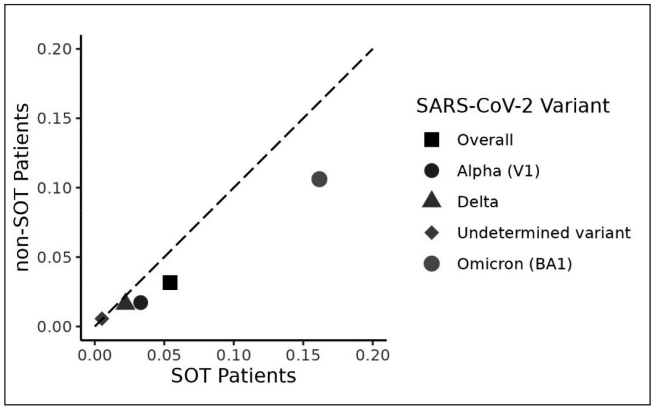

Fig. 3. *PCR positivity rates in SOT vs. non-SOT patients across SARS-CoV-2 variants.*

Each point represents positivity in both groups; points below the diagonal indicate higher positivity in SOT patients.

DISCUSSION

In this extensive retrospective analysis, we assessed the diagnostic utility of RATs versus RT PCR among asymptomatic individuals admitted to a tertiary care facility. The observed overall sensitivity (83.5%) and specificity (99.3%) closely align with meta-analytic estimates: Brümmer et al. reported a pooled sensitivity of 76.3% (95% CI: 69.6–81.9) and specificity of 99.1% (95% CI: 98.2–99.5) among asymptomatic subjects (7), while Drain highlighted enhanced RAT sensitivity at higher viral loads or early infection phases (5). These data reinforce the strategic role of RATs for high-throughput frontline screening, particularly when paired with confirmatory PCR in resource-limited hospital settings.

Our findings confirm that PCR positivity among asymptomatic patients (3.6%) was non-negligible, with approximately half showing high viral loads (Ct < 28). This threshold aligns with infectious potential established in prior studies (5). Given that donors with Ct < 28 or high viral loads are considered more likely to be transmissible, even asymptomatic cases in immunocompromised wards may contribute significantly to nosocomial spread.

Importantly, we found a higher incidence of PCR positivity among solid organ transplant recipients compared to the non-transplant cohort, consistent across variant-dominant periods. This aligns with evidence of prolonged and sometimes replication-competent viral shedding in immunocompromised hosts: a systematic review found median RNA detection of up to 60 days, and culture-positive virus was documented beyond 20 days post-diagnosis in these populations (13). Case reports in cardiac and lung transplant recipients document mild symptoms despite extended viral persistence (14, 15). These data support the hypothesis that immunosuppression prolongs viral clearance, necessitating tailored infection prevention and control (IPC) strategies in transplant units.

The two-tiered testing algorithm used – RAT on admission followed by PCR confirmation – ensured rapid identification of high-risk patients and helped minimize diagnostic delays. This approach aligns with infection control recommendations prioritizing frequency and turnaround time over test sensitivity alone (10). Our experience supports models emphasizing layered testing strategies in high-risk patient cohorts.

Notably, we observed no nosocomial outbreaks traceable to RAT negative but subsequently PCR positive cases. Although some professional societies questioned the added benefit of universal asymptomatic screening during low-incidence phases (16), our data suggest that in high-risk admission settings, especially transplant wards, such protocols remain effective when implemented alongside robust PPE use, patient cohorting, and adequate ventilation.

Nevertheless, several limitations deserve mention. First, the retrospective single-centre design may limit generalizability. Second, Ct values as proxies for infectivity vary by assay and sampling method and were not standardized across the study period. Third, we lacked longitudinal follow-up to link detected cases to outcomes or onward transmission. Fourth, variant attribution was based on prevailing epidemiology, with limited individual sequencing data.

Our findings have potential clinical implications. Although RAT sensitivity appeared slightly lower in transplant recipients than in non-SOT patients, the differences were not statistically significant (Table 3). Nevertheless, given the altered viral kinetics and potential for prolonged viral shedding in immunosuppressed hosts, confirmatory PCR testing remains advisable in this group, especially during variant shifts or in the presence of symptoms. Additionally, as SARS CoV 2 evolves, rapid diagnostic tools must be continuously validated. In settings with high patient turnover and limited molecular capacity, a layered RAT+PCR strategy remains a practical and effective approach for reducing transmission risk.

CONCLUSION

This large retrospective study confirmed that rapid antigen tests offer high specificity and reasonable sensitivity (83.5%) for detecting SARS CoV 2 infection in asymptomatic individuals, particularly those with high viral loads (Ct < 28). While RT PCR remains the gold standard, the use of RATs proved beneficial as an initial screening tool in pre-admission workflows, providing a practical, rapid, and resource-efficient method for early detection of potentially infectious patients.

The significantly higher rate of asymptomatic SARS CoV 2 positivity among solid organ transplant (SOT) recipients, observed consistently across multiple phases of the pandemic, underscores their vulnerability and the need for enhanced screening and infection control measures tailored to immunocompromised patients. Extended viral shedding in this group may pose a continued transmission risk, even in the absence of symptoms.

Notably, no nosocomial outbreaks were linked to RAT negative but PCR positive individuals throughout the study period, indicating that a layered diagnostic approach, when coupled with robust infection control, can effectively mitigate in-hospital transmission risks.

In conclusion, RATs can be safely and effectively integrated into hospital admission workflows as part of a tiered testing strategy, especially in high-throughput or resource-limited settings. For transplant recipients and other immunosuppressed populations, confirmatory PCR testing and close follow-up remain essential. These findings support the ongoing refinement of diagnostic algorithms that balance speed, sensitivity, and clinical risk, particularly

in evolving epidemiological contexts shaped by new viral variants and shifting levels of population immunity.

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Conflicts of Interest

None declared

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