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Budget Impact Analysis of the GeneXpert System for Preventing Acute Respiratory Infections in Nursing Homes

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Title: Budget Impact Analysis of the GeneXpert System for Preventing Acute Respiratory Infections in Nursing Homes:

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Key summary points

Aim: This study assessed the clinical and budgetary consequences of introducing point-of-care multiplex PCR testing with the GeneXpert® system for acute respiratory infections in French nursing homes.

Findings: The GeneXpert® strategy was projected to reduce annual testing by 67% and ARI clusters, cases, and hospitalizations by 35%. Screening costs remained unchanged, while fewer hospitalizations generated estimated annual savings of €15.2 million, with sensitivity analyses ranging from €12.0 million to €19.2 million.

Message: Point-of-care multiplex PCR testing may improve the control of acute respiratory infections in nursing homes while generating substantial savings for the French health insurance system.

Abstract

Purpose: Acute respiratory infections (ARIs) cause substantial morbidity, mortality, and healthcare use in nursing homes, where delayed diagnosis facilitates transmission. This study assessed the clinical and budget impact of introducing point-of-care multiplex PCR testing with the GeneXpert® system and Xpert® Xpress CoV-2/Flu/RSV plus in French nursing homes.

Methods: A one-year budget impact model compared the current standard of care, based on rapid antigen tests and delayed PCR testing, with a “Test and Isolation” strategy using GeneXpert® at symptom onset. The analysis adopted the French mandatory health insurance perspective and included all 587,566 permanent residents of 7,519 nursing homes. Inputs were derived from published literature, national surveillance networks, and French health insurance data. Outcomes included numbers of tests, ARI clusters, hospitalizations, screening costs, and total budget impact. Key parameters were varied by ±10% in deterministic sensitivity analyses.

Results: GeneXpert® was projected to reduce annual testing by 67%, from 119,693 to 39,898 tests, and ARI clusters by 35%, from 6,439 to 4,165. ARI cases decreased from 141,669 to 91,634, while hospitalizations fell by 35%, from 9,208 to 5,956. Despite a higher unit test cost (€45 vs €15), total screening costs were identical (€1,795,400) because fewer tests were required. Reduced hospitalizations generated annual savings of €15,202,734. Sensitivity analyses estimated savings ranging from €12.0 million to €19.2 million.

Conclusion: Point-of-care multiplex PCR testing with GeneXpert® may enable earlier detection and isolation of ARIs in nursing homes, reducing transmission and hospitalizations while generating substantial savings for the French health insurance system.

Keywords: Acute respiratory infections; Nursing homes; Point-of-care testing; Multiplex PCR; Budget impact analysis.

Introduction

Acute respiratory infections (ARIs) represent a significant public health challenge, particularly in elderly populations residing in nursing homes. ARIs encompass a broad spectrum of viral infections affecting both the upper and lower respiratory tracts, commonly caused by viruses such as influenza, respiratory syncytial virus (RSV), and SARS-CoV-2[1]. Outbreaks in these settings exhibit a high cumulative incidence, affecting an average of 24% of residents and 3.3% of staff during an episode, while hospitalization rates among residents can reach 6.5% and the average case fatality rate is approximately 2.5%[2]. In elderly individuals, ARIs are often associated with severe complications such as pneumonia or acute respiratory distress syndrome (ARDS), which can exacerbate underlying diseases and increase mortality[3]. The risk of ARI transmission is elevated in nursing homes due to communal living and frequent resident interactions, with advanced age, comorbidities, prolonged virus shedding and weakened immune systems[3]. Given the significant burden of ARIs in nursing homes, effective surveillance and management strategies are essential to mitigate the impact of these infections.

In France, the surveillance and management of ARI outbreaks in nursing homes are coordinated through a national reporting system. This system is designed to rapidly identify and control ARI clusters, thereby minimizing morbidity and mortality among residents. The current protocol mandates the reporting of an ARI outbreak when at least three cases are detected among residents within a four-day period[4]. This threshold is consistent with the fact that the sensitivity of diagnostic tests, such as rapid antigen tests (TROD/TAG) is approximately 90%[5]. By requiring three cases, the cumulative probability of detecting at least one true positive case approaches 100%.

Despite the implementation of these surveillance measures, the current diagnostic strategy has several limitations. The sensitivity of rapid antigen tests is lower compared to PCR tests, which can lead to false-negative results and delayed isolation of infected individuals[5]. This delay in isolation can exacerbate the spread of infections within nursing homes, leading to higher rates of hospitalization.

The GeneXpert system emerges as an innovative solution for the rapid and reliable testing of respiratory pathogens directly within nursing homes[6]. This molecular diagnostic platform employs automated Reverse Transcription Polymerase Chain Reaction (RT-PCR) technology to detect multiple pathogens from a single sample, including SARS-CoV-2, Influenza A, Influenza B, and Respiratory Syncytial Virus (RSV). The system enhances the speed of diagnosis, allowing for immediate clinical decisions regarding patient management and isolation protocols, which are critical in high-risk environments such as nursing homes.

This study aims to conduct a comprehensive medico-economic analysis of the introduction of the GeneXpert system in nursing homes, focusing on its potential to alleviate the clinical and economic burdens associated with ARIs. By comparing the current standard of care with a "Test and Isolation" strategy utilizing GeneXpert, the study seeks to quantify the benefits in terms of reduced incidence of ARIs, decreased hospitalization rates, and overall healthcare costs.

Methodology

Budget Impact Model

A budget impact model was developed comparing two strategies to assess the budget impact of GeneXpert system in French nursing homes. The first scenario, called "Current Strategy," represents the existing diagnostic approach, which relies on rapid antigen tests (TROD/TAG) and PCR testing initiated only after three ARI cases are detected. The second scenario, called "Test and Isolation Strategy," involves the implementation of the GeneXpert system for immediate PCR testing upon the appearance of ARI symptoms. The target population includes all residents of French nursing homes. The perspective of the analysis is that of the French mandatory health insurance system, which covers the costs of healthcare services, including diagnostic testing and hospitalization. The time horizon for the analysis is set at one year, corresponding to the annual cycle of respiratory infections. This time horizon is selected to capture the seasonal variations in ARI incidence and to provide a focused assessment of the budget impact within a single season.

Data relating to nursing homes

The data relating to nursing homes used in this study are sourced from the Jeandel Guérin report[7], which provides comprehensive information on the characteristics of nursing home residents in France. According to the report, there are 7,519 nursing homes in France, accommodating a total of 587,566 residents. The average number of residents per nursing home is 78, with variations in capacity across different facilities.

The distribution of nursing homes by capacity is an important consideration in the analysis, as it influences the potential impact of the GeneXpert system on ARI transmission and hospitalization rates. Larger nursing homes, with higher resident populations, may experience more frequent ARI outbreaks and greater challenges in controlling the spread of infections. These capacity variations were incorporated into the model to enhance accuracy in assessing the budget impact of the GeneXpert system.

Data relating to ARI

The data relating to acute respiratory infections (ARIs) used in this study are obtained from multiple sources, including national surveillance systems and epidemiological reports. Data from Santé Publique France show that, during the 2023/2024 season, 7,155 ARI clusters of ARI were reported in nursing homes[8], accounting for 90% of all ARI clusters identified that year.[9]

According to a study by Kucharski et al.[10], which evaluated the impact of various COVID-19 transmission control strategies, self-isolation of symptomatic cases and household quarantine would contribute to a 37% reduction in virus transmission. This analysis estimated that the implementation of early screening would similarly reduce the transmission of ARI by 37% compared to the baseline situation.

In addition, the analysis also considers the hospitalization rates associated with these infections. According to epidemiological reports, the hospitalization rate for ARI cases in nursing homes is approximately 6.5%[2].

Screening strategies

Current strategy (without GeneXpert®)

The number of tests performed was estimated based on positivity rates for influenza, respiratory syncytial virus (RSV), and SARS-CoV-2 observed in hospitals, taken from weekly data published by Santé Publique France in November 2024[11]. The average positivity rate for the 2023/2024 season was 16.14%. This rate corresponds to the proportion of diagnosed cases over those tested. By dividing the number of reported ARI clusters by the positivity rate, the model estimates the number of screening tests required to detect these clusters.

ARI cluster declaration occurs when at least three symptomatic cases are identified, consistent with the 90% sensitivity of TROD/TAG rapid tests[5]. The model estimates the number of tests according to the following formula:

$$number\ of\ screening\ tests\ performed = 3 \times \frac{number\ of\ grouped\ IRAs}{positivity\ rate}$$

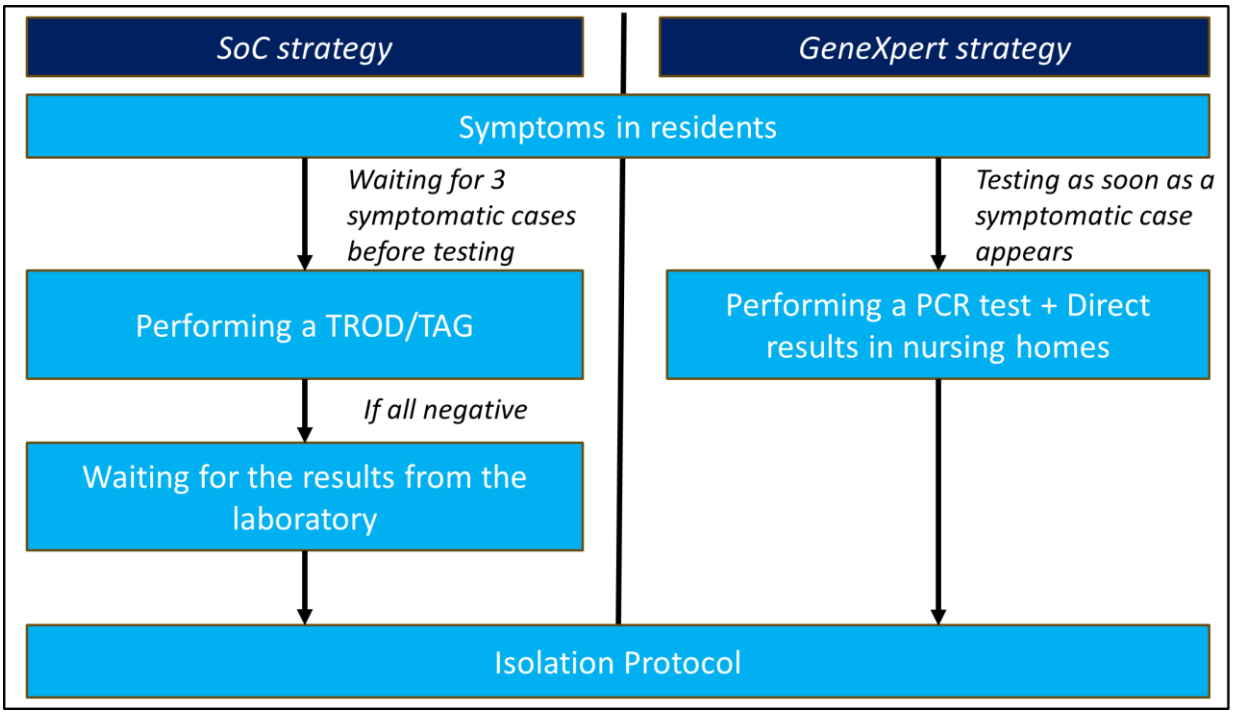
Test and Isolation Strategy (With GeneXpert®)

In this scenario, when the first symptomatic ARI case appears, immediate quadriplex PCR testing is performed using the GeneXpert® device, with no waiting period for three cases. The PCR test sensitivity is considered 100%. The same average positivity rate of 16.14% is applied. Consequently, the number of tests required is three times lower compared to the strategy using TROD/TAG, as the PCR-based approach eliminates the need for repeated testing to confirm an outbreak. The number of tests conducted is estimated using the following formula:

$$number\ of\ screening\ tests\ performed = \frac{number\ of\ grouped\ IRAs}{positivity\ rate}$$

Consequently, the number of tests conducted under the GeneXpert® strategy is estimated to be one-third of those required in the current strategy. Both strategies are illustrated in Figure 1.

Figure 1: Comparison of screening strategies



Abbreviations: TROD, Test Rapide d'Orientation Diagnostic ; TAG, Test Antigénique ; PCR, Polymerase Chain Reaction ; SoC, Standard of Care.

Cost data

Screening costs

Standard screening for acute respiratory infections (ARI) in nursing homes was evaluated using two testing modalities: rapid diagnostic tests (TROD/TAG) and PCR testing. The cost of influenza TROD/TAG was estimated at €6 per test, based on market prices[12]. For SARS-CoV-2 antigen detection (NABM code 4274, 36B)[13], the cost was €9 per test according to the French medical biology nomenclature. RSV screening was not included in the standard approach, as Public Health France data indicate that RSV is rarely associated with reported ARI cases and is not systematically screened[11] The screening strategy was modeled assuming systematic use of both an influenza TROD and a SARS-CoV-2 antigen test for each ARI episode as recommended in the current guidelines[1]. Thus, the total cost per screening episode using standard methods was €15. The alternative screening strategy utilized the GeneXpert multiplex PCR system, capable of simultaneously detecting SARS-CoV-2, influenza A/B, and RSV. The unit cost of GeneXpert testing was estimated at €45 per test, according to manufacturer pricing data.

Hospitalization costs

Hospitalization costs for lower respiratory tract infections (LRTI) attributable to ARI were derived from a French health economics study evaluating the burden of influenza and RSV hospitalizations[14]. Given that RSV infections are rarely reported in ARI surveillance, only influenza-related hospitalization costs were included in the analysis. Age-stratified hospitalization costs were reported as €5,624 for patients aged 60-64 years, €5,499 for those aged 65-74 years, and €4,413 for patients ≥75 years[14]. To account for the age distribution in nursing homes, where 10% of residents are under 75 years (5% in each younger age bracket), a weighted average hospitalization cost of €4,528 was calculated (Table 1).

Table 1: Hospitalization costs estimation

Age	**60-64 years**	**65-74 years**	**75 years and older**
Cost of hospitalization	€5,624	€5,499	€4,413
Distribution in nursing homes	5%	5%	90%
Weighted average cost	€4,528		

Medical transport costs were added to hospitalization costs to capture round-trip ambulance transfers between nursing homes and hospitals. Based on 2020 National Assembly Social Affairs Commission data[15], the average cost of one-way medical transport (including ambulances, light medical vehicles, and taxis) was €68.08, with a 93.1% reimbursement rate by French National Health Insurance. After inflation adjusted to 2024 values, the round-trip medical transport cost was estimated at €146.65 per hospitalization.

Deterministic sensitivity analysis

A deterministic sensitivity analysis (DSA) was conducted to account for uncertainties in the model parameters. The analysis varied key inputs, by ±10% to evaluate their impact on the overall budget impact. The main objective of this analysis was to assess the impact of uncertainty surrounding the different parameters on the results, while identifying and prioritizing the relative influence of these parameters.

Results

Clinical Results over 1 year

Based on our model projections and underlying assumptions, the clinical results indicate that over a one-year period, the implementation of the GeneXpert system could reduce the number of ARI screening tests by 67%, from 119,693 to 39,898 tests annually.

In addition to reducing the number of screening tests, the GeneXpert system also may lead to a 35% decrease in the number of ARI clusters, from 6,439 to 4,165 clusters. This projected reduction in ARI clusters is further reflected in a 35% reduction in hospitalization rates, with estimated cases declining from 9,208 to 5,956 cases.

Table 2: Clinical results over 1 year of implementing the GeneXpert system in french nursing homes over 1 year

	Scenario without GeneXpert®	**Scenario with GeneXpert®**	**Differential**
Screenings carried out	119,693	39,898	79,796 (-67%)
Number of Pooled ARIs (clusters)	6,439	4,165	- 2,274 (-35 %)
Total Number of ARIs cases	141,669	91,634	- 50,034 (-35 %)
Number of hospitalizations	9,208	5,956	- 3,252 (-35 %)

Abbreviations: ARI, Acute Respiratory Infection.

Budget Impact over 1 year

Screening costs

Despite the cost per test for the GeneXpert system is three times higher (€45 compared to €15 for rapid antigen tests), the threefold reduction in the number of screening tests conducted results in identical total screening costs for both scenarios, amounting to €1,795,400 annually.

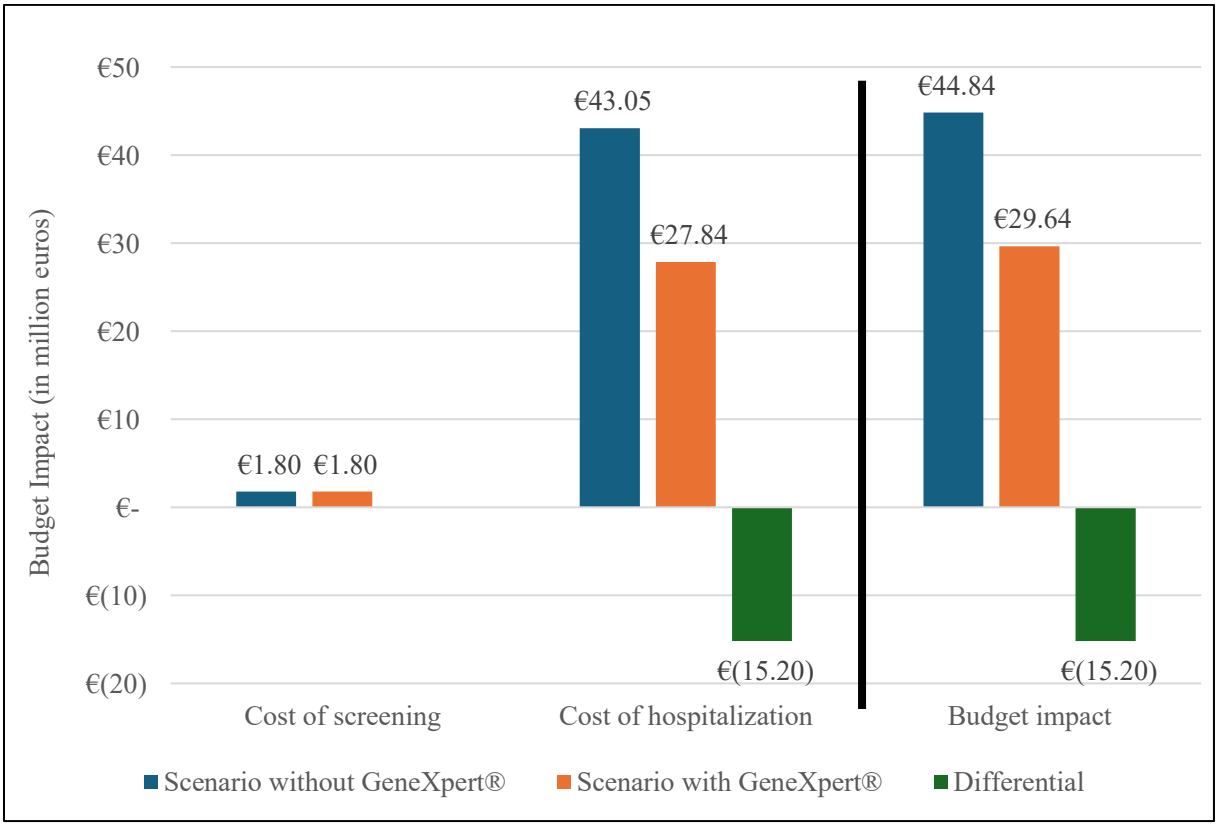
Hospitalization costs

The implementation of the GeneXpert system could lead to a reduction in hospitalization costs, with savings of €15,202,734 over a one-year period.

Budget Impact

In summary, the implementation of the GeneXpert system in French nursing homes could results in a net budgetary impact of €15.2 million in savings over one year, primarily driven by reduced hospitalization costs due to a 35% decrease in acute respiratory infection clusters and associated hospitalizations.

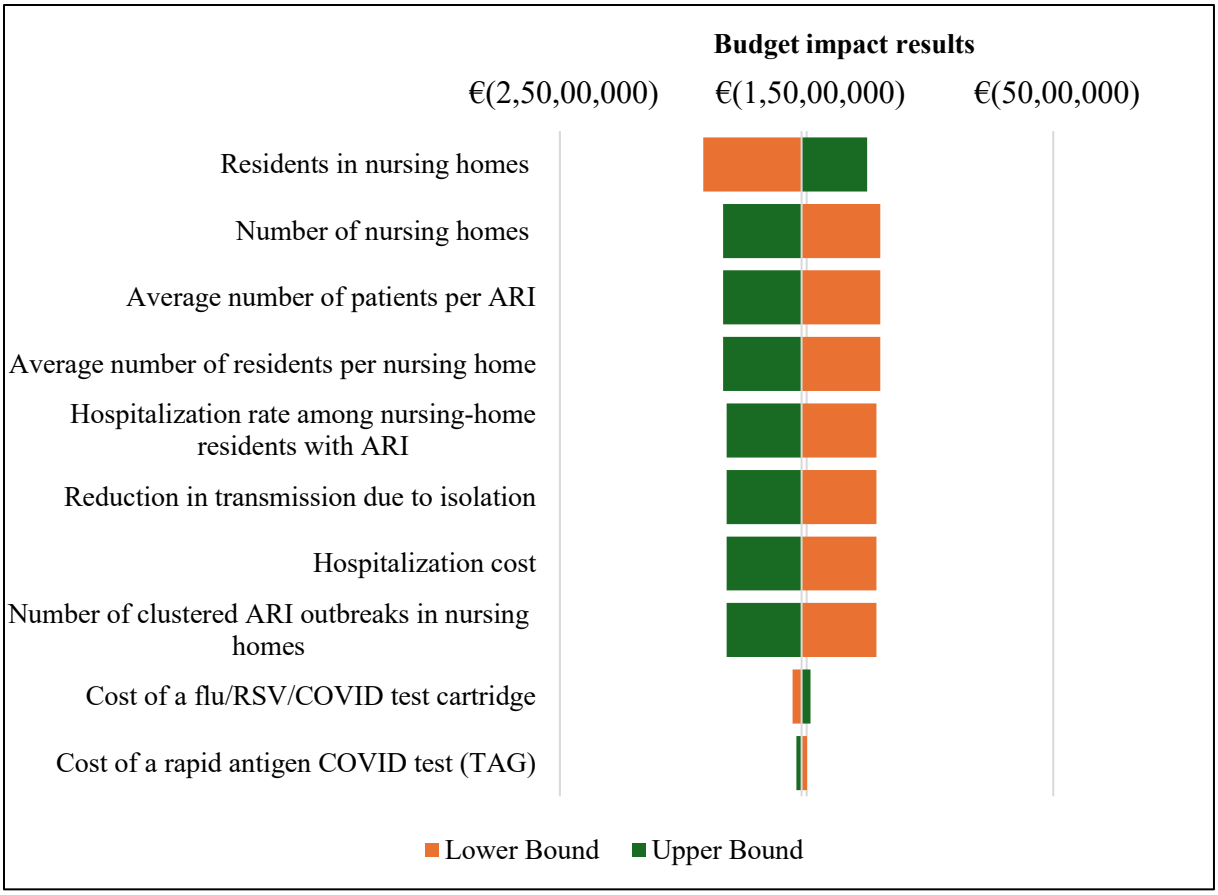
Figure 2: Budget impact results of implementing the GeneXpert system in french nursing homes over 1 year



Deterministic Sensitivity Analysis Results

The sensitivity analysis identifies the key parameters that influence the budget impact of the GeneXpert system, including the number of residents per nursing home, the number of ARI clusters, and the hospitalization rate. Variations in these parameters result in budget impacts ranging from €12,017,399 to €19,184,402 in savings.

Figure 3: Deterministic Sensitivity Analysis of the annual budget impact in euros



Abbreviations: ARI, Acute Respiratory Infection ; TROD, Test Rapide d'Orientation Diagnostic ; TAG, Test Antigénique ; PCR, Polymerase Chain Reaction ; SoC, Standard of Care ; RSV, Respiratory Syncytial Virus

Discussion

This study evaluates the budget impact of implementing the GeneXpert system in French nursing homes to manage acute respiratory infections (ARIs). The analysis compares the current diagnostic strategy, which relies on rapid antigen tests and delayed PCR testing, with a "Test and Isolation" strategy utilizing the GeneXpert system for immediate PCR testing.

The results of this study demonstrate the significant clinical and economic benefits of implementing the GeneXpert system in French nursing homes. The system reduces the number of ARI screening tests by 67%, from 119,693 to 39,898 tests annually, while also decreasing the incidence of ARI clusters by 35%. This reduction in ARI transmission is reflected in a corresponding 35% decrease in hospitalization rates, from 9,208 to 5,956 cases. The clinical benefits of the GeneXpert system are further highlighted by the substantial cost savings of €15,202,734, driven primarily by the reduction in hospitalization costs.

The interpretation of these results underscores the potential of the GeneXpert system to enhance the management of ARIs in elderly populations. By enabling early detection and isolation of infected residents, the system limits the transmission of infections and reduces the burden on healthcare resources. The economic benefits of the GeneXpert system, including the substantial cost savings associated with reduced hospitalization rates, further support its adoption as a cost-saving solution for managing ARIs in nursing homes.

These findings are consistent with results from a similar study which evaluated the use of multiplex PCR testing for respiratory pathogens in hospitals[16]. It showed that rapid and accurate diagnostics improved clinical decision-making, enhanced patient outcomes. Additionally, the study highlighted economic benefits, such as shorter hospital stays and better resource utilization. Although conducted in a hospital setting, these findings align with our results, emphasizing the value of rapid diagnostics for timely pathogen detection and effective isolation measures.

This study offers several strengths, including the use of comprehensive data from national surveillance systems and epidemiological reports, as well as a robust budget impact model to evaluate the budget impact of the GeneXpert system. The inclusion of sensitivity analysis further enhances the reliability of the findings, as it allows for the assessment of parameter variability and its impact on the economic outcomes of the analysis.

Despite these strengths, several limitations should be acknowledged. First, the number of reported ARIs for the 2023/2024 season was derived from Public Health France surveillance data. However, information regarding the proportion of nursing homes participating in this reporting system and the distribution of ARIs across individual facilities was not available. Consequently, the analysis assumed uniform ARI distribution across all nursing homes, which may affect the precision and representativeness of the results.

Second, the model's estimates of avoided hospitalizations and associated cost savings depend critically on the assumed effectiveness of isolation measures. This effectiveness was based on a study conducted during the COVID-19 pandemic. The applicability of isolation effectiveness observed for SARS-CoV-2 to other respiratory viruses (influenza, RSV) represents a source of uncertainty in the model. A prospective study specifically evaluating isolation effectiveness for multiple respiratory pathogens in nursing home settings would enhance the robustness of future analyses.

Third, successful implementation of the GeneXpert system across nursing homes requires adequate staff training and logistical organization to ensure proper specimen collection, testing procedures, and timely isolation of positive cases. The clinical and economic outcomes observed in this analysis depend on consistent adherence to screening and isolation protocols across participating facilities.

In addition, it should be noted that some TROD (rapid diagnostic orientation tests) can simultaneously detect influenza, SARS-CoV-2, and RSV within a single assay. However, their diagnostic performance may be lower than that of single-pathogen molecular tests.

Finally, the analysis does not take into account the organizational impact that reducing infections at the facility level could have. This could translate into a healthier and more available healthcare workers, thanks to a more specific isolation policy.

Conclusion

The implementation of a Test and Isolate strategy in nursing homes, supported by the GeneXpert® device, appears to be both clinically and economically effective. This intervention significantly reduces the incidence of clustered ARIs and associated hospitalizations. From a budgetary perspective, this strategy generates substantial net savings in hospitalization costs. These findings suggest that adopting such strategies could contribute to improved management of respiratory infections in nursing homes and optimize healthcare resource utilization, while ensuring enhanced quality of life for residents through point-of-care diagnostics.

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Statements and Declarations

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Henri Lesage and Quentin Berkovitch. The first draft of the manuscript was written by Henri Lesage and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability:

All data generated or analyzed during this study are included in this published article.

Conflict of interest :

Slim Fourati has served as an advisor or speaker for GlaxoSmithKline, AstraZeneca, MSD, Pfizer, Sanofi, Cepheid and Moderna, and his institution has received funding from Moderna and AstraZeneca. Olivier Hanon has received honoraria from Pfizer, GSK, Moderna and Sanofi. Slim Fourati, Florence Decottignies, Thomas Celarier and Olivier Hanon received funding from Cepheid to conduct this work. Henri Lesage and Quentin Berkovitch are employees of PHE-Cencora, which received funding from Cepheid to conduct this work.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Informed Consent

For this type of study informed consent is not required.

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