AMERICAN JOURNAL OF RESEARCH IN MEDICAL SCIENCES, 2021
VOL 6, NO. 2, PAGE 1 – 6

RESEARCH ARTICLE

Open Access

A Risk Score Proposal for Covid-19 in Nursing Homes

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ABSTRACT

Background/Objectives: During the SARS-CoV-2 pandemic currently ongoing worldwide, several challenges were encountered in managing patients in out-of-hospital residences. The aim of this study is to establish a risk score indicating the probability of SARS-CoV-2 infection and estimate the seroprevalence in nursing homes.

Design: This is a retrospective cross-sectional observational study.

Participants and Setting: 231 patients (median age 86 years, min 53 max 100 years) were enrolled from three nursing homes of Pavia and its surroundings.

Measurements: Medical history, clinical and instrumental data were correlated to the results of nasopharyngeal swab and serology.

Results: Patients with positive nasopharyngeal swab and/or serology were 170 (74%, 95%CI: 67%-79%) and seroprevalence was 64%. Variables associated with COVID-19 infection used to build the clinical score were: anosmia and ageusia, pulse oximetry <90%, conjunctivitis, rhinorrhea, myalgia. The probability of COVID-19 positivity increased linearly over the clinical score values (score 0: 55%; score 1: 83%: score 2+: 95%). By adding lung ultrasound to the score, a *Clinical & LUS Risk Score* was created, which allowed further stratification. The area under the ROC Curve for the two models was 0·73 and 0·77, respectively. Of note, fever, one of the pivotal signs in COVID-19 patients, was not a common manifestation among nursing home residents with SARS-CoV-2 infection, therefore it was not included in the scores.

Conclusions: Given the high SARS-CoV-2 seroprevalence in nursing homes, the *Clinical San Matteo Risk Score,* implemented by lung ultrasound when available, can help for an early identification, isolation and treatment of possible positive cases.

ARTICLE HISTORY

Received 20 February 2021
Accepted 02 March 2021
Published 20 March 2021

KEYWORDS

SARS-CoV-2, COVID-19 symptoms, health facilities, lung ultrasound, older adults.

Impact Statement

The authors certify that this work is novel; the manuscript confirms the most recent observation of COVID-19 signs and symptoms in older adults and suggests two scores, applicable to nursing homes residents, with progressively higher probability of being SARS-CoV-2 positive (*Clinical San Matteo Risk Score* and *Clinical & LUS Risk Score*). This is important because SARS-CoV-2 infection in the nursing home setting can spread fast, as we saw in the first pandemic wave, and precipitate the clinical conditions of older and comorbid subjects, most at risk of fatal course of the disease. Thus, the *Clinical San Matteo Risk Score,* implemented by LUS when available, can help for an early identification, isolation and treatment of possible positive cases.

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Key Points

- Among older nursing home residents, the seroprevalence of SARS-CoV-2 infection during the first pandemic wave was very high (64% in Northern Italy).
- Combining the most common signs and symptoms, two risk scores (clinical and implemented by LUS) were created, with progressively higher probability of SARS-CoV-2 positivity.
- The two scores can help for an early identification, isolation and treatment of possible COVID-19 cases.

Why does this matter?

This is important because SARS-CoV-2 infection in the nursing home setting can spread fast, as we saw in the first pandemic wave, and precipitate the clinical conditions of older and comorbid subjects, most at risk of fatal course of the disease.

Introduction

In Italy, the SARS-CoV-2 pandemic officially began at the end of February 2020. Since then, several outbreaks occurred, particularly in Northern Italy. In addition to the emergency in hospital facilities, the nursing homes have also become the site of serious outbreaks.

Nursing homes are health facilities with a lower severity setting, designed for those patients who are not yet able to return to their homes for health reasons. However, the level of monitoring is lower than in hospital, with more contacts between patients and relatives, so early isolation is essential to prevent large COVID-19 outbreaks. The lack of a prevention strategy with well-defined protocols during the first pandemic wave caused a nation-wide spread of the virus. Given the importance of early identification of COVID-19-positive subjects, the diagnostic challenge is particularly difficult in the context of older adults, who often have atypical and/or non-specific symptoms such as delirium, low-grade pyrexia and abdominal pain [1]. As demonstrated by several studies, testing only patients with cough or fever is misleading and at least 1 in 3 cases in those over the age of 70 is undiagnosed [2]. In addition, according to the most recent data provided by the Italian Superior Institute of Health (*Istituto Superiore di Sanità*), there is a very high rate of lethality among nursing home residents. Indeed, patients in those facilities are mainly frail older adults with numerous comorbidities, with a high risk of developing a serious and potentially fatal course of the disease [3]. Furthermore, nursing homes are structures in which it is not always possible to rapidly implement all diagnostic-therapeutic instrumental procedures on site, as in hospital setting.

As suggested by the World Health Organization, the solution to this problem cannot be represented by the hospitalization, because of the large number of patients in nursing homes who would require this procedure. Furthermore, an excessive hospitalization could lead, as already happened in the first pandemic wave, to the saturation of the hospital structures and to a potential greater spread of the virus. It is therefore necessary to isolate, evaluate and treat, whenever possible, the greatest number of patients in their own nursing homes. The ability to quickly isolate suspected cases and carry out medical checks on site is the most suitable and feasible solution to reduce the spread of COVID-19.

The aim of this study is therefore to propose a rapid and easily applicable COVID-19 infection probability score in the context of residences for older adults; second endpoint is to estimate the seroprevalence among residents.

Methods

Collection of clinical-instrumental data

This is a cross-sectional observational study. Over the course of a 2 months period (April-May 2020), 231 patients residing in various nursing homes of Pavia (Santa Margherita Rehabilitation and Care Institute and nursing home F. Pertusati) and Belgioioso (Pii Istituti Unificati Onlus) were enrolled. Subjects with positive nasopharyngeal swab and / or positive IgG serology were considered positive. Nasopharyngeal swabs were performed according to recognized standards of good practice by trained personnel to minimize false negatives. The serology was carried out by means of venous blood sampling and with LIAISON® SARS-CoV-2 S1/S2 IgG test, with research of IgG antibodies. The samples were processed at the Microbiology and Virology Department of IRCCS San Matteo Hospital.

Nasopharyngeal swab was generally performed the same day of the clinical evaluation, when clinical suspicion occurred. Serology was taken afterwards to intercept all COVID-19 patients, even those asymptomatic or with a misleading negative nasopharyngeal swab.

A team of specialists and ultrasound experts, composed by two Infectious Disease Specialists and a nurse from IRCCS San Matteo Hospital, Infectious Disease-Ultrasound Department, carried out clinical-instrumental evaluation to identify potentially infected patients, with particular attention to the following symptoms: fever, cough, dyspnea, anosmia, ageusia, conjunctivitis, myalgia, rhinorrhea, pharyngodynia, diarrhea, abdominal pain, dermatological signs. According to the most recent literature, the dermatological signs considered were erythematous rash (macular, papular, maculopapular, and erythema multiforme-like eruptions), diffuse urticaria, varicelliform eruptions [4].

Instrumental data were collected as follow: i) finger pulse oximetry (< or ≥ 90%); ii) external body temperature (measured with an infrared thermometer, <or ≥ 37 ° C) [5]; iii) lung ultrasound (LUS) and iv) nasopharyngeal swab tested for the presence of SARS-CoV-2 RNA and when possible blood sample tested for the presence of IgG specific for SARS-CoV-2.

Lung ultrasound is a simple bedside examination to identify interstitial pneumonia, a frequent finding in SARS-CoV-2 infection. Therefore, enrolled patients underwent bedside LUS evaluation with an Esaote MyLab25 sonograph (Esaote Spa, Genova, Italy) or Hitachi Noblus sonograph (Hitachi Medical Systems Europe) equipped with a convex 3.5 MHz probe. Gain was adjusted to obtain the best possible image of the pleura, B-lines (localized vertical artifacts due to the alterations of the subpleural tissue) and bronchogram [6]. The thorax of each patient was studied in the supine, semi-supine or sitting position, depending on cooperation level. In order to perform an accurate but fast assessment, lungs were scanned on posterior and lateral fields [7]. Pulmonary ultrasound was considered positive in the presence of B lines, white lung, focal parenchymal consolidation, irregularities of the pleural line or pleural effusion [8].

Statistical analysis

Qualitative variables were described as absolute and relative frequencies (percentage) of each category. Quantitative variables were summarized as median and Interquartile Range (IQR). The association between two categorical variables was tested via Fisher's exact test. Mann-Whitney test was used to compare quantitative variables between two independent groups of patients.

The COVID-19 positive seroprevalence of the entire population under examination was estimated together with the corresponding 95% exact binomial confidence interval (95%CI). In order to build a Clinical Score able to predict positive status of nasopharyngeal swab and/or serology, the associations between a series of clinical candidate predictors and COVID-19 positive status was assessed by exact logistic regression. Non-collinear variables, with a p-value lower than 0.2 at the univariable analysis, were candidates to enter a multivariable model. In a further step, the additional role of LUS positivity was assessed by including both the clinical score and the LUS in a new logistic model to derive a *Clinical & LUS Score*.

To calculate the scores, the coefficients were rounded from each multivariable regression model to the nearest integer and summed them up. For each score, the probability of COVID-19 positive status was derived using logistic regression and plotting them in a nomogram. The model Area under the ROC Curve (AUC) of classic logistic models was computed to assess the discrimination ability of the two scores.

2-sided P values <0.05 were considered as statistically significant. All statistical analyses were conducted using the Stata 16 software (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX, USA).

Results

The study enrolled two hundred thirty-one patients, mainly represented by females (84%), with a median age of 86 years (IQR: 80-90; min 53 max 100 years).

Seroprevalence (IgG) was 64% in the studied population.

Patients with nasopharyngeal swab positive for the presence of SARS-CoV-2 RNA and/or detection of IgG SARS-CoV-2-specific were defined as positive (170, 74%, 95%CI 67%-79%), while patients with both test negative were negative (61, 26%). Among positive group, 70 subjects (41.2%; 70/170) had positive nasopharyngeal swab, 77 negative nasopharyngeal swab but positive serology and 23 positive serology and no available nasopharyngeal swab. No significant difference was found in terms of age and sex between positive and negative patients (Table 1).

Symptoms and clinical signs

Table 1 summarizes the comparison of symptoms and clinical signs between the two groups of patients. Cough (31%), rhinorrhea (33%) and myalgia (26%) were the most frequent symptoms in the entire cohort. Conjunctivitis, OTD symptoms (olfactory and taste dysfunction, i.e. ageusia and anosmia), cough, rhinorrhea, dyspnea and myalgia were significantly more frequent in positive than in negative patients. On the contrary, the occurrence of pharyngodynia, abdominal pain, diarrhea and dermatological signs was not different between groups.

Instrumental assessments

Only 7 subjects had temperature ≥37 °C and only 9 presented pulse oxymetry <90% (Table1). Positive patients had more frequently pulmonary abnormalities at LUS as compared to the negative ones (53% vs 23%, p<0.001). No other significant differences in instrumental examinations were found between groups.

The "Clinical San Matteo Risk Score"

As showed in Table 2, the multivariable associations of predictors and COVID-19 positivity status was derived. OTD symptoms, rhinorrhea and myalgia retained their predictive effect on COVID-19 positivity, while cough and dyspnea had no

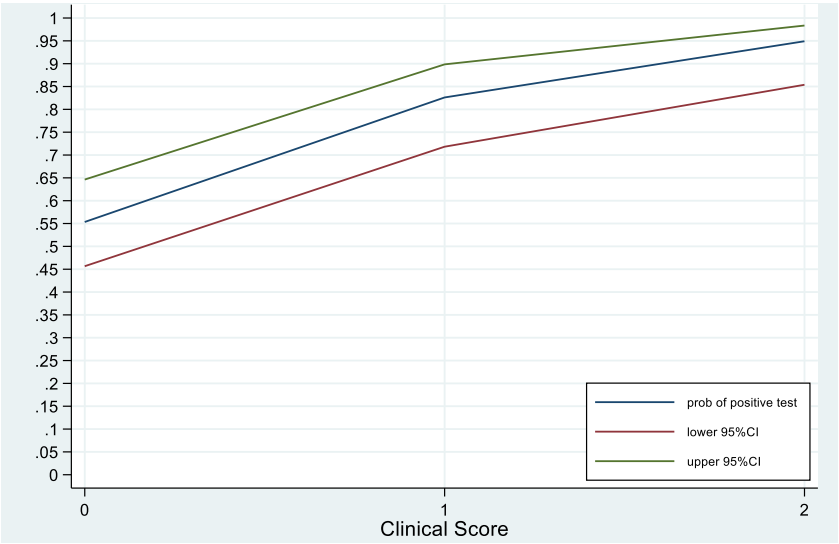
Table 1: General characteristics of the population. Positive patients defined as positive nasopharyngeal swab and/or positive serology.

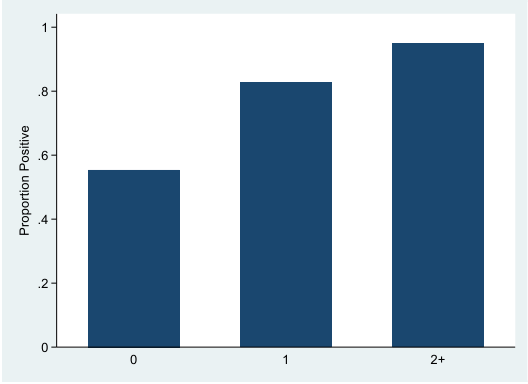
	Total (n=231)	Negative (n 61)	Positive (n 170)	p-value
Demographics				
Age (years), median (IQR)	86 (80-90)	87 (79-91)	85 (80-90)	0.509
Sex female n (%)	193 (84%)	50 (82%)	143 (84%)	0.691
Symptoms and signs				
Conjunctivitis	12 (5%)	0 (0%)	12 (7%)	0.039
OTD symptoms	26 (11%)	0 (0%)	26 (15%)	<0.001
Cough	71 (31%)	12 (20%)	59 (35%)	0.035
Rhinorrhea	76 (33%)	11 (18%)	65 (38%)	0.004
Dyspnea	34 (15%)	4 (7%)	30 (18%)	0.036
Myalgia	60 (26%)	7 (11%)	53 (31%)	0.002
Pharyngodynia	50 (22%)	9 (15%)	41 (24%)	0.149
Abdominal pain	17 (7%)	2 (3%)	15 (9%)	0.251
Diarrhea	18 (8%)	3 (5%)	15 (9%)	0.414
Dermatological signs	4 (2%)	0 (0%)	4 (2%)	0.575
Instrumental assessments				
Pulse oximetry < 90%	9 (4%)	0 (0%)	9 (5%)	0.117
Temperature ≥ 37°C	7 (3%)	2 (3%)	5 (3%)	>0.900
Pulmonary US positive	104 (45%)	14 (23%)	90 (53%)	<0.001

Table 2: Exact logistic regression (multivariable model) for COVID-19 positivity status based on clinical information.

	OR (95%CI)	Coefficient (log OR)	p-value	Weights
Conjunctivitis	4.03 (0.55 - +Inf)	1.39	0.192	1
OTD symptoms	12.24 (1.91 - +Inf)	2.51	0.004	2
Cough	0.89 (0.34 - 2.33)	-0.11	>0.900	0
Rhinorrhea	2.69 (1.11 - 7.00)	0.99	0.025	1
Dyspnea	1.25 (0.33 - 5.88)	0.23	>0.900	0
Myalgias	3.12 (1.23 - 9.04)	1.14	0.013	1
Pulse oximetry < 90%	2.35 (0.25 - +Inf)	0.85	0.482	1

Abbreviations: OTD - Olfactory and Taste Dysfunction; LUS - Lung Ultrasound; IQR - Interquartile Range; AUC - Area under the ROC Curve.





Clinical San Matteo Risk Score	N (%)	Probability of COVID-19 positivity (95%CI)
Low risk (score 0)	103 (44.6%)	55% (46%-65%)
Intermediate risk (score 1)	69 (29.9%)	83% (74%-92%)
High risk (score 2+)	59 (25.5%)	95% (89%-101%)

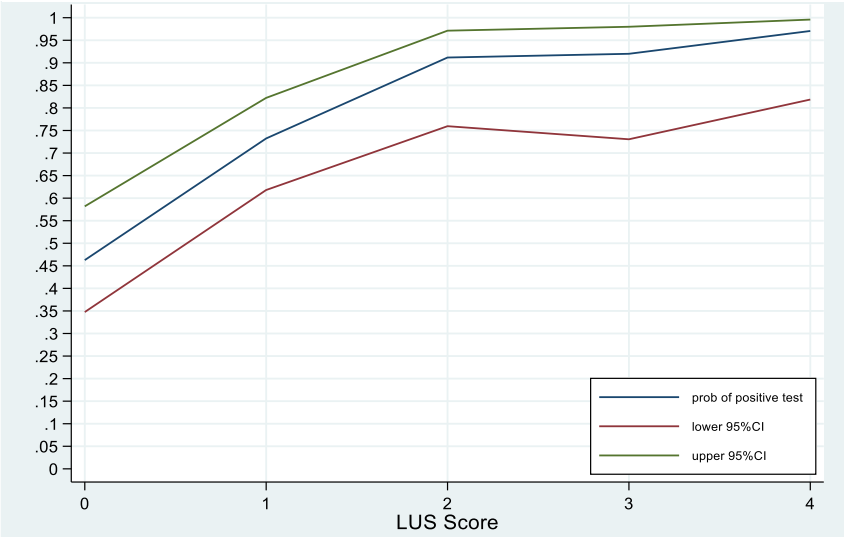
Figure 1: Nomogram with the probability of being COVID-19 positive given the "*Clinical San Matteo Risk Score*". The score is obtained by summing up the weights from Table 2 for each patient.

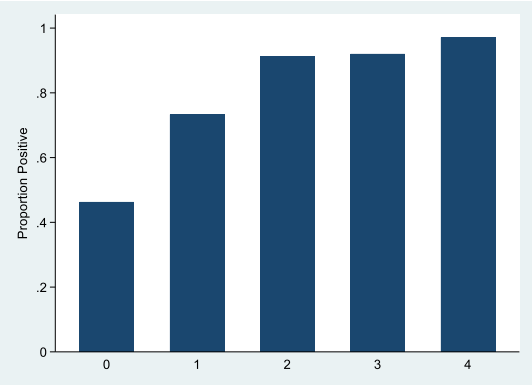
significant effect. Pharyngodynia did not enter the multivariable model due to the high correlation with cough and rhinorrhea.

From this model the Clinical Score was generated by assigning weights to each variable, derived from their regression coefficients, rounded to the closest integer. Conjunctivitis, rhinorrhea, myalgias and pulse oximetry <90% were assigned weight 1; OTD symptoms weight 2. Thus, the score, calculated as the sum of the weights, ranges from 0 to 6. Given the paucity of negative with scores 3 and above, they were collapsed with the score 2 category. The probabilities associated with the score categories, computed from the logistic model, and the corresponding nomogram, and are shown in Figure 1. The probability of positivity increases progressively from the low risk (score=0) to the intermediate risk (score=1) and to the high risk (score=2+). The AUC of this Clinical Score is 0·73 (95%CI: 0·67-0·79).

The "Clinical & LUS - San Matteo Risk Score"

Combining clinical score with pulmonary ultrasound positivity in a multivariable logistic regression model, this last parameter retained a significant and independent effect on positivity status (Table 3). The score was computed as described above, using the weights from Table 3. The *Clinical & LUS score* ranges from 0 to 5. The computed probabilities and the corresponding nomogram are shown in Figure 2. The probability of positivity increases steadily from a score 0 to 2, and minimally afterwards. The AUC of this LUS model is 0·77; 95%CI: 0·71-0·84, higher than the AUC for the clinical score.





LUS San Matteo Risk Score	N (%)	Probability of COVID-19 positivity (95%CI)
0	67 (29%)	46% (34%-58%)
1	71 (31%)	73% (63%-84%)
2	34 (15%)	91% (82%-101%)
3	25 (11%)	92% (81%-103%)
4	34 (15%)	97% (91%-103%)

Figure 2: Nomogram with the probability of being COVID-19 positive given the "*Clinical & LUS San Matteo Risk Score*". The score is obtained by summing up the weights from Table 3 for each patient.

Discussion

The main result of the present study is the proposal of two scores: the "*Clinical San Matteo Risk Score*" and "*Clinical & LUS San Matteo Risk Score*". Both scores aim to stratifies, based on simple clinical/instrumental variables, the risk of being COVID-19 positive in a nursing home residents populations. As already known from the international literature, the most frequent symptoms of SARS-CoV-2 infection span from flu-like ones in less severe cases, up to high fever, severe cough and dyspnea in advanced cases. Older adults, often weakened by multiple comorbidities, represent the population most at risk for a serious and potentially fatal course of the disease [3]. Despite this, the initial course is often atypical or paucisymptomatic [1]. Immunosenescence and alterations in the cytokine cascade seem to play a central role in the pathogenesis of the disease [9].

Among the most useful instrumental tests are the measurement of the pulse oximetry and lung ultrasound (LUS). Lung ultrasound is a quick method, easy to perform and with a fast learning curve. Due to its ease of handling it has already been used both in medical wards and in emergency departments. LUS usefulness in the evaluation of COVID-19 pulmonary signs (B lines, lung consolidations, etc.) has been widely demonstrated. Furthermore, LUS evaluation is able to significantly predict mortality in nursing home residents affected by COVID-19, supporting that this simple tool could be routinely used in this setting instead of others techniques available only in hospital, such as chest x-ray [10]. The usefulness of portable wireless scanner echography have been already reported, particularly in nursing homes [11].

In this study the most frequent signs and symptoms in COVID-19 positive patients residing in nursing homes were dyspnoea, conjunctivitis, anosmia and ageusia, pulse oximetry <90%, cough, rhinorrhea, myalgia. Signs and symptoms of greater clinical and statistical significance were selected to compose the "*Clinical San Matteo Risk Score*". Different weights were assigned depending on estimated coefficients from a logistic multivariable model. The computed score identifies three groups of patients (score 0 vs 1 vs 2 or more) with progressively increasing risk.

The parameters used in the "*Clinical San Matteo Risk Score*" (see Table 2) are simple and easily applicable in a less intensive care setting such as that of nursing homes. With just a few questions and the measurement of pulse oximetry it can be possible to verify the patient's risk of being COVID-19 positive. Adding lung ultrasound (an independent predictor of risk in the *Clinical & LUS Score* categorized population) the *Clinical & LUS Score* obtained can further stratify the cohort.

It is worth remembering that in this study lung ultrasound was performed using a simplified and fast protocol, scanning only the posterior and lateral lung fields, depending on the patient's

mobility. Indeed, in COVID-19 pulmonary disease the most affected thoracic fields are the posterior and the lower ones, as described in some recent studies [7]. Although a simplified protocol could represent a limit (older adults often have cardiac-pulmonary comorbidities or mild imbibition which can be confusing), we believe that this represents a point of strength, as shown by the additional and independent value of LUS positivity in the statistical model when added to the clinical score. Indeed, in this category of patients even only a few simple scans, in the appropriate clinical setting, could suggest COVID-19 positivity.

Of note, fever, a sign commonly used for first level screening for positivity, was not included in the proposed scores. Indeed, during data collection it became evident that prevalence of this sign was extremely low among nursing home residents, even considering lower cut off as suggested by some studies (only 7 total subjects had body temperature ≥ 37,5°C, five COVID-19 positive in our series) [5]. This may be linked to the anergy of older adults (average age over 80 years), in which the immunosenescence on the one hand makes the onset of high fever less likely, on the other favours an unregulated inflammatory response.

From a practical point of view, the *Clinical San Matteo Risk Score* could be used by nursing staff already at the first assessment, whereas molecular testing is not always performed upon admission to the nursing home. This evaluation could stratify the subject's risk of being positive and the medical staff will be able to decide if it is appropriate to proceed with the preventive isolation until the result of the nasopharyngeal swab. Ideally, in nursing homes where lung ultrasound is available, this could represent a second level bedside tool to select, via the *Clinical & LUS Score*, those who need isolation and / or nasopharyngeal swab for COVID-19 (especially in intermediate-risk patients).

Limitations

This study has several limitations including the temporality; our study was carried out during the Italian pandemic, with the initial aim of evaluating for COVID-19 nursing home residents in Pavia and its Province. For this reason, lung ultrasound was performed only with a limited number of projections, to ensure the speed of execution given the large number of patients analysed in a short time. Despite this, LUS positivity yield an additional and independent prognostic value when added to the clinical score in the identification of COVID-19 positivity. Finally, our Risk Scores currently lack a validation population, which would certainly make their applicability in the clinical field more verifiable.

Conclusions

COVID-19 seroprevalence (IgG) was 64% in the nursing homes under study. Two risk scores (*Clinical and Clinical & LUS San Matteo Risk Scores*) were created with few elements, mainly clinical, simple and quickly suitable, to stratify the risk of SARS-CoV-2 infection in patients hospitalized in nursing homes. From a practical point of view, the *San Matteo Risk Scores* could be easily used to select patients with a high probability of being affected by COVID-19 already upon entry into nursing homes. These subjects are often multi-pathological older adults, on the one hand more prone to developing serious complications from COVID-19, on the other often with non-specific or atypical symptoms. The identification of high-risk individuals could help medical staff decide whether to carry out more in-depth instrumental examinations (such as lung ultrasound). The proposed scores could therefore be useful in the population of nursing home residents for early isolation, diagnosis and supportive therapy.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. We would like to thank Nadio Locatelli for her contribution in this project.

Acknowledgement

We would like to thank Nadia Locatelli for her contribution in this project.

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