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REVIEW

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# Hospital length of stay for COVID-19 patients: a systematic review and meta-analysis

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ABSTRACT

The length of stay in the hospital for COVID-19 can aid in understanding the disease's prognosis. Thus, the goal of this study was to collectively estimate the hospital length of stay (LoS) in COVID-19 hospitalized individuals. To locate related studies, international databases (including Google Scholar, Science Direct, PubMed, and Scopus) were searched. The $I^2$ index, the Cochran Q test, and $T^2$ were used to analyze study heterogeneity. The mean LoS in COVID-19 hospitalized patients was estimated using a random-effects model. COVID-19's total pooled estimated hospital LoS was 15.35, 95%CI:13.47-17.23; $p<0.001$, $I^2 = 80.0$). South America had the highest pooled estimated hospital LoS of COVID-19 among the continents, at 20.85 (95%CI: 14.80-26.91; $p<0.001$, $I^2 = 0.01$), whereas Africa had the lowest at 8.56 8 (95%CI: 1.00-22.76). The >60 age group had the highest pooled estimated COVID-19 hospital LoS of 16.60 (95%CI: 12.94-20.25; $p<0.001$, $I^2 = 82.6$), while the 40 age group had the lowest hospital LoS of 10.15 (95% CI: 4.90-15.39, $p<0.001$, $I^2 = 22.1$). The metanalysis revealed that COVID-19's hospital LoS was more than 10 days. However, it appears that this duration varies depending on a number of factors, including the patient's age and the availability of resources.

**Key words:** COVID-19; length of stay; hospital.



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**Contributions:** YA, study concept, analysis design and performing, project supervision, conceived and designed the analysis, manuscript drafting and revision; EMY, data collection, manuscript drafting, check out of the full texts, preparation of the table, critical appraisal of the articles; MS, data collection, contribution to analysis tools, data analysis, preparation of table and figures; MSh, data collection, check out of the full texts, preparation of the table, critical appraisal of the articles; MA, data collection, check out of the full texts, manuscript drafting; EH, search strategy, databases and articles screening, manuscript drafting, critical appraisal of the articles. All authors discussed the results and contributed to the final manuscript, read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

**Conflict of interest:** The authors declare that they have no competing interests, and all authors confirm accuracy.

**Ethics approval:** Ethics clearance was not sought as this review was based on published articles.

**Availability of data and materials:** All data generated or analyzed during this study are included in this published article, and its supplementary information files.

## Introduction

In late 2019, in Wuhan, China, a novel coronavirus of severe acute respiratory syndrome (coronavirus 2; SARS-CoV-2) caused a disease called COVID [1]. On January 30, 2020, the World Health Organization announced this situation as a public health emergency. At the date of December 1, 2020, more than 1.45 million deaths had occurred worldwide [2]. This disease creates serious challenges to the health system. The demand for hospital beds, intensive care beds, and mechanical ventilators is one of the challenges facing the health system [3-6].

The rapid spread of COVID-19 led to severe shortages of hospital beds. To plan a response, hospital and public health officials need to understand how many people in their area are likely to require hospitalization for COVID-19 [7]. The COVID-19 pandemic overburdens the intensive care units with the influx of critically ill patients and challenges the health systems' capacity to respond to the need [8]. In Winnipeg, Manitoba, critical care was severely challenged during the initial peak of the influenza A (H1N1) virus pandemic in June 2009, as intensive care units (ICUs) were at full capacity [9]. Since the shortage of ICU beds may engender a trade-off between saving the life of one patient over another, the ability to timely forecast the impact of the epidemic on ICU bed capacity usage is a critical component of adequate outbreak management [10].

The study by Jamshidi *et al*. compared the length of hospital stay during the COVID-19 pandemic in the USA, Italy, and Germany, the length of hospitalization for the fatal cases in the USA, Italy, and Germany are 2-10, 1-6, and 5-19 days, respectively. Overall, this length in the USA is 2 days more than that in Italy and 5 days less than in Germany [11].

Understanding how long COVID-19 patients require healthcare in hospitals is important for predicting bed demand and planning resource allocation, particularly in resource constraint settings [12]. Because of the pathogen COVID-19, the characteristics of the disease vary at different times and places [13,14]. Therefore, following these changes, it is essential to update our findings to better manage this disease. Thus, this study was aimed to estimate the hospital length of stay of COVID-19 patients.

## Methods

### Search strategy

We performed this study according to PRISMA guidelines. To identify all studies that reported hospital length of stay in COVID-19 hospitalized patients, a comprehensive search of several electronic databases, including PubMed, Scopus, and Web of Science, was performed on January 29, 2021. The search term comprised the following keywords: "length of stay"," Stay Length"," Hospital Stay", "Admission duration", "Admission length"," COVID 19", "COVID-19", "2019-ncov", "2019 ncov", "sars cov 2", "sars-cov 2", "Coronavirus", "hospital".

The following inclusion criteria were selected for meta-analysis: the study subjects were adults (≥18 years old) infected with COVID-19 and hospitalized, the primary outcome was mean or median hospital length of stay or ICU length of stay, and finally, studies were included in which the study population was not limited to a specific group of chronic patients. Furthermore, the exclusion criteria were articles that include a letter to the editor, case reports and case series, review, and meta-analysis.

### Study selection and data extraction

Titles and abstracts of all studies were screened to identify those that met the inclusion criteria. We send all of the related articles to Endnote X8 software. Afterward, we removed the duplicate articles. The remaining articles were reviewed in three steps. In the first step, we reviewed the title of the article and then the abstract, and finally, the article's full texts were evaluated. Full-texts were assessed for studies that were difficult to screen with titles and abstracts only. Two authors screened the final full texts, and each study was decided after reading the full texts of all potentially eligible articles. In cases of disagreement, a third review author was consulted.

The extracted data included: the first author's last name, publication year, country, sample size, mean age or age range, gender, mean or median hospital length of stay, IQRs, mean or median ICU length of stay (LoS), and standard deviations. Data extraction was done by the same two review authors who conducted the study selection independently.

### The assessment of methodological quality and risk of bias

The Newcastle-Ottawa Scale was applied to evaluate the quality of selected studies [15]. The NOS consists of three domains. These domains include the selection of study groups, comparability of groups, and description of exposure and outcome. This scale, including eight items and star scores, assesses the quality of each study in each domain. The total score of each of the articles was calculated. Study quality was rated on a scale from one star, very poor, to 10 stars, high quality. Studies are rated as high (7-10), medium (5-6), or low quality (<4). Two review authors completed quality assessments independently. A third review author was involved in cases of disagreement.

### Statistical analysis

Cochran's Q test assessed heterogeneity in the CRF of COVID-19 between different studies with a significance level of $p<0.1$ and $I^2$ statistic with values >75% [13]. The random-effects meta-analysis model was used to estimate pooled CFR because of high heterogeneity ($I^2$ =99.7% and Cochran's Q ($p<0.001$). The univariate meta-regression model was used to assess the effect of sample size on the heterogeneity of pooled CFR. Publication bias was assessed by Beggs and Eggers tests. Data were analyzed by STATA v 11 (StataCorp, College Station, TX, USA).

## Results

### Description of included studies

In the current systematic review and meta-analysis, 126 records with 428,977 cases estimated hospital length of stay, were included. These studies were from different continents.

A total of 4,745 records were retrieved through an electronic databases search, and 3,425 possibly relevant articles were identified after removing 1,320 articles due to duplication and irrelevance for the review purpose. In the second step, 2,655 articles were excluded after the title and abstract screeded for the inclusion and exclusion criteria. The remaining 644 articles were excluded due to lack of relevant information, or they were not original articles. Finally, 126 articles that reported hospital length of stay of COVID-19 were included in the final analysis (Figure 1; Table 1).

The mean (SD) of hospital LoS among all records was 14.49 (7.92); also, the median and interquartile range (IQR) of reported hospital LoS were 13.00 (17.8-9). The minimum and maximum

**Table 1.** Description of included studies in the current meta-analysis.

| | First author | Year | Country | Study design | Sample size | Age group* | Sex | Mean hospital LoS | LCL | UCL | Se | Continent° | NOS score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Al Sulaiman *et al.* [16] | 2021 | Saudi Arabia | Cohort | 560 | 1 | Both genders | 17/00 | -6/19 | 40/19 | 11/83 | 5 | 7 |
| 2 | Rosenthal *et al.* [17] | 2021 | China | Cohort | 721 | 3 | Both genders | 9/89 | -16/42 | 36/20 | 13/43 | 5 | 7 |
| 3 | Anudeep *et al.* [18] | 2020 | India | Cohort | 50 | 2 | Both genders | 6/00 | -0/93 | 12/93 | 3/54 | 5 | 6 |
| 4 | Zarzosa *et al.* [19] | 2021 | Spain | Cohort | 67 | 1 | Both genders | 14/10 | 6/08 | 22/12 | 4/09 | 2 | 7 |
| 5 | Cai *et al.* [20] | 2020 | China | Cohort | 149 | 3 | Both genders | 16/80 | 4/84 | 28/76 | 6/10 | 1 | 7 |
| 6 | Chen *et al.* [21] | 2020 | China | Case cohort | 114 | 1 | Both genders | 19/56 | 9/10 | 30/02 | 5/34 | 1 | 6 |
| 7 | Creel-Bulos *et al.* [22] | 2020 | Georgia | Cohort | 115 | 1 | Females | 19/00 | 8/49 | 29/51 | 5/36 | 3 | 8 |
| 8 | Daher *et al.* [23] | 2021 | Germany | Cohort | 18 | 1 | Females | 44/00 | 39/84 | 48/16 | 2/12 | 2 | 8 |
| 9 | Davoudi *et al.* [24] | 2021 | Iran | Cross-sectional | 153 | 4 | Both genders | 6/30 | -5/82 | 18/42 | 6/18 | 5 | 6 |
| 10 | Deeb *et al.* [25] | 2021 | UAE | Cohort | 1075 | 2 | Both genders | 6/20 | -25/93 | 38/33 | 16/39 | 5 | 5 |
| 11 | Demir *et al.* [26] | 2021 | Turkey | Retrospective cohort | 227 | 3 | Both genders | 3/88 | -10/89 | 18/65 | 7/53 | 5 | 7 |
| 12 | Diaz De Teran *et al.* [27] | 2021 | Spain/Italy | Cohort | 162 | 1 | Males | 17/00 | 4/53 | 29/47 | 6/36 | 2 | 7 |
| 13 | Seon *et al.* [28] | 2021 | Korea | Cohort | 7969 | | Both genders | 26/70 | -60/78 | 114/18 | 44/63 | 1 | 6 |
| 14 | Xiaofang *et al.* [29] | 2021 | China | Cohort | 75 | | Both genders | 16/10 | 7/61 | 24/59 | 4/33 | 1 | 7 |
| 15 | Fei *et al.* [30] | 2021 | USA | Cohort | 50 | 1 | Both genders | 11/64 | 4/71 | 18/57 | 3/54 | 3 | 8 |
| 16 | Xie *et al.* [31] | 2020 | USA | Cohort | 3641 | 1 | Both genders | 10/00 | -49/13 | 69/13 | 30/17 | 3 | 7 |
| 17 | Abbasi *et al.* [32] | 2021 | Iran | Cross-sectional | 37 | 2 | Both genders | 22/37 | 16/41 | 28/33 | 3/04 | 5 | 8 |
| 18 | Alshukry *et al.* [33] | 2020 | Kuwait | Cohort | 417 | 3 | Both genders | 20/69 | 0/68 | 40/70 | 10/21 | 5 | 5 |
| 19 | Cabanillas *et al.* [34] | 2020 | Spain | Cohort | 329 | 2 | Both genders | 7/85 | -9/93 | 25/63 | 9/07 | 2 | 6 |
| 20 | Capuzzi *et al.* [35] | 2021 | Italy | Cross-sectional | 151 | 1 | Both genders | 16/10 | 4/06 | 28/14 | 6/14 | 2 | 6 |
| 21 | Conlon *et al.* [36] | 2021 | USA | Cohort | 27201 | 3 | Both genders | 10/00 | -151/63 | 171/63 | 82/46 | 3 | 7 |
| 22 | Ersöz *et al.* [37] | 2021 | Turkey | Cohort | 310 | 2 | Both genders | 15/87 | -1/38 | 33/12 | 8/80 | 5 | 8 |
| 23 | Gharebaghi *et al.* [38] | 2021 | Iran | Cross-sectional | 215 | 2 | Both genders | 4/91 | -9/46 | 19/28 | 7/33 | 5 | 6 |
| 24 | Ipekci *et al.* [39] | 2020 | Turkey | Cohort | 51 | 2 | Both genders | 10/49 | 3/49 | 17/49 | 3/57 | 5 | 7 |
| 25 | Lenka *et al.* [40] | 2020 | USA | Cohort | 32 | 1 | Both genders | 14/80 | 9/26 | 20/34 | 2/83 | 3 | 6 |
| 26 | Liu *et al.* [41] | 2021 | China | Cohort | 178 | 3 | Both genders | 32/40 | 19/33 | 45/47 | 6/67 | 1 | 7 |
| 27 | Lu *et al.* [42] | 2020 | China | Cohort | 28 | 2 | Both genders | 14/96 | 9/77 | 20/15 | 2/65 | 1 | 7 |
| 28 | Li *et al.* [43] | 2020 | China | Cohort | 54 | 1 | Both genders | 21/40 | 14/20 | 28/60 | 3/67 | 1 | 7 |
| 28.1 | Li *et al.* [43] | 2020 | China | Cohort | 54 | 1 | Both genders | 29/30 | 22/10 | 36/50 | 3/67 | 1 | 7 |
| 29 | Li *et al.* [44] | 2021 | China | Cohort | 57 | 2 | Both genders | 11/20 | 3/80 | 18/60 | 3/77 | 1 | 8 |
| 30 | Omrani-Nava *et al.* [45] | 2020 | Iran | Case-Control | 279 | 2 | Both genders | 6/00 | -10/37 | 22/37 | 8/35 | 5 | 7 |
| 31 | Payandemehr *et al.* [46] | 2020 | Iran | RCT | 20 | 2 | Both genders | 6/75 | 2/37 | 11/13 | 2/24 | 5 | 8 |
| 32 | Saying *et al.* [47] | 2021 | Turkey | Cohort | 349 | 2 | Both genders | 9/70 | -8/61 | 28/01 | 9/34 | 5 | 8 |
| 33 | Velayos *et al.* [48] | 2020 | Spain | Cohort | 66 | 4 | Both genders | 5/60 | -2/36 | 13/56 | 4/06 | 2 | 7 |
| 34 | Wu *et al.* [49] | 2020 | China | Cohort | 6055 | 1 | Both genders | 3/90 | -72/36 | 80/16 | 38/91 | 1 | 7 |
| 35 | Yasin *et al.* [50] | 2021 | Egypt | Cohort | 210 | 3 | Both genders | 8/56 | -5/64 | 22/76 | 7/25 | 6 | 7 |
| 36 | Yuan, *et al.* [51] | 2020 | China | Cohort | 94 | 3 | Both genders | 14/28 | 4/78 | 23/78 | 4/85 | 1 | 6 |
| 37 | Zhan, *et al.* [52] | 2021 | China | Cohort | 476 | 1 | Both genders | 27/76 | 6/38 | 49/14 | 10/91 | 1 | 6 |
| 38 | Tan *et al.* [53] | 2021 | China | Cohort | 227 | 2 | Both genders | 22/40 | 4/52 | 40/28 | 9/12 | 1 | 6 |
| 38.1 | Tan *et al.* [53] | 2021 | China | Cohort | 15 | 2 | Both genders | 27/33 | 24/49 | 30/17 | 1/45 | 1 | 7 |
| 38.2 | Tan *et al.* [53] | 2021 | China | Cohort | 8 | 2 | Both genders | 14/50 | 7/18 | 21/82 | 3/74 | 1 | 6 |
| 38.3 | Tan *et al.* [53] | 2021 | China | Cohort | 14 | 2 | Both genders | 22/29 | 18/47 | 26/11 | 1/95 | 1 | 7 |
| 38.4 | Tan *et al.* [53] | 2021 | China | Cohort | 19 | 2 | Both genders | 13/42 | 11/54 | 15/30 | 0/96 | 1 | 8 |
| 39 | Jiang *et al.* [54] | 2020 | China | Cohort | 131 | 2 | Both genders | 16/60 | 5/38 | 27/82 | 5/72 | 1 | 7 |
| 40 | M *et al.* [55] | 2020 | China | Cohort | 72 | 1 | Both genders | 19/50 | 11/18 | 27/82 | 4/24 | 1 | 8 |
| 41 | Mallow *et al.* [56] | 2020 | USA | Cohort | 21,676 | 1 | Both genders | 8/90 | -135/38 | 153/18 | 73/61 | 3 | 7 |
| 42 | de Moura *et al.* [57] | 2020 | Brazil | Cohort | 400 | 2 | Both genders | 14/15 | -5/45 | 33/75 | 10 | 4 | 7 |
| 43 | Gupta *et al.* [58] | 2020 | India | Cohort | 200 | 3 | Both genders | 11/17 | -2/69 | 25/03 | 7/07 | 5 | 7 |
| 44 | Özyılmaz *et al.* [59] | 2020 | Turkey | Cohort | 105 | 3 | Both genders | 11/12 | 1/08 | 21/16 | 5/12 | 5 | 7 |

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**Table 1.** Continued from previous page.

| | First author | Year | Country | Study design | Sample size | Age group* | Sex | Mean hospital LoS | LCL | UCL | Se | Continent° | NOS score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | Parry *et al.* [60] | 2020 | India | Cohort | 61 | 3 | Both genders | 18/46 | 10/81 | 26/11 | 3/91 | 5 | 8 |
| 46 | Rahim *et al.* [61] | 2020 | Pakistan | Cross-sectional | 204 | 2 | Both genders | 6/20 | -7/80 | 20/20 | 7/14 | 5 | 8 |
| 47 | Rosenthal *et al.* [62] | 2020 | USA | Cohort | 35,302 | 1 | Both genders | 7/74 | -176/39 | 191/87 | 93/94 | 3 | 6 |
| 48 | Sardiña-González *et al.* [63] | 2020 | Spain | Cohort | 18 | 1 | Both genders | 9/40 | 5/24 | 13/56 | 2/12 | 2 | 6 |
| 49 | Shi *et al.* [64] | 2020 | China | Cohort | 184 | 3 | Both genders | 17/30 | 4/01 | 30/59 | 6/78 | 1 | 6 |
| 50 | Sun *et al.* [65] | 2020 | China | Cohort | 217 | 3 | Both genders | 17/90 | 3/46 | 32/34 | 7/37 | 1 | 7 |
| 51 | Teich *et al.* [66] | 2020 | Brazil | Cohort | 510 | 4 | Both genders | 9/00 | -13/13 | 31/13 | 11/29 | 4 | 7 |
| 52 | Turcotte *et al.* [67] | 2020 | USA | Cohort | 117 | 1 | Both genders | 11/80 | 1/20 | 22/40 | 5/41 | 3 | 6 |
| 53 | UlHaq *et al.* [68] | 2020 | Pakistan | Cohort | 179 | 3 | Both genders | 8/20 | -4/91 | 21/31 | 6/69 | 5 | 7 |
| 54 | Abi Fadel *et al.* 69] | 2020 | USA | Cross-sectional | 495 | 1 | Both genders | 13/90 | -7/90 | 35/70 | 11/12 | 3 | 6 |
| 55 | Erturk *et al.* [70] | 2020 | Turkey | Cohort | 262 | 2 | Both genders | 8/34 | -7/52 | 24/20 | 8/09 | 5 | 7 |
| 56 | Vernaz-Hegi *et al.* [71] | 2020 | Switzerland | Cohort | 840 | 1 | Both genders | 10/38 | -18/02 | 38/78 | 14/49 | 2 | 6 |
| 57 | Wagner *et al.* [72] | 2020 | USA | Cohort | 99 | 2 | Both genders | 32/61 | 22/86 | 42/36 | 4/97 | 3 | 6 |
| 58 | Wu *et al.* [73] | 2020 | China | Cross-sectional | 80 | 3 | Both genders | 8/00 | -0/77 | 16/77 | 4/47 | 1 | 7 |
| 59 | Wu *et al.* [8] | 2020 | China | Cohort | 58 | 2 | Both genders | 10/30 | 2/84 | 17/76 | 3/81 | 1 | 7 |
| 60 | Xie *et al.* [74] | 2020 | China | Case-control | 25 | 2 | Both genders | 21/20 | 16/30 | 26/10 | 2/50 | 1 | 7 |
| 61 | Yuan *et al.* [75] | 2020 | Switzerland | Cohort | 94 | 3 | Both genders | 14/28 | 4/78 | 23/78 | 4/85 | 2 | 7 |
| 62 | Zhang *et al.* [76] | 2020 | china | Cohort | 420 | 2 | Both genders | 17/80 | -2/28 | 37/88 | 10/25 | 1 | 8 |
| 63 | Egol *et al.* [77] | 2020 | USA | Cohort | 17 | 1 | Both genders | 9/80 | 5/76 | 13/84 | 2/06 | 3 | 7 |
| 64 | Del Giorno *et al.* [78] | 2020 | Switzerland | Cohort | 90 | 1 | Both genders | 16/40 | 7/10 | 25/70 | 4/74 | 2 | 8 |
| 65 | Cengiz *et al.* [79] | 2020 | Turkey | Cohort | 30 | 2 | Both genders | 10/40 | 5/03 | 15/77 | 2/74 | 5 | 8 |
| 66 | Ayaz *et al.* [80] | 2020 | Pakistan | Cohort | 66 | 2 | Both genders | 8/30 | 0/34 | 16/26 | 4/06 | 5 | 8 |
| 67 | Battaglini *et al.* [81] | 2020 | Italy | Cohort | 94 | 1 | Both genders | 28/10 | 18/60 | 37/60 | 4/85 | 2 | 7 |
| 68 | Ar Bhuyan *et al.* [82] | 2020 | Bangladesh | Cohort | 33 | 4 | Both genders | 14/50 | 8/87 | 20/13 | 2/87 | 5 | 6 |
| 69 | Agrupis *et al.* [83] | 2021 | Philippines | Cohort | 500 | 3 | Both genders | 12/00 | -9/91 | 33/91 | 11/18 | 1 | 6 |
| 70 | Almas *et al.* [84] | 2021 | Pakistan | Cohort | 699 | 2 | Both genders | 7/26 | -18/65 | 33/17 | 13/22 | 5 | 8 |
| 71 | Arslan *et al.* [85] | 2021 | Turkey | Cohort | 413 | 2 | Both genders | 9/30 | -10/62 | 29/22 | 10/16 | 5 | 7 |
| 72 | Banwait *et al.* [86] | 2021 | USA | Cohort | 2726 | 1 | Both genders | 9/53 | -41/64 | 60/70 | 26/11 | 3 | 9 |
| 73 | Beatty *et al.* [87] | 2021 | Ireland | Cohort | 575 | | Both genders | 17/70 | -5/80 | 41/20 | 11/99 | 2 | 7 |
| 74 | Dagher *et al.* [88] | 2021 | USA | Cohort | 310 | 1 | Both genders | 6/14 | -11/11 | 23/39 | 8/80 | 3 | 7 |
| 75 | Ersöz *et al.* [89] | 2021 | Turkey | Cross-sectional | 310 | 2 | Both genders | 15/87 | -1/38 | 33/12 | 8/80 | 5 | 7 |
| 76 | Zhan *et al.* [90] | 2021 | China | Cohort | 180 | | Both genders | 18/60 | 5/45 | 31/75 | 6/71 | 1 | 8 |
| 77 | Yoon *et al.* [91] | 2021 | USA | Cohort | 13 | 2 | Both genders | 9/00 | 5/47 | 12/53 | 1/80 | 3 | 6 |
| 78 | Yesilkaya *et al.* [92] | 2021 | Turkey | Cohort | 10 | 1 | Both genders | 14/50 | 11/40 | 17/60 | 1/58 | 5 | 6 |
| 79 | Yeates *et al.* [93] | 2021 | USA | Cross-sectional | 110,223 | | Both genders | 12/10 | -313/26 | 337/46 | 166/00 | 3 | 7 |
| 80 | Xiong *et al.* [94] | 2021 | China | Cohort | 75 | 2 | Both genders | 21/05 | 12/56 | 29/54 | 4/33 | 1 | 5 |
| 81 | Vranis *et al.* [95] | 2021 | USA | Cohort | 39 | 2 | Both genders | 20/90 | 14/78 | 27/02 | 3/12 | 3 | 7 |
| 82 | Villamañán *et al.* [96] | 2021 | Spain | Cross-sectional | 327 | 1 | Both genders | 13/20 | -4/52 | 30/92 | 9/04 | 2 | 7 |
| 83 | Varela Rodríguez *et al.* [97] | 2021 | Spain | Cohort | 188 | 1 | Both genders | 5/00 | -8/44 | 18/44 | 6/86 | 2 | 7 |
| 84 | Ferry *et al.* [98] | 2021 | Australia | Cohort | 223 | 3 | Both genders | 3/50 | -11/13 | 18/13 | 7/47 | 1 | 7 |
| 85 | Valverde-López *et al.* [99] | 2021 | Spain | Cohort | 178 | 1 | Both genders | 8/10 | -4/97 | 21/17 | 6/67 | 2 | 7 |
| 86 | Spoldi *et al.* [100] | 2021 | Italy | Cross-sectional | 63 | 1 | Both genders | 12/00 | 4/22 | 19/78 | 3/97 | 2 | 8 |
| 87 | Soares *et al.* [101] | 2021 | Brazil | Cross-sectional | 46 | 2 | Both genders | 22/70 | 16/05 | 29/35 | 3/39 | 4 | 7 |
| 88 | Sikkema *et al.* [102] | 2021 | Netherlands | Cohort | 382 | 1 | Both genders | 22/50 | 3/35 | 41/65 | 9/77 | 2 | 7 |
| 89 | Rubio-Gracia *et al.* [103] | 2021 | Spain | Cohort | 130 | 2 | Both genders | 8/00 | -3/17 | 19/17 | 5/70 | 2 | 6 |
| 90 | Di Fusco *et al.* [104] | 2021 | USA | Cohort | 173,942 | 1 | Both genders | 8/30 | -400/42 | 417/02 | 208/53 | 3 | 6 |
| 91 | Ronan *et al.* [105] | 2021 | Ireland | Case-control | 19 | | Both genders | 6/08 | 1/81 | 10/35 | 2/18 | 2 | 5 |
| 92 | Rojas-Marte *et al.* [106] | 2021 | USA | Cohort | 398 | 1 | Both genders | 19/10 | -0/45 | 38/65 | 9/97 | 3 | 6 |
| 93 | Ramos *et al.* [107] | 2021 | Spain | Cohort | 936 | 1 | Both genders | 17/30 | -12/68 | 47/28 | 15/30 | 2 | 7 |

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reported hospital LOS was 3.5 and 53.8, respectively. The overall pooled estimated hospital LoS of COVID-19 was 15.35, 95% CI:13.47-17.23; p<0.001, $I^2$ = 80.0). The highest pooled estimated Hospital LOS of COVID-19 among the different continents was estimated in South America at 20.85 (95%CI: 14.80-26.91; p<0.001, $I^2$ = 0.01), while in hospitalized patients in Africa was 8.56 (95% CI: 1.00-22.76).

In the comparison of different age groups, the highest pooled estimated LOS in COVID-19 was seen in the >60 years old 16.60 (95%CI: 12.94-20.25; p<0.001, $I^2$ = 82.6), and the lowest hospital LOS was seen in the <40 age groups 10.15 (95% CI: 4.90-15.39, p<0.001, $I^2$ = 22.1). then 200 cases) was higher than the studies with more than 200 understudies cases (16.28 *vs* 11.94 days) (Table2).

## Meta-regression

To identify the cause of different factors on heterogeneity among studies, the variables like sample size, the mean age of participants, study year, and the continent was assessed. The effect of the year of study (p=0.21), age of participants (p=0.13), and sample size (p=0.71), on heterogeneity among studies was not statistically significant; but the continent had a significant effect on heterogeneity among studies (p=0.001) (Table3).

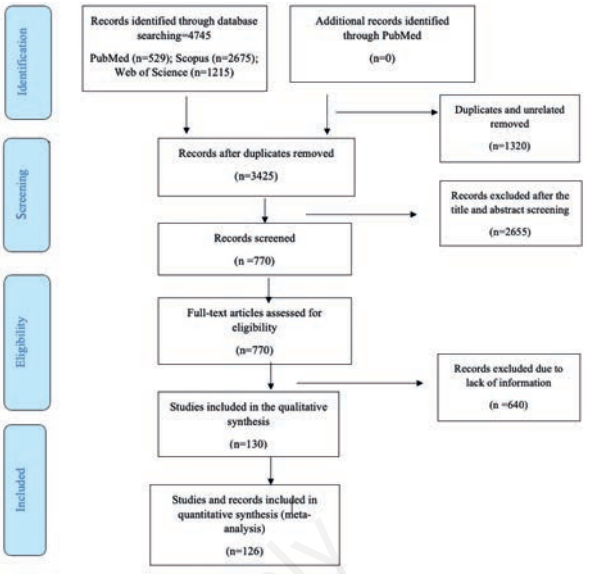


**Figure 1. PRISMA flow diagram for included studies in the current meta-analysis.**

**Table 1. Continued from previous page.**

| | First author | Year | Country | Study design | Sample size | Age group* | Sex | Mean hospital LoS | LCL | UCL | Se | Continent° | NOS score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 94 | Aghajani *et al.* [108] | 2021 | Iran | Cohort | 991 | 1 | Both genders | 6/00 | -24/85 | 36/85 | 15/74 | 5 | 6 |
| 95 | Groah *et al.* [109] | 2021 | USA | Cohort | 82 | 2 | Both genders | 16/40 | 7/53 | 25/27 | 4/53 | 3 | 7 |
| 96 | Oliveira *et al.* [110] | 2021 | USA | Cohort | 98 | 1 | Both genders | 8/30 | -1/40 | 18/00 | 4/95 | 3 | 7 |
| 97 | Martínez-Urbistondo *et al.* [111] | 2021 | Spain | Cohort | 165 | 1 | Both genders | 14/00 | 1/41 | 26/59 | 6/42 | 2 | 7 |
| 98 | Marmarchi *et al.* [112] | 2021 | USA | Cohort | 288 | 1 | Both genders | 18/00 | 1/37 | 34/63 | 8/49 | 3 | 7 |
| 99 | He *et al.* [113] | 2021 | China | Cross-sectional | 2702 | 2 | Both genders | 17/88 | -33/06 | 68/82 | 25/99 | 1 | 8 |
| 100 | Yousef *et al.* [114] | 2021 | India | Cohort | 57 | 1 | Both genders | 10/54 | 3/14 | 17/94 | 3/77 | 5 | 7 |
| 101 | Majeed *et al.* [115] | 2021 | Pakistan | Cohort | 75 | 2 | Both genders | 11/40 | 2/91 | 19/89 | 4/33 | 5 | 7 |
| 102 | Mader *et al.* [116] | 2021 | Germany | Cohort | 50 | 2 | Both genders | 17/22 | 10/29 | 24/15 | 3/54 | 2 | 8 |
| 103 | Ahlström *et al.* [117] | 2021 | Sweden | Cohort | 9905 | 1 | Both genders | 10/50 | -87/03 | 108/03 | 49/76 | 2 | 8 |
| 104 | Al Sulaiman *et al.* [16] | 2021 | Saudi Arabia | Cohort | 560 | 1 | Both genders | 10/00 | -13/19 | 33/19 | 11/83 | 5 | 7 |
| 105 | Alamdari *et al.* [118] | 2020 | Iran | Cohort | 83 | 1 | Both genders | 11/00 | 2/07 | 19/93 | 4/56 | 5 | 8 |
| 106 | Aldhaeefi *et al.* [119] | 2021 | USA | Cohort | 315 | 1 | Both genders | 12/00 | -5/39 | 29/39 | 8/87 | 3 | 6 |
| 107 | Andrade *et al.* [120] | 2021 | USA | Case control | 189 | 1 | Male | 7/00 | -6/47 | 20/47 | 6/87 | 3 | 7 |
| 108 | Bonnet *et al.* [121] | 2021 | France | Case-control | 138 | 2 | Both genders | 12/50 | 0/99 | 24/01 | 5/87 | 2 | 8 |
| 109 | Bozan *et al.* [122] | 2021 | Turkey | Cohort | 263 | 1 | Both genders | 12/60 | -3/29 | 28/49 | 8/11 | 5 | 7 |
| 110 | Breik *et al.* [123] | 2020 | USA | Cohort | 164 | 2 | Both genders | 12/00 | -0/55 | 24/55 | 6/40 | 3 | 7 |
| 111 | Cai *et al.* [124] | 2020 | China | Cohort | 149 | | Both genders | 16/18 | 4/22 | 28/14 | 6/10 | 1 | 7 |
| 112 | Creel-Bulo *et al.* [22] | 2020 | Georgia | Cohort | 115 | 1 | Both genders | 19/00 | 8/49 | 29/51 | 5/36 | 2 | 7 |
| 113 | Jaiswal *et al.* [125] | 2021 | United Arab Emirates | Cohort | 14 | 2 | Both genders | 35/64 | 31/97 | 39/31 | 1/87 | 5 | 7 |
| 114 | Zhang *et al.* [126] | 2021 | China | Cohort | 420 | 2 | Both genders | 17/80 | -2/28 | 37/88 | 10/25 | 1 | 6 |
| 115 | Charoenngam *et al.* [127] | 2021 | USA | Cohort | 1427 | 2 | Both genders | 8/10 | -28/92 | 45/12 | 18/89 | 3 | 8 |
| 116 | Xu *et al.* [128] | 2020 | New York | Cohort | 101 | 1 | Both genders | 13/00 | 3/15 | 22/85 | 5/02 | 3 | 7 |
| 117 | Sarpong *et al.* [129] | 2021 | USA | Cohort | 405 | 2 | Both genders | 8/90 | -10/82 | 28/62 | 10/06 | 3 | 7 |
| 118 | Özçelik Korkmaz *et al.* [130] | 2021 | Turkey | Cohort | 116 | 2 | Both genders | 14/36 | 0/01 | 28/00 | 5/39 | 5 | 9 |
| 119 | Hittesdorf *et al.* [131] | 2021 | USA | Cohort | 116 | 1 | Both genders | 53/80 | 43/25 | 64/35 | 5/39 | 3 | 7 |
| 120 | Diez-Quevedo *et al.* [132] | 2021 | Spain | Cohort | 2150 | 1 | Both genders | 14/00 | -31/44 | 59/44 | 23/18 | 2 | 9 |
| 121 | Forsblom *et al.* [133] | 2021 | Finland | Cohort | 585 | 2 | Both genders | 10/00 | -13/70 | 33/70 | 12/09 | 2 | 9 |

*Age group: 1 = <40, 2= 40-50, 3 = 50-60, 4 = >60; °Continent: 1 = East Asia, 2= Europe, 3 = North America, 4 = South America, 5 = West Asia, 6 = Africa.

### Publication bias

According to the results of Begg's and Egger's test, there was no evidence of publication bias (0.31, 0.51) about the understudied subject (Figure 2).

## Discussion

Understanding the influence of COVID-19 on hospital capacity requires precise estimation of total LoS, which may then be used to predict bed demand. Given the complexity and partiality of numerous data sources, as well as the quickly evolving nature of the COVID-19 pandemic, multiple analysis approaches on many datasets, such as meta-analysis studies, are most suited [134].

In this meta-analysis study, the mean hospital LoS among all records was 14.49, and the median of reported hospital LoS was 13. The study's principal findings include that the majority of research on hospital length of stay among COVID-19 patients were conducted in West Asia. The African area recorded the fewest studies. Our findings demonstrated a considerable effect of study heterogeneity. South America had the highest pooled hospital LoS of COVID-19, whereas hospitalized patients in Africa had the lowest one. This could be due to excellent hospital quality data in America and little or no hospitalization data in Africa. Furthermore, because COVID-19 death rates are higher in Africa, most hospitalized patients die earlier and have a shorter hospital stay. Those over the age of 60 had the highest pooled estimated hospital LoS of COVID-19. It should come as no surprise that elderly patients had a longer hospital stay. As a result, our study backs up prior findings in the literature [135,136]. This could also be attributed to their weakened immune systems and behavioral reactions to the measures implemented. Simultaneously, diabetes or other chronic illnesses in older individuals complicate infection management and lengthen hospital stay [137].

The first formal review on LoS for COVID-19 was conducted on 52 research, 46 of which were from China. The researches showed that the median hospital LoS in China was 14 days, compared to 5 days outside of China. Because only five research recorded LoS outside of China, this comparison is fairly ambigu-

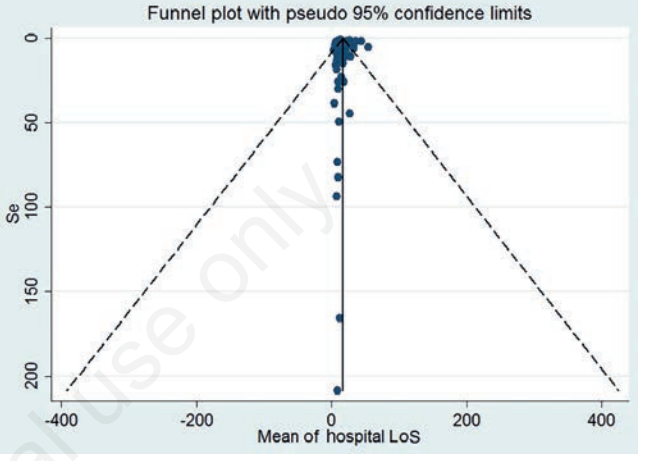


**Figure 2.** The funnel plot to assess the presence of publication bias.

**Table 2.** Pooled estimation of the hospital length of stay for coronavirus disease 2019 according to different variables

| Group | Number of records | Pooled estimation (%) | 95% CI | Q | $I^2$ (%) |
|---|---|---|---|---|---|
| Continent | | | | | |
| East Asia | 33 | 18.41 | 15.70-21.12 | p<0.001 | 71.4 |
| Europe | 24 | 15.31 | 9.03 – 21.59 | p<0.001 | 89.4 |
| North America | 27 | 15.78 | 11.45 – 20.11 | p<0.001 | 71.3 |
| South America | 3 | 20.85 | 14.80-26.91 | p<0.001 | 0.01 |
| West Asia | 34 | 11.93 | 8.26-15.60 | p<0.001 | 80.8 |
| Africa | 1 | 8.56 | 1.00-22.76 | - | - |
| Unknown | 4 | 13.67 | 5.96-21.38 | p<0.001 | 43.8 |
| Age group | | | | | |
| >60 | 50 | 16.60 | 12.94-20.25 | p<0.001 | 82.6 |
| 50-60 | 19 | 15.12 | 12.30-17.94 | p<0.001 | 27.9 |
| 40-50 | 46 | 14.67 | 11.15-18.18 | p<0.001 | 84.0 |
| <40 | 4 | 10.15 | 4.90-15.39 | p<0.001 | 22.1 |
| Unknown | 7 | 12.38 | 6.86-17.91 | p<0.001 | 28.7 |
| Sample size | | | | | |
| Less than 200 | 73 | 16.28 | 14.03-18.52 | p<0.001 | 88.0 |
| More than 200 | 53 | 11.94 | 9.01-14.88 | p<0.001 | 0.0 |
| Overall | 126 | 15.35 | 13.47-17.23 | p<0.001 | 80.0 |

**Table 3.** The meta-regression results to identify the cause of different factors on heterogeneity among studies.

| Variable | Coefficient | SE | p |
|---|---|---|---|
| Sample size | -0.02 | 0.007 | 0.71 |
| Study year | 2.16 | 1.74 | 0.21 |
| Age | -1.68 | 1.10 | 0.13 |
| Continent | -1.46 | 1.77 | 0.001 |

ous. Patients with COVID-19 appeared to be hospitalized for longer in China than elsewhere. This could be explained by changes in admission and discharge criteria among nations, as well as disparities in pandemic timing [138]. The majority of the surveys included in this evaluation focused on the small number of subjects hospitalized during the first month of the outbreak and did not take censoring into account [139]. Our research was more extensive, with publications from East Asia, Europe, North America, South America, and West Asia included. As a result, our estimate is more accurate because we included all publications from various countries in our research.

In Oksuz *et al*.'s cohort study in Turkey on 1,056 patients, 55% were men, and 45% were women. The mean age was 56.6 years. The mean length of stay was 9.1 days. The mean length of stay was 8.0 days for patients hospitalized inwards versus 14.8 days for patients hospitalized in the ICU. During the first months of the COVID-19 pandemic, physicians tended to hospitalize the patients for close monitoring regardless of severity. However, that practice changed over time, and later only patients with higher disease severity, lower oxygen saturation, comorbid conditions, and evidence of chest CT were hospitalized. Therefore, this change in treatment approach may have resulted in a lower number of inpatients in the months following the first peak and higher hospital costs among hospitalized patients [140]. In the study by Fadel *et al*., 495 patients were admitted for severe COVID-19 infection. The mean age was 67.3 years. Most patients (54.9%) were Caucasian, and 192 (38.3%) were African American. Mean ICU and hospital LoS values were 7.4 and 13.9 days, respectively [69].

Contrary to our study, one study in France has shown that fewer older patients were admitted to the ICU. They found that the length of stay in the hospital was highly variable, depending on age and wards (ICU or not). ICU stays were longer in the young patients compared to other pulmonary diseases requiring intensive care [139]. Probably the reason for the shorter hospital stay in old age is the higher mortality at these ages. In addition, their study had little censoring (5%).

Remdesivir is a 5-day treatment and can only be administered during an inpatient stay. Hospital stays that would otherwise be 5–8 days could be shortened with remdesivir therapy but by fewer than 4 days. Patients who would otherwise be discharged in fewer than 5 days could not experience any reduction in LoS and might have their hospital stay prolonged to complete their treatment course. A peak in discharge rates upon completion of therapy suggests that physicians delayed discharge to complete treatment [141]. In a case series, 174 confirmed COVID-19 adult patients hospitalized were included. The median age was 45.5 years, and 91 patients (52.3%) were male. The median duration of hospitalization was 4 days (0-28 days) [134]. The difference between the results of this study and other studies is because of the higher number of men in the study population. In Chiam *et al*.'s study, six hundred and eighty-seven patients with a mean age of 60.94 were included in the investigation. Analysis showed that patients' age, sex, ethnicity, number of Exhauster comorbidities, and number of weeks since the pandemic were significantly associated with LoS. The median LoS was 12.34 days and 5.72 days for ICU and non-ICU patients, respectively. This study, like ours, shows an association between older age with longer hospital LoS [142].

### Limitations

The current study has some limitations, including the continents' difference. Different factors, such as disease prognosis, comorbidities, resource availability, available beds, and so on, can complicate hospital LoS. However, we lack the necessary data in this review to adjust the influence of the aforementioned parameters. In addition, the hospital LoS was reported based on discharge status; those who died had a shorter hospital stay than those who were discharged alive. Furthermore, COVID-19 hospital stays are affected by county-specific factors such as admission criteria and the date of the pandemic. Patients with COVID-19 disease who have comorbidities like hypertension or diabetes are more prone to acquire a more severe course and progression of the disease.

Furthermore, elderly patients, particularly those 65 and older with comorbidities and infections, have a higher rate of admission to the critical care unit (ICU). The most common comorbidities among COVID-19 patients were hypertension, diabetes, and cardiopathy, and they were hospitalized for a longer period of time. Comorbidity is one of the key causes for the varying lengths of hospitalization in different studies, and the average length of hospital stay is reported to be longer depending on the number of patients studied.

Additionally, willingness to pay may influence hospital duration of stay in different countries or continents based on resource availability. Willingness to pay is associated with mortality/morbidity risk reductions by incorporating several highly relevant aspects during an epidemic, namely, healthcare capacity constraints, dynamic aspects of prevention (*i.e.*, interventions aimed at flattening the epidemic curve), and distributional issues due to high heterogeneity in the underlying risks. In countries with abundant resources, patients are more eager to pay for hospital treatments, therefore hospital equipment is sufficient to keep patients in the hospital until they are fully recovered, and hospital lengths of stay are indeed longer. While in low-resource countries, in an epidemic situation where the number of patients is increasing, hospitals may be forced to discharge patients earlier than usual due to a lack of equipment such as ventilators, intensive care equipment, and adequate hospital beds, and thus the average hospital length of stay may be reduced.

These are the most important factors influencing the hospital length of stay of COVID-19 patients in various nations, and they should be considered in the results and interpretations.

## Conclusions

The mean hospital LoS across all records was 14.49 days, with 13 days as the median recorded hospital LoS. In our analysis, the continent had a substantial effect on study heterogeneity. South America had the highest pooled hospital LoS of COVID-19, whereas hospitalized patients in Africa had the lowest one. It should be noted that hospital LoS of COVID-19 patients can be influenced by other factors such as disease prognosis, comorbidities, availability, and accessibility to health services, so this disparity between continents can be muddled by various factors such as major comorbidities, different treatment protocols, different care protocols, availability of resources, available beds, and so on.

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