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SYSTEMATIC REVIEW **Open Access**

Incidence of recovery rate and predictors among hospitalized COVID- 19 infected patients in Ethiopia; a systemic review and meta-analysis

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Abstract

Background Despite global efforts to mitigate COVID-19 infection through vaccination and therapeutic interventions, morbidity and mortality rates continued at variable rates. Although mortality risk and clinical features of COVID-19 are well-documented, recovery patterns and prognostic factors post-admission remain inconclusive, particularly in resource-limited settings like Ethiopia. This systematic review and meta-analysis (SRM) aimed to estimate the pooled incidence rate of recovery and predictors among hospitalized COVID-19 patients in Ethiopia.

Methods We searched (N = 1,191) articles using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline from PubMed/MEDLINE (N = 755), Scopus (N = 137), Web of Science (N = 84), Science Direct (N = 148), Cochran (N = 25), and Google Scholar searching (N = 42) from December 2019 to February 2024. The data were extracted using a Microsoft Excel spreadsheet and exported to Stata TM version 17.0 for further analysis. The Article quality was assessed using the Joanna Briggs Institute checklist. The pooled incidence rate of recovery was estimated using a weighted inverse variance random-effects meta-regression. Heterogeneity among studies was evaluated using the I^2 statistic. Subgroup analyses and sensitivity tests were also conducted to explore publication bias. This file is registered in international Prospero with ID (CRD42024518569).

Result Sixteen (N = 16) published studies with 7,676 hospitalized COVID-19 patients were included in the final report. The mean age of participants ranged from 29 (±17) to 57.5 (±3) years, with male patients constituting the largest proportion of participants, 4,491(58.5%). During recovery screening, 6,304(82.21%) cases were discharged as improved, 159 (2.1%) attriters, and 818 (10.6%) died during inpatient treatment. The pooled incidence of recovery, mortality, and attrition rates were found to be 82.32% (95% CI: 78.81–85.83; I^2 = 94.8%), 14.3% (I^2 = 98.45%), and 2.7% (I^2 = 81.34%), respectively. Incidence of recovery rate varied across regions and epidemic phases, with the highest rate observed in Addis Ababa (89.94%, I^2 = 78.33%) and the lowest reported in the Tigray region (59.7%, I^2 = 0.0%). Across epidemic phases, the recovery rate was 88.05% (I^2 = 29.56%) in Phase II, 84.09% (I^2 = 97.57%) in Phase I, and 78.92% (I^2 = 96.9%) in Phase III, respectively. Factors included being aged 15–30 years (pooled OR = 2.01), male sex (pooled OR = 1.46), no dyspnea (pooled OR = 2.4; I^2 = 79%), and no baseline comorbidities (pooled OR = 1.15; I^2 = 89.3%) were predictors for recovery.

Conclusion and recommendation In Ethiopia, more than eight out of ten hospitalized COVID-19 patients recovered after inpatient treatment. However, the incidence of recovery rates varied significantly across epidemic phases, study settings, and regions. Factors including younger age, male sex, no dyspnea (shortness of breathing),

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and no underlying comorbidity heightened recovery. It is highly recommended those inpatients cares should focus on high-risk groups (older adults) and implement standardized treatment protocols in each study setting. Regions with lower recovery rates need aid in logistical support and training for healthcare providers.

Keywords Admitted patients, COVID-19 infection, Ethiopia, SARS-CoV- 2 cases

Introduction

Coronavirus disease 2019 (COVID- 19) is an infectious disease caused by Severe Acute Respiratory Syndrome Corona-virus 2 (SARS-CoV- 2) and remains a global concern [1, 2]. The disease had different epidemic phases and variant forms of strain infection [3, 4] and presented with diverse and nonspecific clinical presentations, ranging from mild flu-like symptoms to a fatal Acute Respiratory Distress Syndrome (ARDS) of viral pneumonia [5, 6]. In global literature, it is described that coughing [1, 7] and dyspnea [7, 8] influenza-like symptoms of fever, and myalgia [6, 9, 10] were the most prominent. However, the elevation of hematological biomarkers including C-reactive protein (CRP) [11, 12], interleukin- 6 [8, 12], platelets, [13, 14], eosinophil [12, 13], hemoglobin [2, 7], and albumin level [2, 14, 15] were proxy indicators for sever infectivity [11]. During the inpatient treatment of COVID- 19 cases, three physiological changes were reported mainly respiratory failure (hypoxemia, ARDS), circulatory collapse (hypotension, shock, arrhythmias, organ failures) [1, 11, 16], and physical changes (inflammation) [11, 13].

The COVID- 19 pandemic significantly challenged healthcare systems, especially during the second and third waves (late 2020 to mid- 2023), which strained long and short-term strains on the primary healthcare system [5, 8] attributed to post-admission mortality rates of 8.1%–30% for ambulatory and 16%–78% for critical cases [1, 17, 18]. Despite global efforts to combat COVID- 19 through pharmacological and non-pharmacological interventions, both primary and secondary sequels have persisted [19]. According to Worldometer data as of April 13, 2024, there were 704,753,890 confirmed cases worldwide, resulting in 7,010,681 deaths, and 675,619,811 recoveries were reported [20, 21].

In Ethiopia, three COVID- 19 epidemic surges have occurred since the first case was reported in March 2020 [22]. By mid-April 13, 2024, out of 501,157 confirmed cases, 7,574 deaths, and 488,171 recovery cases were reported, which makes the national level recovery rate of 4,148 per 1 million people [20, 21]. Based on Current evidence indicates that prognosis depends on baseline patient characteristics including comorbidities, and laboratory findings [23]. A Systemic review and meta-analysis (SRM) finding highlighted [5, 24, 25] that admission times, age of the patient, viral load, and comorbidities were proxy indicators for prolonged durations of viral shading [23]. A multinational systematic review of 57 studies found that admission rates and recovery proportions varied significantly across different populations and age groups [7]. On the other hand findings from China demonstrated that an inverse relationship between hospital admission and patient age was observed, lowest admission rate (1%) were cases $\leq$20 years, and the highest 31.4%were aged $\geq$60 years [10, 26].

In Ethiopia, clinical features and mortality risks of COVID- 19 have been primarily quantified indifferent epidemic surges, with the pooled incidence of mortality rates of 14.44% in Phase I [17], and 9.13% in Phase II [27] with cases of fatality rate post admission 1–20% [28]. However, the recovery rate among admitted patients remains inconclusive and poorly characterized, with significant variation across treatment settings and study regions [20, 27]. These review metrics are critical for evaluating effectiveness and evaluating tailored healthcare interventions, addressing regional disparities, and guiding future public health planning using aggregated data. Therefore this SRM aimed to estimate the pooled incidence rate and identify predictors for recovery admitted COVID- 19 infected patients in Ethiopia.

Methods

Study setting and methods

This systematic review and meta-analysis (SRM) includes articles published exclusively in Ethiopia, the Federal Democratic Republic with a government structure comprising previously nine regional states [14]. The country spans a total area of 1,100,000 km2 and is organized into regions and zonal clusters, which are further also segmented into district levels. Ethiopia has approximately 112 million populations and stands as Africa's second-most populous country with 56,010,000 females& 56,069,000 males according to 2019 population projections [17, 27].

Protocol registration

To ensure methodological rigor, the study protocol was registered in PROSPERO (ID: CRD42024518569.

Data-searching-tools

The selected articles were reported following Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines as outlined in (S1 Checklist PRISMA 2020) [29].

Search strategy; an extensive article search was carried out from PubMed/MEDLINE (N= 755), Scopus (N= 137), Web of Science (N= 84), Science Direct (N= 148), Cochran (N= 25), and Google Scholar searching (N= 42). We included studies published from 2019 at the end of February 2024. For instance one of the PubMed database searches using Boolean operators included the following:"Recovery rate"OR"Survival Rate"OR"Viral Clearance"AND"Predictors"OR"Determinants"OR"Factors"AND"Hospitalized"OR"Inpatient treatment"AND"Ethiopia". This approach utilized free-text keywords as well as MeSH terms. The refined searching string incorporated both free-text and Mesh Terms as ("COVID- 19"[MeSH Terms] OR"COVID- 19"[Text Word]) AND ("Ethiopia"[MeSH Terms] OR"Ethiopia"[Text Word]) AND ("incidence density rate"[MeSH Terms] OR"incidence density rate"[Text Word] OR"predictors of recovery"[MeSH Terms] OR"predictors of recovery"[Text Word] OR"hospitalized"[MeSH Terms] OR"hospitalized"[Text Word]. An example of search engine approaches in PubMed is shown (((((((recovery from COVID- 19 [Text Word]) OR (cured rate from COVID- 19 disease [Text Word])) OR (SARS-CoV- 2 infected [MeSH Terms])) AND (rate [Text Word])) OR (incidence [Text Word])) OR (Recovery [Text Word])) OR (predictors [Text Word])) OR (patient with COVID- 19 [MeSH Terms])) AND (Ethiopia [MeSH Terms])) OR (Ethiopia [Text Word])".

Eligibility criteria; inclusion criteria

All cohort studies estimated recovery rate among COVID- 19 infected patients and started treatment in Ethiopia". We considered published studies with cohort designing without language and time restriction versions. The eligibility criteria for given articles are established on a logical grid structure that considers"Context, Condition, and Population (COCOPop)."which framework is narrated as (1) Condition: COVID- 19 infection; recovery from COVID-19, including articles reporting the rate and predictors of recovery among hospitalized COVID- 19 patients. (2) Context: Published articles should focus on individuals admitted to public health institutions with laboratory-confirmed COVID- 19 infection and received treatment in ICU.(3)Study Population: Admitted COVID- 19 patients undergoing inpatient treatment either public or private health institutions.

Exclusion criteria

Articles lacking abstracts, publication dates, journal/author names, inaccessible full text, and editorial comments were excluded.

Study population

This SRM examined admitted COVID- 19 patients undergoing inpatient treatment at public health institutions. The study followed a rigorous screening process for article inclusion, accepting publications in any language and restricting study designs to cohort studies, as these are best suited for calculating recovery rate incidence. Articles were excluded if they lacked abstracts, or publication dates, had inaccessible full texts, or were editorial comments.

Outcome ascertainment

This SRM had two main objectives, which included estimating the recovery rate after initiating inpatient treatment for admitted COVID- 19 patients. The recovery rate was calculated by extracting effect sizes from each study, organizing the data into an Excel spreadsheet, and then dividing by the total person-days of risk observation using the Pro-Command in STATA version 17. The second objective was identifying predictors for recovery after aggregating associated factors from each eligible study using weighted inverse random-effects meta-regression.

Operational words

COVID- 19 disease status [30]; the disease status of diagnosed COVID- 19 cases was classified based on the management and treatment guidelines of Ethiopia as follows:"*1.* Mild Disease: Patients with mild symptoms not needing hospitalization can be managed at home or in isolation facilities for specific supportive care and are not admitted to the ICU. *2.* Complicated COVID- 19 cases; Patients exhibit symptoms such as fever, malaise, cough, upper respiratory symptoms, and possibly lower respiratory symptoms with potential chest X-ray infiltrates while maintaining sufficient oxygenation on room air, making them eligible for inpatient treatment and supportive care. *3. Severe, and complicated cases*; Patients who have developed complications such as hypoxia ($SPO2 < 93\%$ on atmospheric air or $PaO2{:}FiO2 < 300$ mmHg), tachypnea in respiratory distress (RR > 30 breaths/minute), and $\geq 50\%$ involvement on chest imaging [31]. 4. Critical and end-stage COVID- 19 cases; Patients with severe respiratory distress including acute respiratory distress syndrome (ARDS), septic shock, and multiple organ failure and critically needed inpatient care at the intensive care unit (ICU). During inpatient treatment, they may need mechanical ventilation, exhibit tachypnea (respiratory rate > 30 breaths/minute), and may have ≥ 50% lung failure in chest imaging [1, 11, 26]. Recovery/viral shading/RNA-negative Conversion) rate: This denotes the resolution of symptoms and/or signs as determined by the respective clinician, irrespective of biochemical factors, especially when the Reverse Transcription Polymerase Chain Reaction (RT-PCR) re-test confirms viral genomic negativity [32, 33]. COVID- 19 Epidemic phases in Ethiopia [3, 30, 34]; Ethiopia experienced a notable surge in COVID- 19 cases, resulting in heightened testing, strain on healthcare facilities, and the implementation of restrictions. The COVID- 19 epidemic phases were classified into three stages until the end of February 2024. However, reporting and updating of daily pandemic data are continued.

1. *First Wave (Phase 1);* this outbreak lasted from December 2019 to December 2020.
2. *Phase 2:* This phase encompasses from the beginning of January 2021 to May 2022.
3. *Phase 3:* This phase extends from the end of May 2022 to February 2024.

Quality assessment and appraisal procedures

In this study, three authors (FKB, TKB, and TT) extracted articles and evaluated their quality based on study eligibility criteria. In cases of disagreement or uncertainty during data extraction and duplicate removal, the third author (GTB), facilitated and resolved the issues through discussions. The reviewers collectively assessed full-text articles, including titles, abstracts, and full content, using a Microsoft Excel spreadsheet for detailed extraction. Two independent reviewers used JBI checklists to assess each article's quality. The quality assessment process involved two authors FKB and TT for independently extracting and evaluating. This included verifying publication details and resolving discrepancies through discussion based on study titles and abstracts. Key information like principal investigators, publication years, study period, setting, population, and sample size was documented in an Excel sheet. Finally, all authors, including FKB, TKB, and TT assessed each article's bias using the JBI (Joanna Briggs Institute) using cohort design of Critical Appraisal Checklist for the quality of eligible articles.

Data extraction, analysis, and biases assessment

EndNote version 8.1 was utilized to export and compile all identified and potentially relevant citations of published articles. Duplications were eliminated during the screening and selection processes. Reviewers evaluated abstracts before advancing to full-text articles, which were assessed based on specific criteria for inclusion of a given article. Data were modified in a Microsoft Excel spreadsheet, and after cleaning and adjustments, STATA version 17 was utilized for further data analysis. Descriptive statistics and weighted inverse variance random-effects meta-regression were employed to estimate the pooled recovery rate post-admission in COVID- 19 infections. The presence of heterogeneity among studies was assessed using Cochran's Q test and quantified with I squared test (I^2) statistic. Potential sources of heterogeneity among studies were assessed using subgroup analyses.

Publication biases assessment

Publication bias was assessed both qualitatively through visual inspection of funnel plots test, and quantitative regression to detect the effect on pooled estimations [35, 36].

Result

Screening of included studies

A total of 1,191 studies were retrieved from PubMed/MEDLINE (*N* = 755), Scopus (*N* = 137), Web of Science (*N* = 84), Science-Direct (*N* = 148), Cochran (*N* = 25), and Google Scholar searching (*N* = 42). After careful screening of articles, 934 were excluded due to duplication. The remaining 257 studies were further assessed and 181 were removed by Titles (*N* = 152) and Abstract readings (*N* = 29). Moreover, 76 publications were screened for final eligibility. Of these 60 excluded due to, unclear data collection methods (*n* = 29), unmet outcomes of interest (*n* = 15), inaccessible full texts (*n* = 9), and (*n* = 6) removed due to qualitative reports. Finally, 16 studies [2, 18, 32, 33, 37–48] met the final inclusion criteria of met-analysis as described (Fig. 1).

Description of the included studies

This studies was conducted using eight Ethiopian regions studies reports; including Amhara (*N* = 3) [18, 40, 41], Addis Ababa (*N* = 3) [2, 37, 38], Oromia (*N* = 3) [32, 44, 45], central Ethiopia regions (*N* = 2) [39, 43], Benishangul Gumuz (*N* = 1) [42], Tigray (*N* = 1) [33], Sidam (*N* = 1) [46, 48] and South West (*N* = 1) [47] regions. Equal proportions of studies were conducted on Phase I [2, 32, 33, 37, 38, 44, 47], and Phase III [18, 39, 41, 42, 45] of epidemic surges.

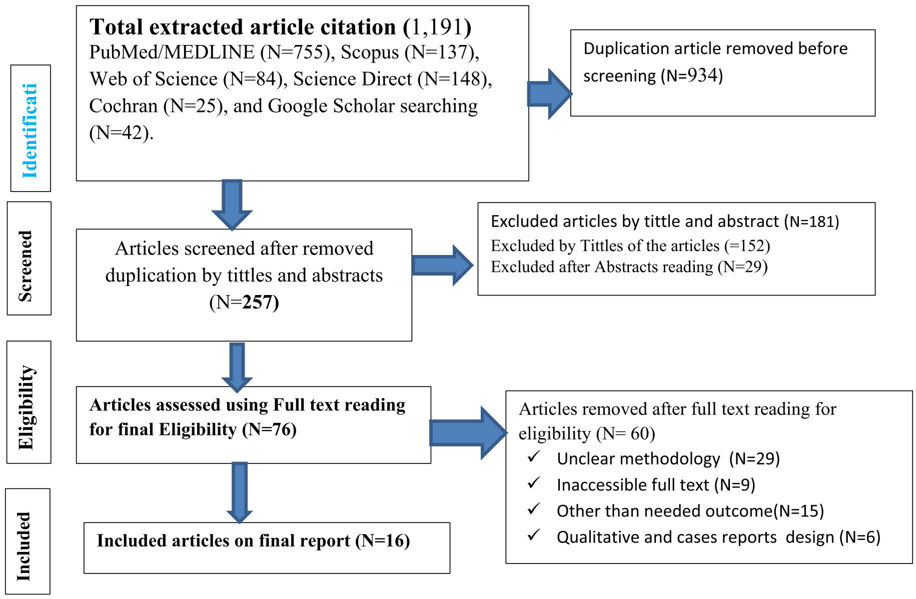

Fig. 1 Article selection of PRISMA flow diagnram for recovery from COVID- 19 infection in Ethiopia

However, the remaining four articles were conducted (*N*= 1) [38, 40, 43, 46, 48]conducted during Phase II of epidemic surges. Almost all studies employed a retrospective cohort [32, 33, 37, 39–48] except three of the studies used a prospective cohort [2, 18, 38]. Majorities of studies conducted at hospital set-ups [32, 37–39, 41, 45–48]; except six [2, 33, 40, 41, 43, 45] studies were in COVID- 19 diagnosing and treatment centers. This review included a sample size ranging from 139 cases in Tigray [33] to largest number of admitted patient 1,345 in Addis Ababa [2]. The largest and smallest mortality proportions of cases reported 80/202(36.6%) in Amhara [49] and 13/276(4.7%) in Oromia regions. Male patients constituted majority of admitted cases, accounting for 58.5%, (4491/7676) vs. 41.5%, (3185/7676) with female. The included studies had mean follow-up periods ranging from 5 (± 2.2) to 19 (± 9.5) days. A large proportion of recovered cases was reported 89.5% in Addis Ababa [2],& 77.24% small number of recoveries was reported in Benishangul [42] regions. Thirty-three percent of 2576(33.6%) of admitted patients had baseline comorbidities as described in (Table 1).

Pooled Incidence rate of recovery from COVID- 19 infection

This review comprised 16 individual studies with 7676 hospitalized COVID- 19 infected patients.

During recovery screening, 6,304(82.21%) cases discharged as improved, 159 (2.1%) attrite, and 818 (10.6%) died during inpatient treatment. The pooled incidence of recovery rate was found 82.32% (95% CI: 78.81–85.83; I^2= 94.8%), 14.3% (I^2= 98.45%), and 2.7% (I^2= 81.34%), as described in (Fig. 2).

Pooled mortality rate among studies reported

In the final review, 16 eligibel studies [18, 22, 32, 33, 38–44, 46–48, 50, 51] reported died cases during inpatient treatments. After we aggregated each effect size from each study, the pooled incidence of the mortality rate was estimated at 14.3%(95%CI;9.16 to 19.43%, I2 =98.45) as shown (Fig. 3).

Pooled attrition rate among studies reported

Out of the total, eight [22, 32, 40, 45, 46, 51] studies reported patient self-discharge during inpatient COVID-19 treatment. The random effect variance regression reported, that the pooled attrition rate was estimated at 2.7%(95%CI; 1.63 to 3.76, I2 =81.34%) as shown (Fig. 4).

Subgroup analysis among studies

During the final report, the highest heterogeneity among studies was observed (I^2= 94.5%). To assess the source of heterogeneity, subgroup analyses were conducted using epidemic phases, study region, and study setting. Accordingly, a recovery rate was higher for patients admitted at epidemic Phase II surges, which is 88.05%(95%; 74.93 to 93.25, I2 =29.56%) compared with rate reported during Phase I, 84.09%(95%CI: 74.93 to 93.25, I2 =97.57%) and phases III 78.92%(95%CI: 71.81 to 86.03, I2 =96.9%) as shown (Fig. 5). Likewise, the COVID- 19 recovery rate was higher for patients treated in hospital settings (87.15%; 95% CI: 77.1–90.99; I^2= 97.5%) compared with treated cases in COVID- 19 diagnosing and treatment centers (76.98%; 95% CI: 68.48–85.48; I^2= 98.5%) as shown (Fig. 6).

Table 1 Descriptive characteristics of included study in this systematics review and meta-analysis for treatment recovery of admitted COVID-19 patients

First Author name	Place	Study periods	Comorbidity Status	PublicationDD/ MM/YY	Phase of COVID-19	Study setting	Design	Male/ Female	Mean age (±) Y	Mean recovery time / days	Death	Cured	Self-discard/ T/out	Total	Quality
Saro Abdella et.al [1]	AA	18/03/2020 to 27/06/ 2020	Yes =41 No =265	30/12/ 2020	Phase 1	Hospital	Retro-spective	Male =208 Female=98	34	19(±9.5)	20	286	NR	306	3
Tadesse Tolossa et.al [2]	Oromia	29/03/2020 to 30/09/ 2020	Yes =21 No =206	10/06/2021	Phase 1	Hospital	Retro-spective	Male =155 Female=72	36.8	18(±8)	36	227	NR	263	3
Haftom Temesgen et.al [3]	Tigray	7 /5/2020 to 28/10/2020	Yes =40 No =99	11/08/2022	Phase 1	COVID-19 Rx centers	Retro-spective	Male =69 Female= 17	35(±33)	18(±16)	56	83	NR	139	3
Lire Lemma Tiror et.al 2022 [4]	SNNPR	30/5 2020 to 15/10/ 2021	Yes =143 No =608	11/ 8/2022	Phase 2	COVID-19 Rx centers	Retro-spective	Male =493 Female =258	30(±25)	10(±8.0)	94	751	NR	845	3
Anteneh Mengistet. al 2022 [5]	Amhara	13/03/2020 to 30 /02 2021	Yes =156 No =466	12/4/ 2022	Phase 2	COVID-19 Rx centers	Retro-spective	Male =348 Female=274	41(±23)	11(±5.01)	58	540	7	622	3
Serkalem Tsegay et.al [6]	Oromia	7/08/2020 to 7/02/2022	Yes =287 No =9	17 /11/ 2022	Phase 3	Hospital	Retro-spective	Male =191 Female =109	38.5(±16.)	11.1(±1.3)	13	276	7	300	3
Desiyalew-Habtamu et.al [7]	Amhara	1/11/2022to 15/11/2021	Yes =153 No =299	12/10/2023	Phase 3	Hospital	Retro-spective	Male =302 Female= 150	57.5(±3)	9(± 7.0)	37	397	18	452	3
Maru Zewdu et.al [8]	Benis-hangul	01/02 2021 to01/07/ 2021	Yes =116 No =218	05/11/2023	Phase 3	COVID-19 Rx centers	Retro-spective	Male=172 Female=162	45.2(± 12.2)	16(±5.5)	76	258	NR	334	2
Saro Abdella et.al [9]	AA	18/03/2020 to20/09/ 2020	Yes =36 No =88	06/08/2021	Phase 1	Hospital	Prospec-tive	Male= 94 Female= 30	42(±17)	16(±13)	NR	105	NR	124	2
Gemechu Churiso et.al [10]	SNNR	01/09/ 2020 to01/07/ 2021	Yes =176 No =44	04/03/ 2022	Phase 3	Hospital	Retro-spective	Male= 123 Female= 97	47(±NR)	5(±2.3)	49	171	NR	220	3
Tigist W. Leulseged [11]	AA	01/6/2020to 01/9/2020	Yes =454 No =891	09/10/2021	Phase 1	COVID-19 Rx centers	Prospec-tive	Male= 557 Female=778	41(± 18.2)	14(±?)	71	1202	72	1345	3
Getaneh Atikilt et.al [12]	Amhara	30/12/2020 to01/ 04/2021	Yes=70 No=132	23/05/2022	Phase 3	COVID-19 Rx centers	Prospec-tive	Male= 163 Female=39	41.2 (± 19)	5(±2.2)	80	115	5	202	2
Abdene Weya Kaso et.al [13]	Oromia	1/6/2020, to 10/30/ 2021	Yes =245 No=177	13/12/2021	Phase 1	Hospital	Retro-spective	Male =244 Female =178	43 (± 19)	13(±8)	42	354	12	422	3

Table 1 (continued)

First Author name	Place	Study periods	Comorbidity Status	PublicationDD/MM/YY	Phase of COVID-19	Study setting	Design	Male/Female	Mean age (±) Y	Mean recovery time / days	Death	Cured	Self-discard/T/out	Total	Quality
Samrawit Fantaw et.al [14]	Sidama	01/5/2020, to 30/5/ 2022.	Yes = 204 No=500	29/ 10/2023	Phases 3	COVID-19 Rx centers	Retro-spective	Male =712 Female= 326	43.1 ±20.3)	14(±8)	181	715	29	1038	3
Ali B. Anteneh Et.al [15]	Sidama	24/9/2020, to 26/11/ 2021	Yes =395 No=409	07/01/2025	Phases 3	Hospita	Retro-spective	Male =515 Female=289	NR	12(±.3)	NR	595	NR	804	2
Angesom weldu et.al [16]	South west region	2/11/ 2020	Yes =39 No=221	03/6/2023	Phases 1	Hospital	Retro-spective	Male =145 Female=115	29 (±17)	10(±8-10)	5	229	9	260	3

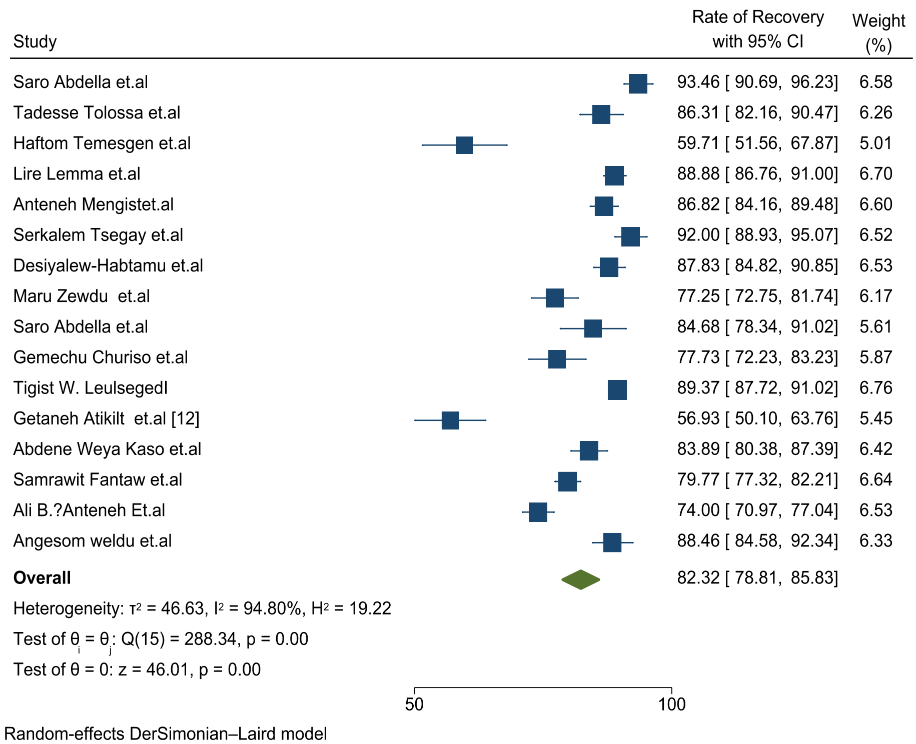

Fig. 2 Forest plot of polled recovery rate of admitted patient with COVID- 19 infection in Ethiopia

In addition, studies conducted in prospective cohorts reported lower COVID- 19 patient recovery rates compared to retrospective cohorts as described in 87.5% (95% CI: 76.03 to 99.14, I^2= 96.23%) VS. 91.7% (95% CI: 88.51 to 94.96, I^2= 93.1%) as described in (Fig. 7).

The regional disparities for treatment recovery rate were evident, with Addis Ababa had the highest reports (89.94%; 95% CI: 86.13–93.75; I^2= 78.33%), followed by South West Ethiopia Region (88.8%; 95% CI: 84.52–92.4; I^2= 0.00%), Oromia Region (87.48%; 95% CI: 82.36–90.36; I^2= 83.9%), and Central Ethiopia Region (83.6%; 95% CI: 72.5–94.6; I^2= 92.5%). However, lower recovery rates were described in Amhara (77.46%; 95% CI: 65.3–90.3; I^2= 88.12%), Benishangul Gumuz (77.23%; 95% CI: 72.51–81.71; I^2= 0.0%), and Sidama (76.96%; 95% CI: 71.33–82.6; I^2= 88.12%) regions, while Tigray region recorded the lowest recovery rate (59.7%; 95% CI: 51.5–67.5; I^2= 0.0%) compared with Addis Ababa (Fig. 8).

Publication Bias'

The funnel plot analysis indicated asymmetry funnel plot was observed in (Fig. 9). However, further regression using Egger's test (P= 0.199) and Begg's test (P= 0.241) indicated no significant evidence of publication bias and evidenced with rated as'high'inGRADE assessment.

A leave-one-out sensitivity analysis

The final results of a leave-one-out sensitivity analysis indicated no individual study significantly affected the overall pooled estimate, which confirmed the robustness of final reports and no evidence of influential outliers of studies for pooled estimation as described in (Fig. 10).

Predictors for recovery post admission in COVID- 19 infection

This systematic review analyzed adjusted odds ratios from primary studies to identify predictors of recovery from COVID- 19 hospitalization, focusing on socio-demographic, clinical, and immunological factors. However, age, gender, and absence of comorbidity during admission increased the recovery rate. Accordingly, male patients had twice increased the likelihood of recovery rate compared with female patients (pooled Odds Ratio =1.46, 95% CI: 1.14–1.88; I^2= 47.2%). Likewise, patients aged 15–30 years (pooled OR =2.01, 95% CI: 1.41–2.86; I^2= 33.3%), and no comorbidity other than COVID- 19 infection (Pooled OR =1.15 (95%CI: 1.12 to 1.79, I2 =89.3%) and absence of dyspnea at admission) (Pooled OR =2.4; (95%CI: 1.68–17.4, I2 =79%) were predictors for recovery compared with counter groups as presented (Table 2). Table 2; Pooled

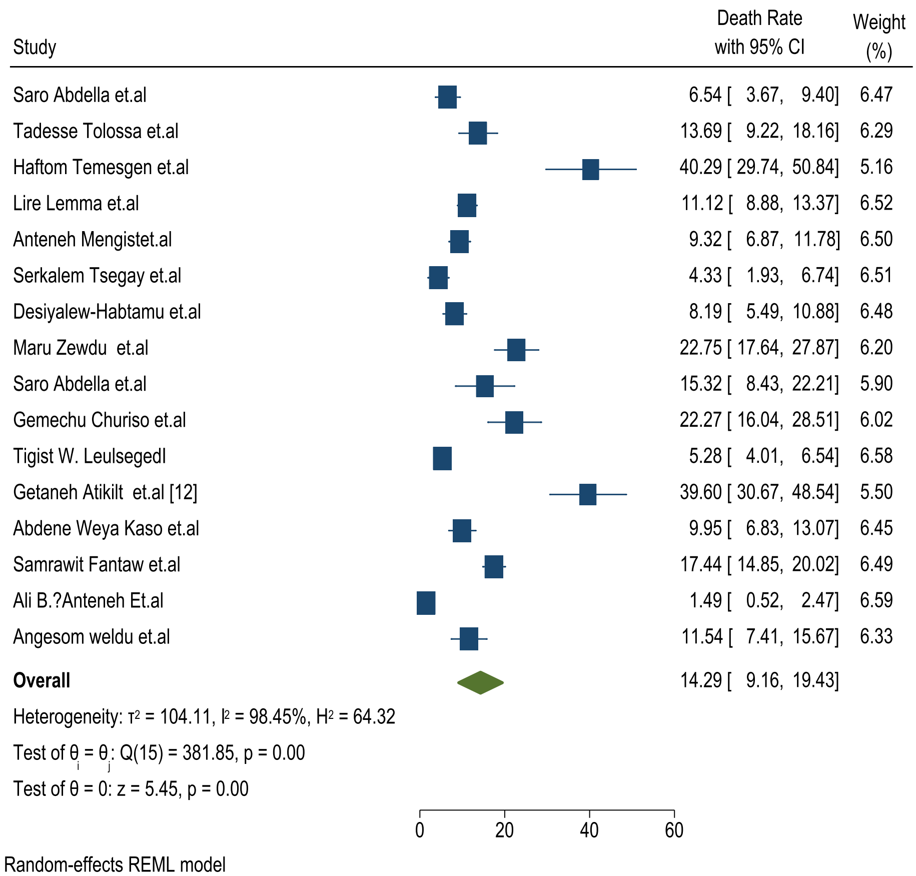

Fig. 3 Forest plot of polled mortality rate among admitted COVID- 19 patients in Ethiopia

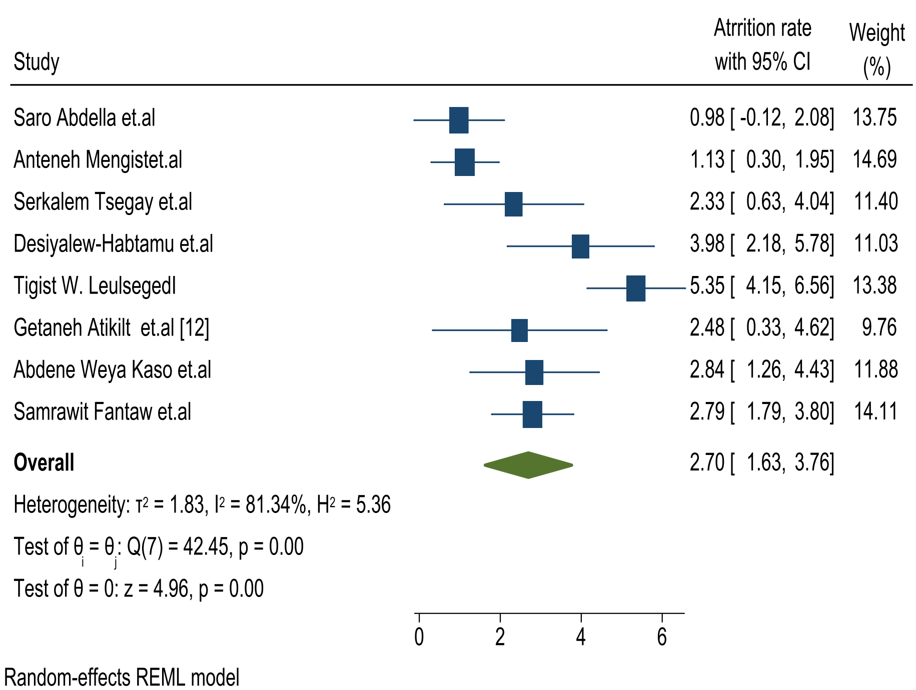

Fig. 4 Forest plot of polled attrition rate among studies reported self-discharge from treatment setting

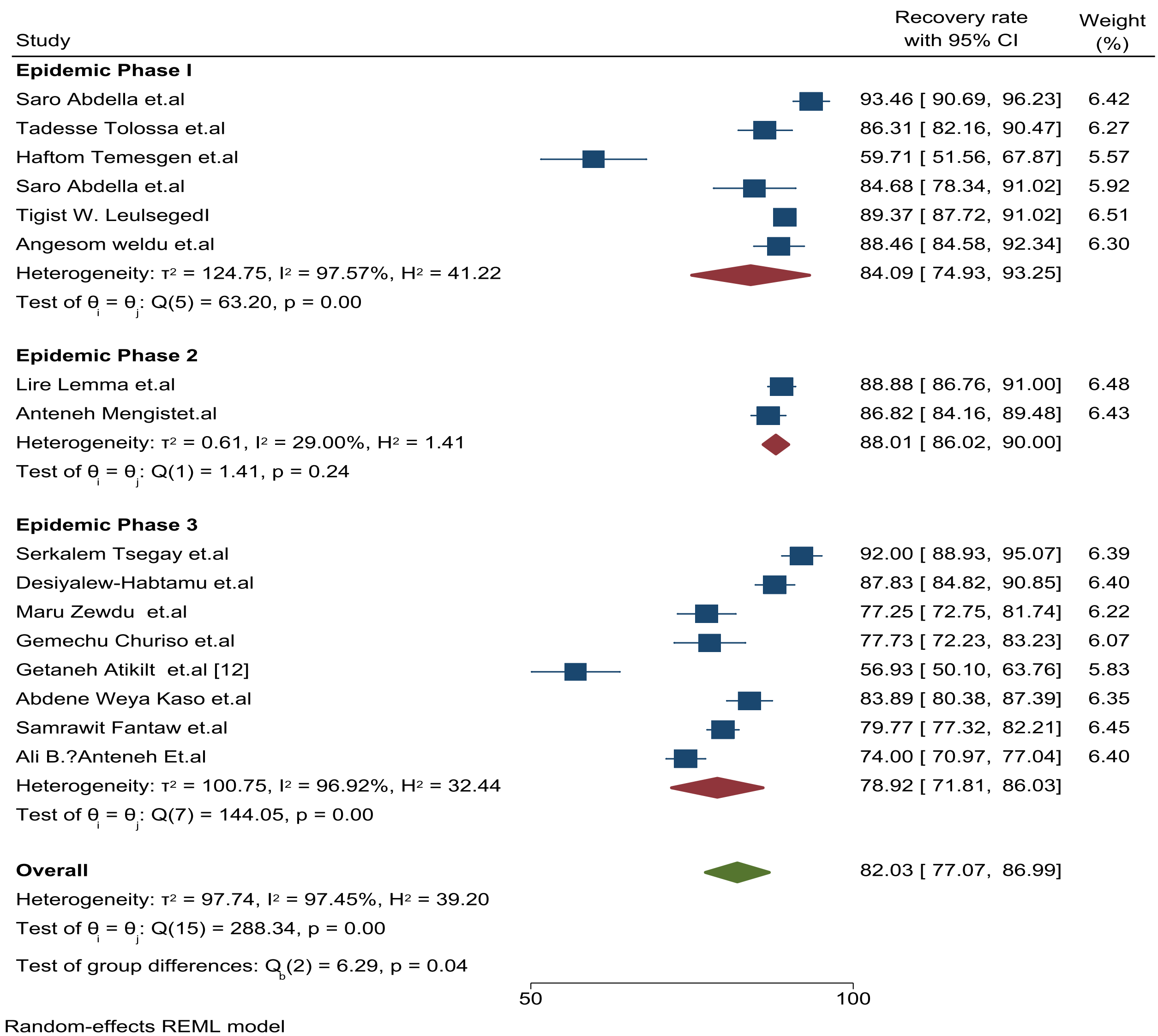

Fig. 5 Subgroup analysis by COVID- 19 epidemic phases and treatment recovery of patient

estimates of predictors for treatment recovery of admitted COVID- 19 patient in Ethiopia.

Discussion

In the final review of 16 studies, 7,676 confirmed COVID- 19 patients were screened for recovery from eight Ethiopian regions. Of the total, 6,304(82.1%) cases quit as recovered, 159 (2.07%) self-discharged from the center and 818 (10.6%) died. This made the pooled incidence rate of recovery post-admission with COVID- 19 infection 82.32% (95% CI: 78.81, 85.83; $I^2 =$ 94.81%). This report is higher than the previous population level aggregated finding of 76.6% in Ethiopia [14], 81.7% in Spain [52], and 52.4% in six Sub-Saharan African Countries [53]. The differences in the findings may be due to the variations in the study population, study period, and disparities in socioeconomic among included participants. However, the final report is lower than 94.6% of population-level recovery descriptions in China [54]. The disparity likely results from differences in healthcare infrastructure between China and Ethiopia during the COVID- 19 surge. Ethiopia's response to epidemics includes approximately 35 treatment centers, compared to China's 1,500 +. Ethiopia has about 1 doctor per 10,000 people, while China has 3 per 1,000. Additionally, Ethiopia has 0.3 ICU beds per 100,000 people, compared to over 3 in China. This disparity is reflected

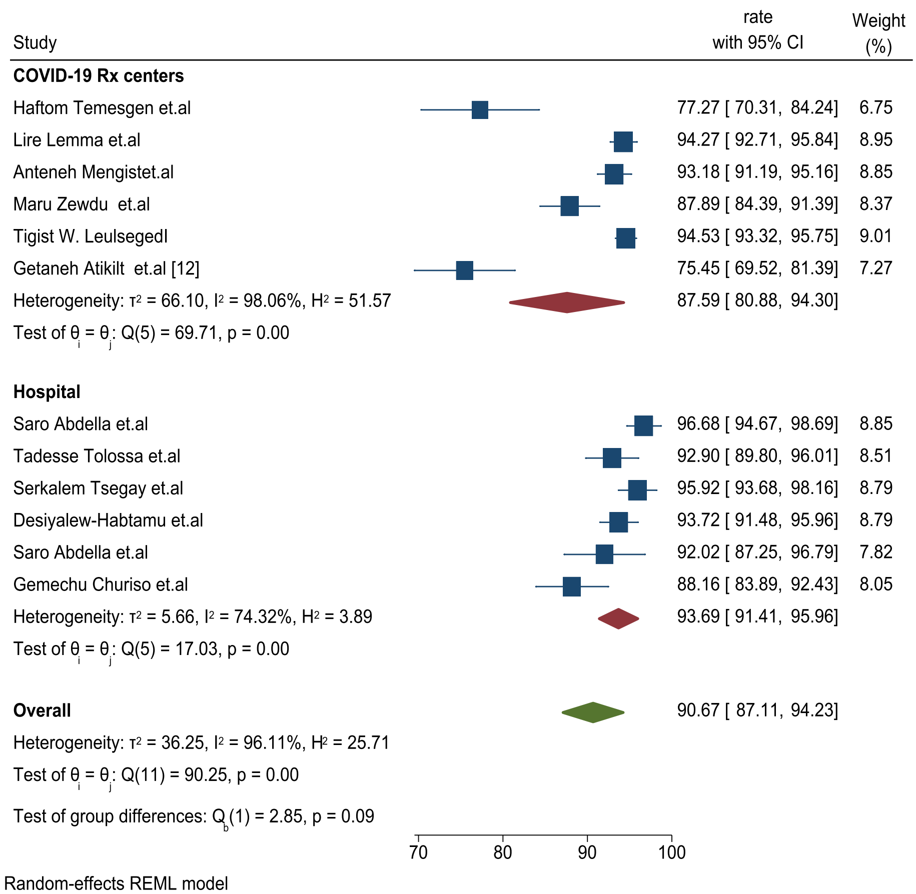

Fig. 6 Subgroup analysis by Study-Setting and treatment recovery of COVDI- 19 infected patient

in inpatient death rates: 1.7% in Ethiopia versus 0.4% in China [14, 55].

In this review, significant regional variation in recovery rates was observed. Addis Ababa reported the highest recovery rate (89.94%), followed by South West (88.8%), Oromia (87.48%; Central Ethiopia (83.6%), Amhara (77.46%), Benishangul Gumuz (77.23%;), and Sidama (76.96%) regions. In contrast, Tigray Region recorded the lowest recovery rate (59.7%) compared with Addis Ababa. This might be related to issues of escalated conflicts in Ethiopia, particularly in the Tigray War (2020–2022) with the central government, severely undermining regional healthcare capacity during epidemics. This is expressed in the majority of health facilities that had 30% damaged physical structures in main conflict sites (Tigray, Amhara, and Afara). Additionally, the exodus of trained medical personnel and health care providers during war correlated with a lower incidence of recovery, as evidenced by WHO surveillance data [56, 57].

In the current review, predictors of recovery were identified, accordingly being male cases increased the likelihood of early recovery compared with females. This finding is consistent with study results reported in Addis Ababa [49, 58] and Iran [59]. This may be related to the effects of sex-related hormonal influence for females on delayed COVID- 19 symptom resolution. A study finding from 73 countries from 2020 to 2021 for effects of sex different risk of cases fatality rate indicated, that female immune response was inflicted by steroid hormones (e.g., steroid/sex hormones) for admitted patients and delayed viral genomic negative conversion time. Which directly increased inpatient deaths compared with male patients [60]. In contrast to this, in our recovery screening reported, admission rates were increased for male patients and accounted for the largest proportions compared with counter-female admitted patients (Male 58.5%, N= 4,491) Vs. (females (41.5%, N= 3,185).

Consistent with previous studies finding [61, 62] an inverse association between increased patient ages and viral clearance rate, our study reported, being patients aged 15–30 years twice increased the likelihood of recovery post admissions compared with older age(≥ 60 years). This might be related to low physiological corpulence for age-related lung function, and caused severe hypoxia

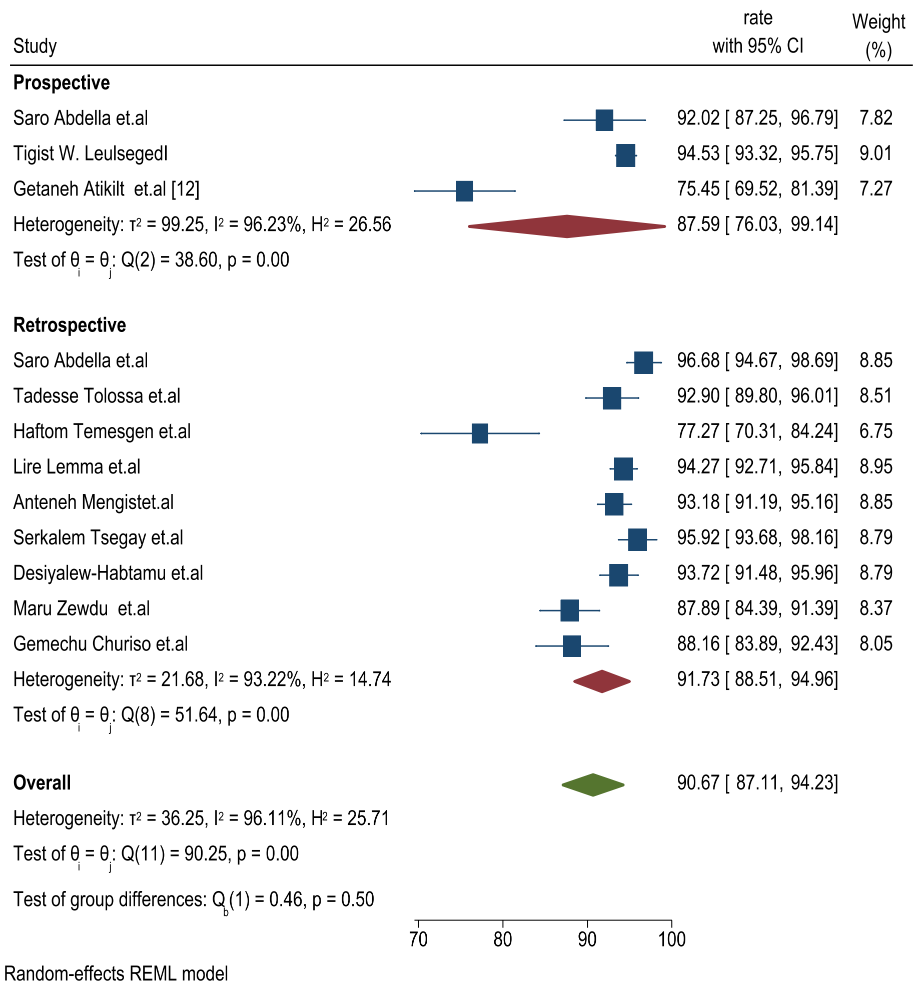

Fig. 7 Subgroup analysis by Study Design and treatment recovery of COVDI- 19 infected patients

(SpO_2 < 90%) in older cases compared with young cases. This is supported by findings in Ethiopia that hospitalized patients had a higher death risk at age > 60 (22.4%) compared to those < 40 years (3.1%) [63].

The current review reported, that the absence of baseline comorbidities, other than SARS-CoV- 2 infection, increased twice the likelihood of recovery rate. This is consistent with systematic review findings in Greece [64], Portugal [23], and Kurdistan [65]. The presence of comorbidity with COVID- 19 infection declined innate immunity, particularly white blood cell counts, which engulfed foreign antigens including the virus. Thought thus, the risk of prolonging viral clearance rate decreased when declining the number of white blood cells and prolonged recovery time. On the other hand, the study finding in Australia, [66], Gambia [19], patients with chronic comorbidity had varied mortality risk [66] including obstructive pulmonary disease (AOR = 4.9), and severe obesity (AOR = 3.2) had prominent mortality risk [66].

Consistent with previous studies reported in Greece [64], and the USA [67]; in this review, the absence of dyspnea at admission was twofold increased the likelihood of recovery. This may result from reduced tidal volume and impaired oxygen exchange in the lung; particular surfactant dysfunction related to SARS-CoV- 2 infection creates an edematous alveolar environment. This indirectly reduces blood oxygenation and causes the incidence of acute respiratory distress (ARDS). Findings from Germany [68] and Italy [69] supported that ARDS reduces blood oxygenation by 20–30% and impacts on RNA negativity conversion rate [66].

Strengths and limitations of the studies

This SRM reported several strengths including more than three reviewers and the use of multiple databases used for searching. The absence of comprehensive demographic data and clinical variables is not mainly elaborated which can significantly influence the generalizability of the

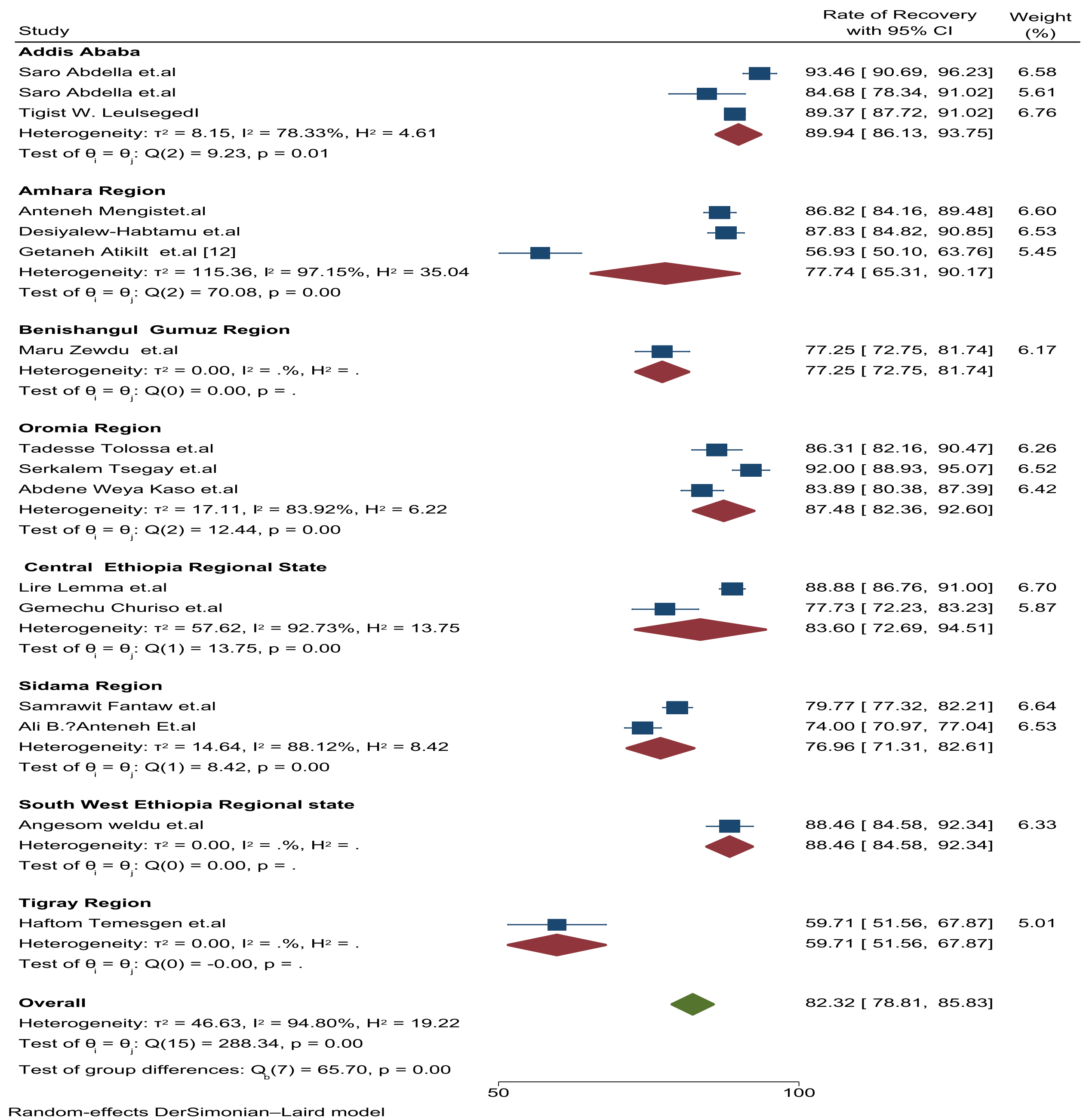

Fig. 8 Subgroup analysis by study regions and treatment recovery of COVDI- 19 infected patients

overall results. An important limitation is nine articles in full text is/are in-accessible for eligibility selection and all studies depend on cohort design, which also affected the overall estimation of the final report.

Conclusion and recommendation

In Ethiopia, eight out of ten hospitalized COVID- 19 patients recovered after inpatient treatment. However, the incidence of recovery rates varied significantly across epidemic phases, study settings, and regions. Factors including younger age, male sex, no dyspnea (shortness of breathing), and no underlying comorbidity heightened recovery. It is highly recommended that inpatient care should focus on high-risk groups (older adults,) and implementing standardized treatment protocols in each study setting. Regions with lower recovery rates need aid in logistical support and training for healthcare providers.

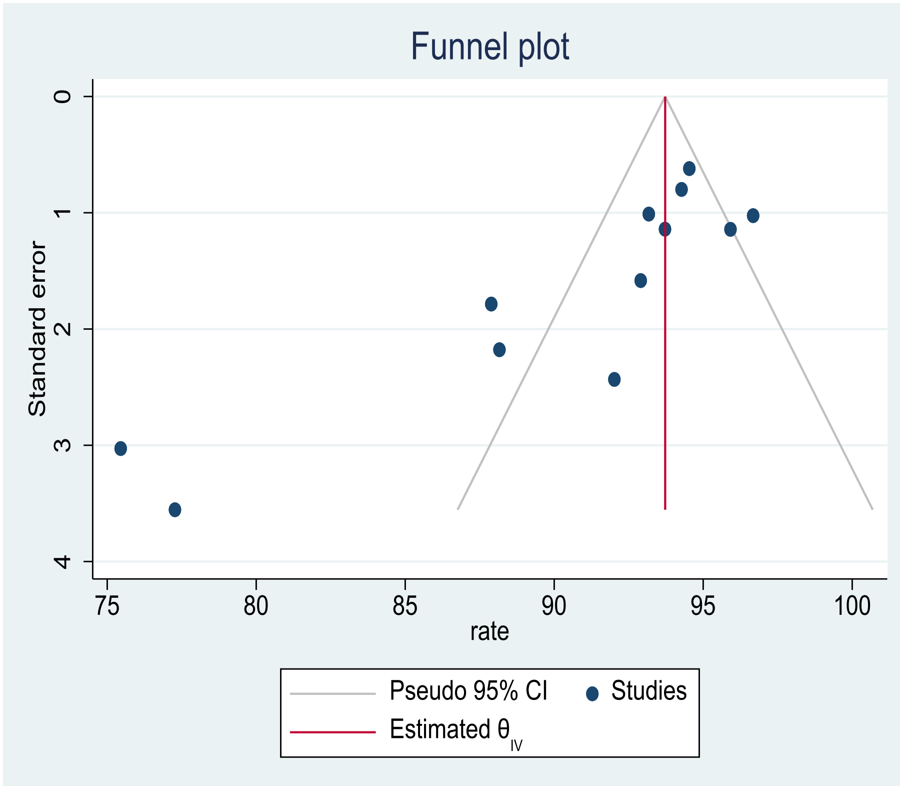

Fig. 9 Funnels plot for publication biases assessment for treatment recovery from COVID- 19 patients

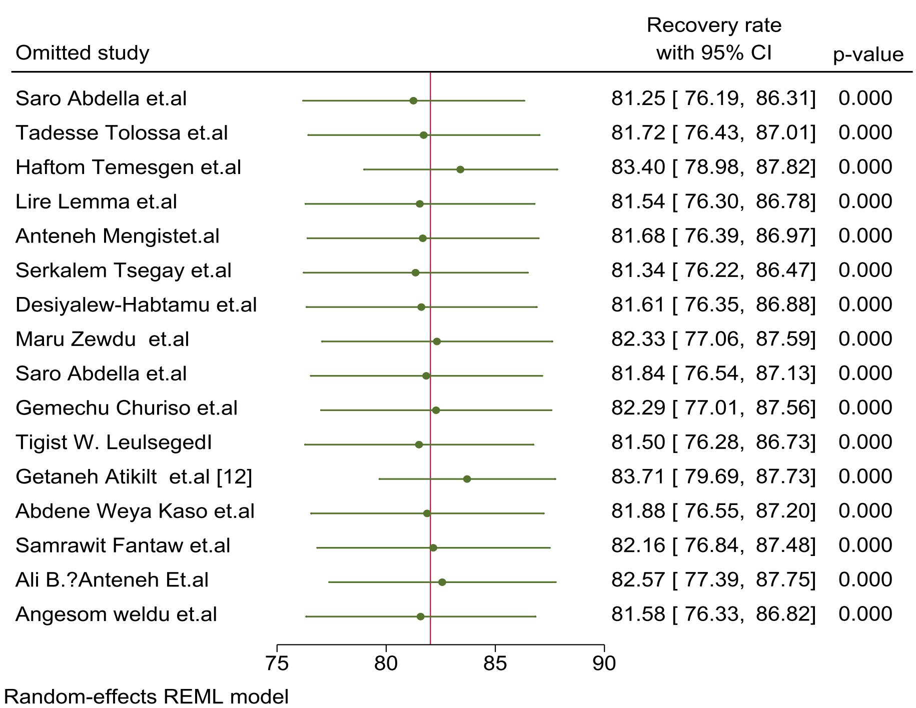

Fig. 10 A leaves one out sensitivity analysis for detection of outliers’

Table 2 Pooled estimates of predictors for treatment recovery of admitted COVID- 19 patient in Ethiopia

Associated factors	Risk groups	Pooled effect size & 95%CI	I2	Pooled studies
Gender status at admission	Being Male	1.46 (1.14–– 1.88)	47.2%	[17, 28] *
	Being Female	Reference		
Being age on admission	Between 15–30	2.01(1.41–2.86)	33.3&	[18, 25] *
	Greater than (≥ 30) Years	Reference		
Comorbidity status	No comorbidity	1.25(1.31–2.89)	89.3%	[20, 23]
	At least one commodity	Reference		
Shortness of breath	No, SOB at admission	2.4(1.68–– 17.4)	0.79%	[21, 23, 26]
	Yes, SOB at admission	Reference		
Body temperature (≥ 37.5 C)	Yes ≥ 37.5 C	1.2(0.92–– 1.89)	47.8%	[18, 21, 22] *
	No < 37.5 C	Reference		

Implications for actions; the study highlights regional variations in COVID- 19 recovery rates across each treatment center. Which called emphasizing critical care and prioritizing tailored treatment for critical cases during admission. Stakeholders, including the government and healthcare workers, are urged to focus on allocating resources for timely care and monitoring recovery trends within each admission ward daily. It is crucial to consider patients'ages, and genders, as predictors for recovery in intensive care, necessitating the development of tailored treatment strategies and resource allocation for critically ill patients.

Abbreviations

AHR	Adjusted hazard ratio
SRM	Systemic review and meta-analysis
RT-PCR	Reverse Transcription Polymerase Chain Reaction
COVID- 19	Short for Coronavirus Disease 2019, is an infectious disease caused by the novel coronavirus SARS-CoV-2
SARS-CoV- 2	(Severe Acute Respiratory Syndrome Coronavirus 2) is the specific coronavirus strain responsible for causing COVID-19

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-22841-x.

Supplementary Material 1. S1 Checklist: PRISMA 2020(DOCX).

Supplementary Material 2. S2 Data: Full Excel data set (DOCX) for final SRM.

Supplementary Material 3. S3 files; Eger's and Beg regression tests.

Supplementary Material 4.

Supplementary Material 5.

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Authors' contributions

"FKB =conceptualized, designed, and wrote the original draft of the manuscript, as well as participated in writing, editing, and investigation. TT =contributed to writing, article searching editing, and full manuscript. TKB =had a formal analysis and methodology. GTB =assisted with data curation and software-related tasks. All authors reviewed and approved the final version of the manuscript, contributed to the article, approved the submitted version, and reviewed the manuscript".

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Data availability

All data generated for this study are submitted with the manuscript and for further information, please contact the corresponding author for non-commercial research purposes

Declarations

Consent for publication

There is no consent for the publication of this study.

Competing interests

The authors declare no competing interests.

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References

1. Gize A, Kassa M, Ali S, Tadesse Y, Fantahun B, Habtu Y, Yesuf A. Epidemiological, clinical and laboratory profile of patients presenting with severe acute respiratory syndrome (SARS-CoV-2) in Ethiopia. PLoS ONE. 2023;18(12): e0295177.
2. Leulseged TW, Hassen IS, Maru EH, Zewsde WC, Chamiso NW, Bayisa AB, Abebe DS, Ayele BT, Yegle KT, Edo MG, Gurara EK, Damete DD, Tolera YA. Characteristics and outcome profile of hospitalized African patients with COVID-19: The Ethiopian context. PLoS ONE. 2021;16(11): e0259454.
3. Attinsounon Cossi Angelo1, 3,4*, Yamongbè Clodel1,2,3, Codjo Léopold2,3,4, Adé Serge2,3,4, Mama Cissé Ibrahim2,4,5, Attinon Julien4,5, Klikpezo Roger2,4,5 and Savi de Tovè Kofi-Mensa2, Epidemiological, clinical, therapeutic features and predictors of death among COVID-19 patients hospitalized in Parakou: a cross-sectional study in Northern

Benin, BMC Infectious Diseases 23:484 https://doi.org/10.1186/s12879-023-08445-z (2023).

4. Peng M, Hu M, Peng X, Gong Y, Qian K, Li J, Zhao J, Li X, Huang J, Zhang M, Chai L, Chen L, Zhang D, Peng L. What contributes to the re-positive nucleic acid test results for the omicron variant of SARS-CoV-2 in the shelter cabin hospital in Shanghai, China? Heliyon. 2023;9(5): e15679.
5. Fernández-de-Las-Peñas C, Palacios-Ceña D, Gómez-Mayordomo V, Florencio LL, Cuadrado ML, Plaza-Manzano G, Navarro-Santana M. Prevalence of post-COVID-19 symptoms in hospitalized and non-hospitalized COVID-19 survivors: A systematic review and meta-analysis. Eur J Intern Med. 2021;92(2021):55–70.
6. Angelo AC, Clodel C, Léopold A, Serge MC, Ibrahim A, Julien K, de Roger S. Epidemiological, clinical, therapeutic features and predictors of death among COVID-19 patients hospitalized in Parakou: a cross-sectional study in Northern Benin. BMC Infect Dis. 2023;23(1):484.
7. Groff D, Sun A, Ssentongo AE, Ba DM, Parsons N, Poudel GR, Lekoubou A, Oh JS, Ericson JE, Ssentongo P, Chinchilli VM. Short-term and Long-term Rates of Postacute Sequelae of SARS-CoV-2 Infection: A Systematic Review. JAMA Netw Open. 2021;4(10): e2128568.
8. Gudina EK, Ali S, Girma E, Gize A, Tegene B, Hundie GB, Sime WT, Ambachew R, Gebreyohanns A, Bekele M, Bakuli A, Elsbernd K, Merkt S, Contento L, Hoelscher M, Hasenauer J, Wieser A, Kroidl A. Seroepidemiology and model-based prediction of SARS-CoV-2 in Ethiopia: longitudinal cohort study among front-line hospital workers and communities. Lancet Glob Health. 2021;9(11):e1517–27.
9. C R V, Sharma R, Jayashree M, Nallasamy K, Bansal A, Angurana SK, L Mathew J, Sankhyan N, Dutta S, Verma S, Kumar R, Devnanai M, Vaidya PC, Samujh R, Singh MP, Goyal K, Lakshmi PVM, Saxena AK. Saxena, Epidemiology, Clinical Profile, Intensive Care Needs and Outcome in Children with SARS-CoV-2 Infection Admitted to a Tertiary Hospital During the First and Second Waves of the COVID-19 Pandemic in India. Indian J Pediatr. 2023;90(2):131–8.
10. Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, Qiu Y, Wang J, Liu Y, Wei Y, Xia J, Yu T, Zhang X, Zhang L. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet (London, England). 2020;395(10223):507–13.
11. Garcia-Carretero R, Vazquez-Gomez O, Gil-Prieto R, Gil-de-Miguel A. Hospitalization burden and epidemiology of the COVID-19 pandemic in Spain (2020–2021). BMC Infect Dis. 2023;23(1):476.
12. Latifi-Pupovci H, Namani S, Ahmetaj-Shala B, Pajaziti A, Bunjaku G, Ajazaj Berisha L, Gegaj V, Kotori A. Biomarkers of Inflammation among Patients with COVID-19: A Single-Centre Prospective Study from Prishtina, Kosovo. Can J Infect Dis Med Microbiol. 2022;2022:4461647.
13. Awoke MA, Adane A, Assefa B, Getawa S, Legese GL, Yimer M. Hematological parameters and their predictive value for assessing disease severity in laboratory-confirmed COVID-19 patients: a retrospective study. American Journal of blood research. 2023;13(4):117–29.
14. Khalili M, Karamouzian M, Nasiri N, Javadi S, Mirzazadeh A, Sharifi H. Epidemiological characteristics of COVID-19: asystematic review and meta-analysis. Epidemiol Infect. 2020;148:e130. https://doi.org/10.1017/S0950268820001430. PMID: 32594937; PMCID: PMC7343974.
15. Abera A, Fenta EH, Woldehanna BT, Wolde FB, Legesse M, Regassa LD, Mor S, Kaba M. Impact of COVID-19 on essential healthcare services in Addis Ababa, Ethiopia: Implications for future pandemics. PLoS ONE. 2024;19(10): e0308861.
16. Dessie ZG, Zewotir T. Mortality-related risk factors of COVID-19: a systematic review and meta-analysis of 42 studies and 423,117 patients. BMC Infect Dis. 2021;21(1):855.
17. Wondmeneh TG, Mohammed JA. COVID-19 mortality rate and its determinants in Ethiopia: a systematic review and meta-analysis. Front Med. 2024;11:1327746.
18. Yemata GA, Tesfaw A, Mihret G, Tiruneh M, Walle Z, Molla E, Sisay E, Admassu FT, Habtie E, Desalagn T, Shimels H, Teshome F. Survival Time to COVID-19 Severity and Its Predictors in South Gondar Zone. North-West Ethiopia: A Prospective Cohort Study, Journal of multidisciplinary healthcare. 2022;15:1187–201.
19. S.O. Bittaye, A. Jagne, A.-K. Iddrisu, R. Njie, L.E.S. Jaiteh, O. Nyan, Y.F.B.M. Jobe, S. Joof, S. Joof, M. Danso, E. Bah, M. Cham, C. Roberts, M. Bittaye, J. Zhang, Clinical Characteristics and Prognostic Factors of COVID-19 Patients Admitted to the National Treatment Center in The Gambia, Advances in Public Health 2024(1) (2024).
20. WHO, COVID-19 Epidemiological Update, file:///C:/Users/Fassikaw%20k/Downloads/covid-19_epi_update_173.pdf Accessed november 26 2024 (2024).
21. WorldoMeter, Wolrdometer Population, and COVID-19 daily report https://www.worldometers.info/coronavirus/country/ethiopia/ (April 13, 2024, 01:00 GMT).
22. M.T. Saro Abdella AbrahimID Eshetu EjetaID, Atkure Defar1, Alemayehu Hussen et.al Time to recovery and its predictors among adults hospitalized with COVID-19: A prospective cohort study in Ethiopia, PLoS ONE 15(12): e0244269. https://doi.org/10.1371/journal.pone.0244269 (2020).
23. Besteiro B, Coutinho D, Gomes F, Almeida M, Almeida J. Review of the Prognosis Factors of COVID-19 Infection. Advances in Infectious Diseases. 2021;11(02):196–215.
24. Plymoth M, Mogessie YG, Mohammed I, Mengesha D, Wang M, Musa SS, Bekele BK, Tatere HY, Musa MB, Lucero-Prisno Iii DE. Conflict, community, and COVID-19: response and implications in Ethiopia. J Public Health Afr. 2022;13(3):1957.
25. Wassie GT, Ambelie YA, Adebabay T, Yeshiwas AG, Fenta ET, Abebe EC, Wassie GT, Adella GA, Anley DT. Covid-19 vaccine uptake and its associated factors among adult population in Dangila district, Awi Zone, Northwest Ethiopia: A mixed method study. PLoS ONE. 2024;19(5): e0302531.
26. Giacomelli A, Ridolfo AL, Milazzo L, Oreni L, Bernacchia D, Siano M, Bonazzetti C, Covizzi A, Schiuma M. 30-day mortality in patients hospitalized with COVID-19 during the first wave of the Italian epidemic: A prospective cohort study. Pharmacol Res. 2020;158: 104931.
27. Birhanu MY, Jemberie SS. Mortality rate and predictors of COVID-19 inpatients in Ethiopia: a systematic review and meta-analysis. Front Med. 2023;10:1213077.
28. Girma D, Dejene H, Adugna L, Tesema M, Awol M. COVID-19 Case Fatality Rate and Factors Contributing to Mortality in Ethiopia: A Systematic Review of Current Evidence. Infection and drug resistance. 2022;15:3491–501.
29. JBI, Critical Appraisal tools for use in JBI Systematic Reviews, CHECKLIST FOR COHORT STUDIES, https://jbi.global/sites/default/files/2020-08/Checklist_for_Cohort_Studies.pdf (2020).
30. FMOH, NATIONAL COMPREHENSIVE COVID19 MANAGEMENT HANDBOOK IN ETHIOPIA, https://www.covidlawlab.org/wp-content/uploads/2020/06/National-Comprehensive-COVID19-Management-Handbook.pdf (2020).
31. I.S.H. Tigist W. LeulsegedID*, Endalkachew H. Maru, Wuletaw C. Zewsde, Negat W. Chamiso, Abdi B. BayisaID, Daniel S. AbebeID, Birhanu T. Ayele¤, Kalkidan T. Yegle, Mesay G. Edo, Eyosyas K. Gurara, Dereje D. Damete, Yared A. Tolera2021, Characteristics and outcome profile of hospitalized African patients with COVID-19: The Ethiopian context, PLoS ONE 16(11): e0259454. https://doi.org/10.1371/journal.pone.0259454 (2021).
32. Abdene Weya Kaso a , Habtamu Endashaw Hareru a , Taha Kaso b , Gebi Agero c, Time to recovery from Covid-19 and its associated factors among patients hospitalized to the treatment center in South Central Ethiopia, Environmental Challenges 6 (2022) 100428 (https://doi.org/10.1016/j.envc.2021.100428) (2021).
33. Abebe HT, Zelelow YB, Bezabih AM, Ashebir MM, Tafere GR, Wuneh AD, Araya MG, Kiros NK, Hiluf MK, Ebrahim MM, Gebrehiwot TG, Welderufael AL, Mohammed AH. Time to Recovery of Severely Ill COVID-19 Patients and its Predictors: A Retrospective Cohort Study in Tigray. Ethiopia, Journal of multidisciplinary healthcare. 2022;15:1709–18.
34. FMOH, National Comprehensive COVID 19 Clinical Management Handbook for Ethiopia, Clinical manamgment guidline https://covidlawlab.org/wp-content/uploads/2020/06/National-Comprehensive-COVID19-Management-Handbook.pdf (2020).
35. Borenstein M, Hedges LV, Higgins JP, Rothstein HR. A basic introduction to fixed-effect and random-effects models for meta-analysis. Research synthesis methods. 2010;1(2):97–111.
36. Duval S, Tweedie R, Nonparametric A. Trim and Fill. Method of Accounting for Publication Bias in Meta-Analysis, Journal of the American Statistical Association. 2000;95(449):89–98.
37. Abrahim SA, Tessema M, Defar A, Hussen A, Ejeta E, Demoz G, Tereda AB, Dillnessa E, Feleke A, Amare M, Nigatu F, Fufa Y, Refera H, Aklilu A, Kassa M, Kifle T, Whiting S, Tollera G, Abate E. Time to recovery and its predictors among adults hospitalized with COVID-19: A prospective cohort study in Ethiopia. PLoS ONE. 2020;15(12): e0244269.

38. S.A. Abrahim, M. Tessema, E. Ejeta, M. Ahmed, A. Defar, A. Hussen, G. Demoz, E. Degu, M. Aseratie, B. Merga, E. Dillnessa, T. Regassa, D. Duguma, S. Whiting, Median duration and factors that influence the duration of symptom resolution in COVID-19 patients in Ethiopia: A follow-up study involving symptomatic cases, Lifestyle medicine (Hoboken, N.J.) 2(4) (2021) e46.
39. Churiso G, Diriba K, Girma H, Tafere S. Clinical Features and Time to Recovery of Admitted COVID-19 Cases at Dilla University Referral Hospital Treatment Center. South Ethiopia, Infection and drug resistance. 2022;15:795–806.
40. Dessie AM, Feleke SF, Anley DT, Anteneh RM, Demissie ZA. Assessment of Factors Affecting Time to Recovery from COVID-19: A Retrospective Study in Ethiopia. Advances in Public Health. 2022;2022(1):7182517.
41. D. Habtamu Tamiru, A. Gedef Azene, G. Wudie Tsegaye, K. Mulatu Mihretie, S. Hunegnaw Asmare, W. Arega Gete, S. Animen Bante, Time to Recovery from COVID-19 and Its Predictors in Patients Hospitalized at Tibebe Ghion Specialized Hospital Care and Treatment Center, A Retrospective Follow-Up Study, North West Ethiopia, Global health, epidemiology and genomics 2023 (2023) 5586353.
42. M.Z. Kassie, M.G. Gobena, Y.M. Alemu, A.S. Tegegne, Time to recovery and its determinant factors among patients with COVID-19 in Assosa COVID-19 treatment center, Western Ethiopia, Pneumonia (Nathan Qld.) 15(1) (2023) 17.
43. L. Lemma Tirore, S. Abose Nadamo, H. Tamrat Derilo, D. Erkalo, T. Sedore, T. Tadesse, D. Ermias, T. Yaekob, Time to Recovery from Covid-19 and Its Predictors Among Patients Admitted to Treatment Centers of Southern Nations Nationalities and Peoples Region (SNNPR), ETHIOPIA: Multi-Center Retrospective Cohort Study, Infection and drug resistance 15 (2022) 3047–3062.
44. T. Tolossa, B. Wakuma, D. Seyoum Gebre, E. Merdassa Atomssa, M. Getachew, G. Fetensa, D. Ayala, E. Turi, Time to recovery from COVID-19 and its predictors among patients admitted to treatment center of Wollega University Referral Hospital (WURH), Western Ethiopia: Survival analysis of retrospective cohort study, PloS one 16(6) (2021) e0252389.
45. Tsegaye S, Bekele F, Lulu Y, Debele GR, Bekana T, Tolesa LD, Bidira K. Time to recovery and its predictors among COVID-19 positive patients admitted to treatment centers of Southwestern Ethiopian hospitals. A multicenter retrospective cohort study, Annals of medicine and surgery. 2012;84(2022): 104917.
46. Fantaw S, Debeko DD. Time to recovery and determinant factors of COVID-19 patients under treatment in Sidama region, Ethiopia: A retrospective cohort study. Heliyon. 2024;10(1): e23245.
47. A. weldu, A. Asres, M. Ayenew, D. Getachew, Recovery time from COVID-19 and its predictors among patients admitted to treatment centers in Southwest Ethiopia: multiple center retrospective cohort study, Journal of Public Health (2023).
48. Anteneh AB, Asfaw ZG. Time to recovery of COVID-19 patients and its predictors: a retrospective cohort study in HUCSH, Sidama, Ethiopia. BMC Public Health. 2025;25(1):74.
49. S.A.A.M.T.M.E.D.T.R.A.D.M. Aseratie1, Median duration and factors that influence the duration of symptom resolution in COVID-19 patients in Ethiopia: A follow-up study involving symptomatic case, Lifestyle Med. 2021;2:e46. https://doi.org/10.1002/lim2.46 (2021).
50. T.W. Leulseged, I.S. Hassen, E.H. Maru, W.C. Zewsde, N.W. Chamiso, A.B. Bayisa, D.S. Abebe, B.T. Ayele, K.T. Yegle, M.G. Edo, E.K. Gurara, D.D. Damete, Y.A. Tolera, Characteristics and outcome profile of hospitalized African patients with COV-19: The Ethiopian context, PloS one 16(11 November) (2021).
51. I.S.H. Tigist W. Leulseged1*, Endalkachew H. Maru1, Wuletaw C. Zewde1, Nigat W. Chamesew1, Kalkidan Yegele1, Abdi B. Bayisa1, Tariku B. Jagema1, Teketel T. Admasu1,Mesay G. Edo1, Eyosias K. Gurara, Meseret D. Hassen1, Etsegenet Y. Menyilshewa1, Firaol M. Abdi1, Mahlet B. Tefera1, Siham S. Ali1, Determinants of time to viral clearance among SARS-CoV-2 infected individuals at Millennium COVID-19 care center in Ethiopia: A prospective observational study, Ethiopian Medical Journal 2023, ISSN 0014–1755 eISSN 2415–2420 (2023).
52. F. Martos Pérez, J. Luque Del Pino, N. Jiménez García, E. Mora Ruiz, C. Asencio Méndez, J.M. García Jiménez, F. Navarro Romero, M.V. Núñez Rodríguez, Comorbidity and prognostic factors on admission in a COVID-19 cohort of a general hospital, Revista clinica espanola 221(9) (2021) 529–535.
53. J.B. Nachega, N.A. Sam-Agudu, R.N. Machekano, H. Rabie, M.M. van der Zalm, A. Redfern, A. Dramowski, N. O'Connell, M.T. Pipo, M.B. Tshilanda, L.N. Byamungu, R. Masekela, P.M. Jeena, A. Pillay, O.W. Gachuno, J. Kinuthia, D.K. Ishoso, E. Amoako, E. Agyare, E.K. Agbeno, C. Martyn-Dickens, J. Sylverken, A. Enimil, A.M. Jibril, A.M. Abdullahi, O. Amadi, U.M. Umar, L.N. Sigwadhi, M.P. Hermans, J.O. Otokoye, P. Mbala-Kingebeni, J.-J. Muyembe-Tamfum, A. Zumla, N.K. Sewankambo, H.T. Aanyu, P. Musoke, F. Suleman, P. Adejumo, E.V. Noormahomed, R.J. Deckelbaum, M.G. Fowler, L. Tshilolo, G. Smith, E.J. Mills, L.W. Umar, M.J. Siedner, M. Kruger, P.J. Rosenthal, J.W. Mellors, L.M. Mofenson, R. African Forum for, C.-R.C.o.C. Education in Health, Adolescents, Assessment of Clinical Outcomes Among Children and Adolescents Hospitalized With COVID-19 in 6 Sub-Saharan African Countries, JAMA Pediatrics 176(3) (2022) e216436-e216436.
54. Yin C, Hu B, Li K, Liu X, Wang S, He R, Ding H, Jin M, Chen C. Clinical characteristics and prognostic nomograms of 12555 non-severe COVID-19 cases with Omicron infection in Shanghai. BMC Infect Dis. 2023;23(1):606.
55. Chen X, Zhu B, Hong W, Zeng J, He X, Chen J, Zheng H, Qiu S, Deng Y, Chan JCN, Wang J, Zhang Y. Associations of clinical characteristics and treatment regimens with the duration of viral RNA shedding in patients with COVID-19. Int J Infect Dis. 2020;98:252–60.
56. M.J.F. Kebede2, Exploring multi-level risk factors and post-war burdens of trachomatous trichiasis among displaced population in Raya Kobo districts, implication for urgent action, Int J Ophthalmol, Vol. 16, Tel: 8629–82245172 No. 8, Aug.18, 2023 8629–82210956 Int J Ophthalmol 2023;16(8):1299–1308 (2023).
57. Mohamed SOO, Ahmed EM. Prevalence and determinants of antenatal tetanus vaccination in Sudan: a cross-sectional analysis of the Multiple Indicator Cluster Survey. Trop Med Health. 2022;50(1):7.
58. M.T. Saro Abdella Abrahim, Atkure Defar1, Alemayehu Hussen1, 1, Getachew Demoz2, Addisu Birhanu Tereda2, Enatenesh Dillnessa1, Time to recovery and its predictors among adults hospitalized with COVID-19: A prospective cohort study in Ethiopia, PLoS ONE 15(12): e0244269. https://doi.org/10.1371/journal.pone.0244269 (2020).
59. L.A. SeyedAhmad SeyedAlinaghi1, 2*, Mohammad Solduzian3*, Niloofar Ayoobi Yazdi4, Fatemeh Jafari2, Alireza Adibimehr2, Aazam Farahani2, Arezoo Salami Khaneshan2, Parvaneh Ebrahimi Alavijeh2, Zahra Jahani2, Elnaz Karimian2, Zahra Ahmadinejad2, Hossein Khalili5, Arash Seifi2, Fereshteh Ghiasvand2, Sara Ghaderkhani2 and Mehrnaz Rasoolinejad2, Predictors of the prolonged recovery period in COVID-19 patients: a cross-sectional study, European Journal of Medical Research Eur J Med Res (2021) 26:41 https://doi.org/10.1186/s40001-021-00513-x (2021).
60. Ramírez-Soto MC, Ortega-Cáceres G, Arroyo-Hernández H. Sex differences in COVID-19 fatality rate and risk of death: An analysis in 73 countries, 2020–2021. Infez Med. 2021;29(3):402–7.
61. G.M. Getaneh Atikilt Yemata Aragaw Tesfaw 1, Mulu Tiruneh 1, Zebader Walle 1, Eshetie Molla1, Ermias Sisay 3, Fitalew Tadele Admassu 4, Eyaya Habtie5, Tsion Desalagn1, Habtamu Shimels 3, Fentaw Teshome, Survival Time to COVID-19 Severity and Its Predictors in South Gondar Zone, North-West Ethiopia: A Prospective Cohort Study, Journal of Multidisciplinary Healthcare 2022:15 1187–1201 (2022).
62. B.W. Tadesse Tolossa 1*, Dejene Seyoum GebreID Atomssa1, Motuma Getachew1, Getahun FetensaID 2, Diriba Ayala3, Ebisa Turil, Time to recovery from COVID-19 and its predictors among patients admitted to treatment center of Wollega University Referral Hospital (WURH), Western Ethiopia: Survival analysis of retrospective cohort study, PLoS ONE 16(6): e0252389. https://doi.org/10.1371/journal. pone.0252389 (2021).
63. Shah KM, Shah RM, Sawano M, Wu Y, Bishop P, Iwasaki A, Krumholz HM. Factors Associated with Long COVID Recovery among US Adults. Am J Med. 2024;137(9):896–9.
64. V. Bellou, I. Tzoulaki, M. van Smeden, K.G.M. Moons, E. Evangelou, L. Belbasis, Prognostic factors for adverse outcomes in patients with COVID-19: a field-wide systematic review and meta-analysis, Eur Respir J 59(2) (2022).
65. E. Zandkarimi*, Factors affecting the recovery of Kurdistan province COVID-19 patients: a cross-sectional study from March to,. Epidemiol. Methods. June2020;10(s1):2021, 20200041. https://doi.org/10.1515/em-2020-0041.
66. W.H. Ng, T. Tipih, N.A. Makoah, J.G. Vermeulen, D. Goedhals, J.B. Sempa, F.J. Burt, A. Taylor, S. Mahalingam, Comorbidities in SARS-CoV-2 Patients: a Systematic Review and Meta-Analysis, mBio 12(1) (2021).
67. Oelsner EC, Sun Y, Balte PP, Allen NB, Andrews H, Carson A, Cole SA, Coresh J, Couper D, Cushman M, Daviglus M, Demmer RT, Elkind MSV,

Gallo LC, Gutierrez JD, Howard VJ, Isasi CR, Judd SE, Kanaya AM, Kandula NR, Kaplan RC, Kinney GL, Kucharska-Newton AM, Lackland DT, Lee JS, Make BJ, Min YI, Murabito JM, Norwood AF, Ortega VE, Pettee Gabriel K, Psaty BM, Regan EA, Sotres-Alvarez D, Schwartz D, Shikany JM, Thyagarajan B, Tracy RP, Umans JG, Vasan RS, Wenzel SE, Woodruff PG, Xanthakis V, Zhang Y, Post WS. Epidemiologic Features of Recovery From SARS-CoV-2 Infection. JAMA Netw Open. 2024;7(6):e2417440.

68. Gattinoni L, Chiumello D, Caironi P, Busana M, Romitti F, Brazzi L, Camporota L. COVID-19 pneumonia: different respiratory treatments for different phenotypes? Intensive Care Med. 2020;46(6):1099–102.
69. Zacchetti L, Longhi L, Bianchi I, Di Matteo M, Russo F, Gandini L, Manesso L, Monti M, Cosentini R, Di Marco F, Fagiuoli S, Grazioli L, Gritti P, Previdi F, Senni M, Ranieri M, Lorini L. Characterization of compliance phenotypes in COVID-19 acute respiratory distress syndrome. BMC Pulm Med. 2022;22(1):296.

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