# Supplementary Materials

**The J-shaped relationship between body mass index and mortality in patients with COVID-19:**

**A dose-response meta-analysis**

**Supplemental Table S1.** Quality assessment of the included cohort studies using the Newcastle–Ottawa Scale

| Author and year | Selection | | | | Comparability | | Outcome | | | Total Quality Score |
| | Representativeness of exposed cohort | Selection of non-exposed cohort | Ascertainment of exposure | The outcome of interest was not present at the start of the study | Adjusted for age/sex | Adjusted for comorbidities | Assessment of outcome | Follow-up length | Loss to follow-up rate | |
|---|---|---|---|---|---|---|---|---|---|---|
| Anderson 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Baronia 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Czernichow 2020 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 8 |
| Eastment 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Fai2r 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Goyal 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Gu 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Gupta 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Hajifathalian 2020 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 8 |
| Halasz 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Hendren 2021 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Iannelli 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Ioannou 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Kabarriti 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Kim 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Kim 2021 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Klang 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Nakeshbandi 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| Nimkar 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Olivas-Martı́nez 2021** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| **Palaiodimos 2020** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| **Petrilli 2020** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| **Rottoli 2020** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| **Schmidt 2021** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| **Shah 2020** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| **Smati 2021** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| **Tartof 2020** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| **Yoshida 2021** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |

Selection:

1) Representativeness of exposed cohort: 1, truly or somewhat representative of a community/population-based study; 0, selected group of users or lack of description of the derivation of the cohort.

2) Selection of non-exposed cohort: 1, drawn from the same community as the exposed cohort; 0, drawn from a different source or lack of description of the derivation of the non-exposed cohort.

3) Ascertainment of exposure: 1, validation of BMI with secure record or structured interview; 0, written self-report or lack of description of validation of BMI.

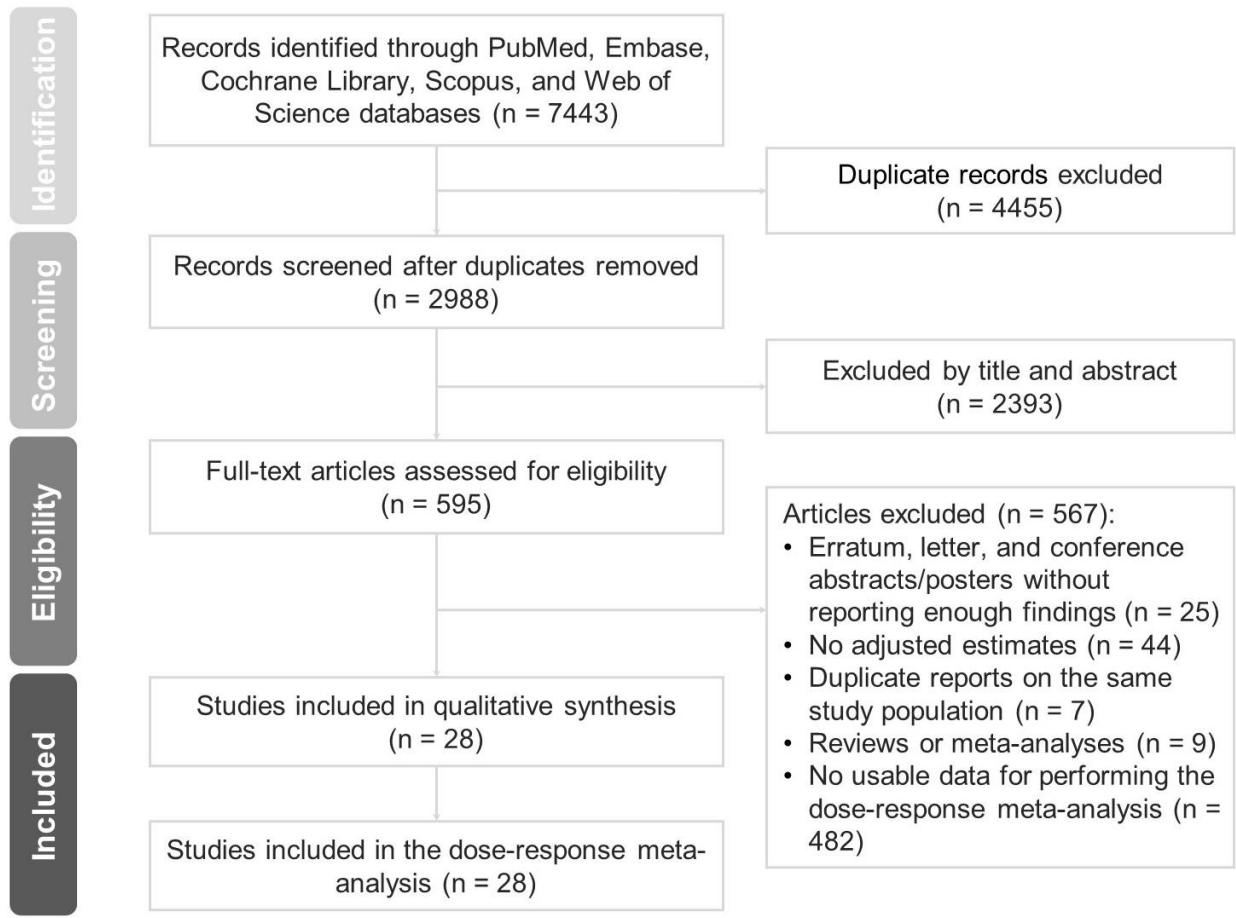4) Demonstration that outcome of interest was not present at start of study: 1, yes; 0, no.

Comparability:

1) Study adjusted for age and sex: 1, yes; 0, no
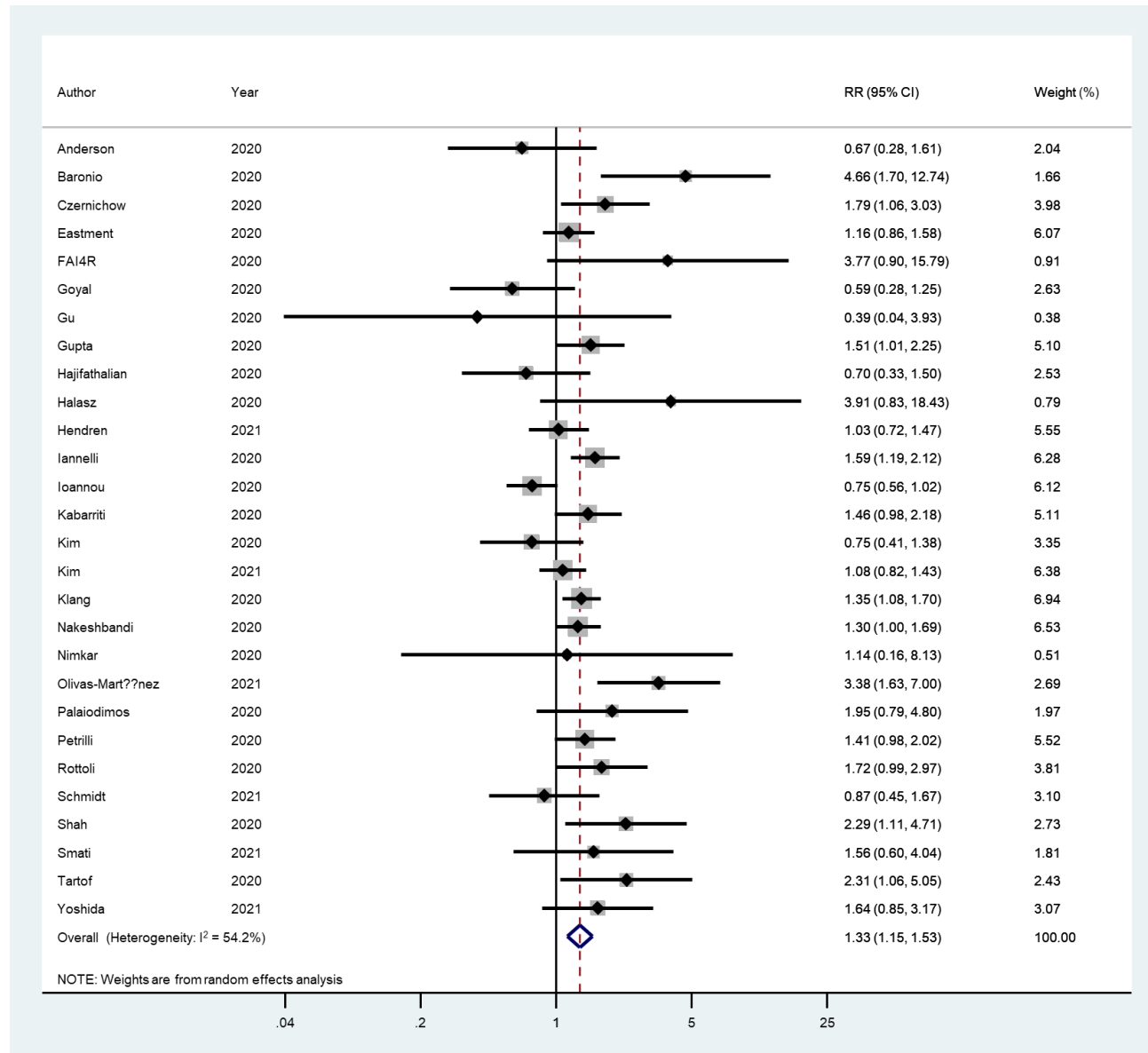
2) Study adjusted for any comorbidities: 1, yes; 0, no.

Outcome:

1) Assessment of outcome: 1, independent blind assessment, confirmed by medical records or record linkage; 0, self-reported or no description.

2) Was follow-up long enough for outcomes to occur: 1, duration of follow-up at least 7 days or until discharges; 0, duration of follow-up < 7 days.

3) Loss to follow-up rate: 1, complete follow-up or loss to follow-up rate less than 20%; 0, loss to follow-up rate more than 20% or no statement.
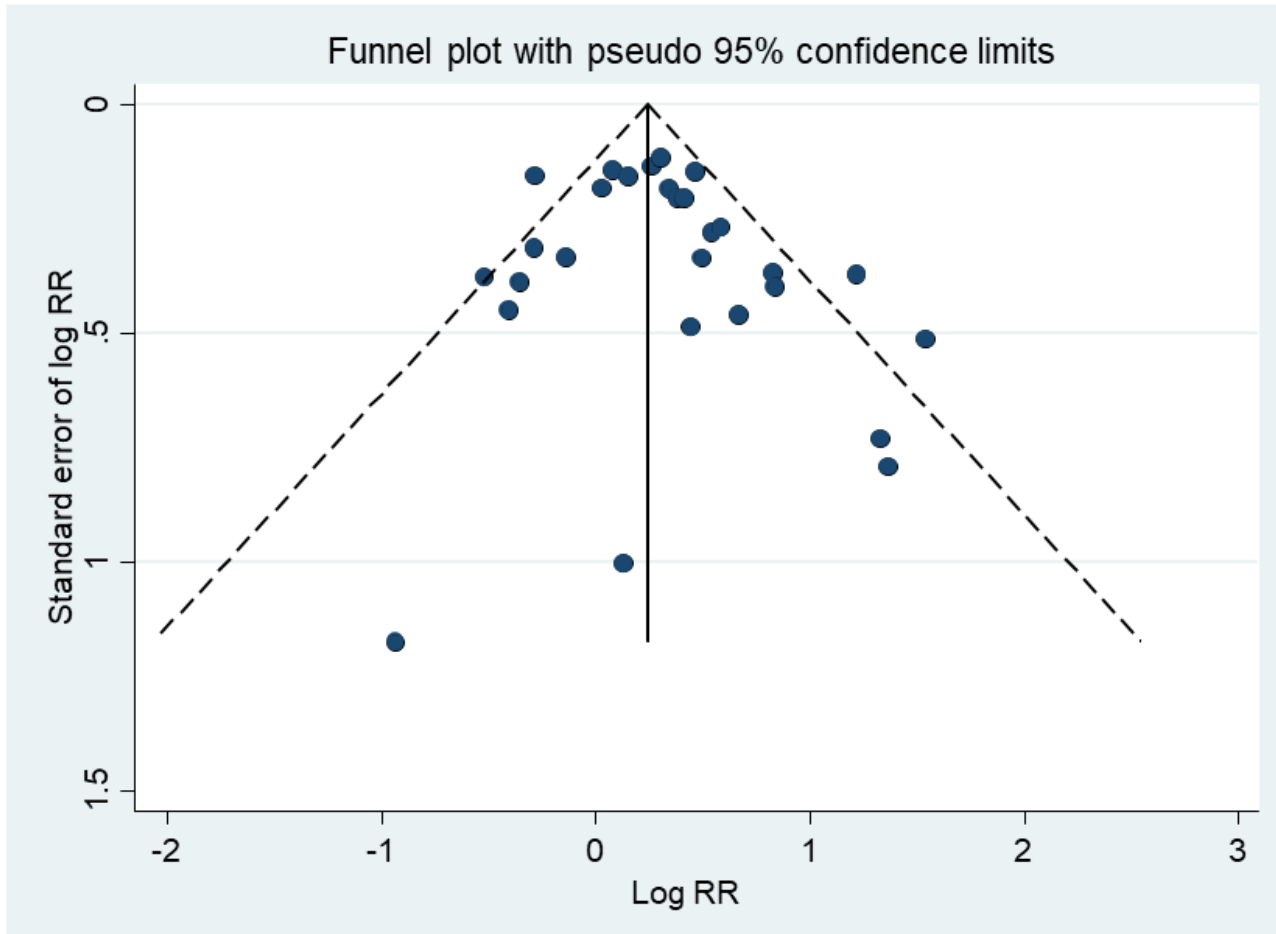
**Supplemental Figure S1:** PRISMA flow diagram of the literature search and article selection



```
Identification

Records identified through PubMed, Embase,
Cochrane Library, Scopus, and Web of
Science databases (n = 7443)
                                          →  Duplicate records excluded
                                             (n = 4455)

Screening

Records screened after duplicates removed
(n = 2988)
                                          →  Excluded by title and abstract
                                             (n = 2393)

Eligibility

Full-text articles assessed for eligibility
(n = 595)
                                          →  Articles excluded (n = 567):
                                             • Erratum, letter, and conference
                                               abstracts/posters without
                                               reporting enough findings (n = 25)
                                             • No adjusted estimates (n = 44)
                                             • Duplicate reports on the same
                                               study population (n = 7)
Included                                     • Reviews or meta-analyses (n = 9)
                                             • No usable data for performing the
Studies included in qualitative synthesis      dose-response meta-analysis (n =
(n = 28)                                        482)

Studies included in the dose-response meta-
analysis (n = 28)
```
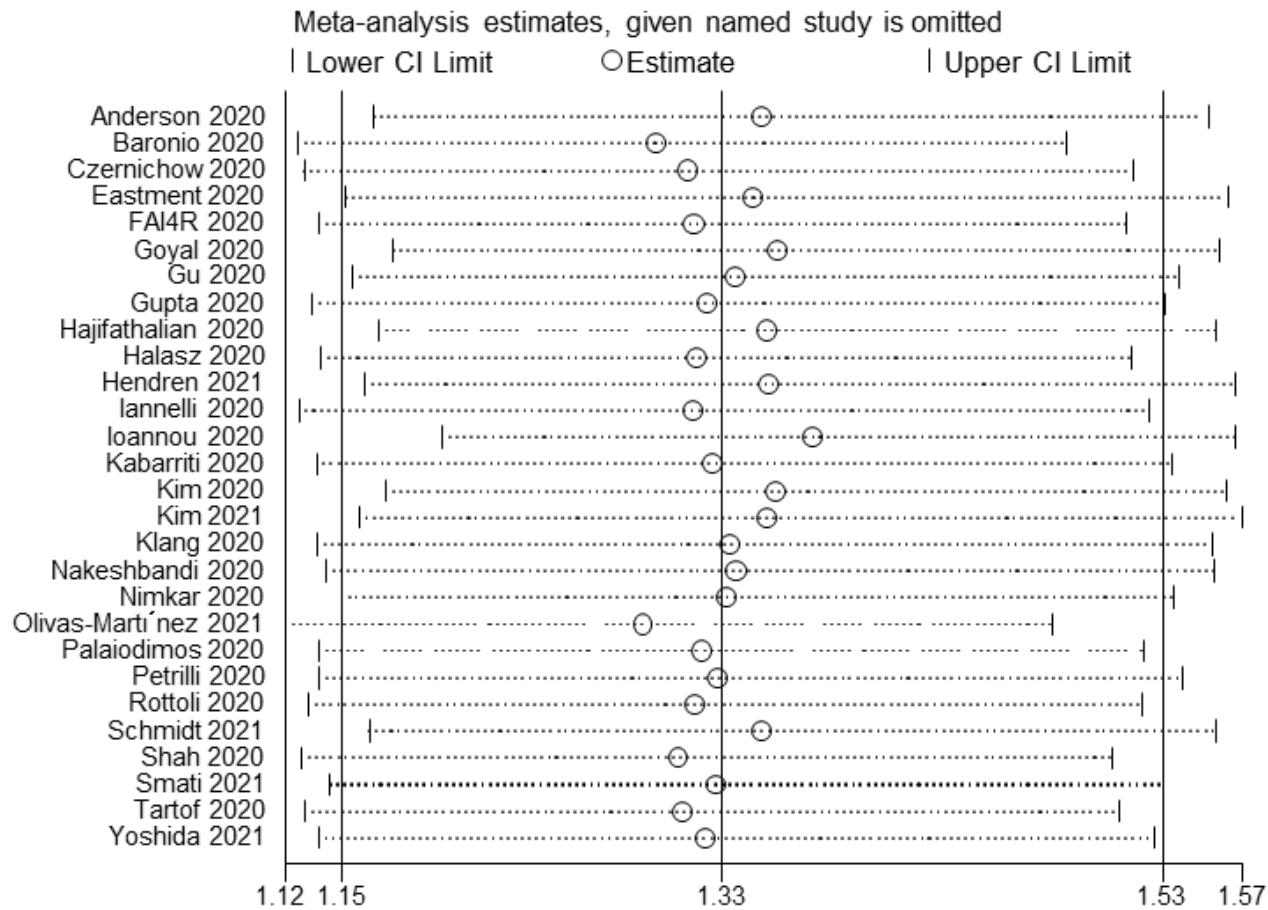
**Supplemental Figure S2:** Forest plot of the relative risk of mortality for highest versus lowest categories of body mass index in COVID-19 patients

| Author | Year | RR (95% CI) | Weight (%) |
|---|---|---|---|
| Anderson | 2020 | 0.67 (0.28, 1.61) | 2.04 |
| Baronio | 2020 | 4.66 (1.70, 12.74) | 1.66 |
| Czernichow | 2020 | 1.79 (1.06, 3.03) | 3.98 |
| Eastment | 2020 | 1.16 (0.86, 1.58) | 6.07 |
| FAI4R | 2020 | 3.77 (0.90, 15.79) | 0.91 |
| Goyal | 2020 | 0.59 (0.28, 1.25) | 2.63 |
| Gu | 2020 | 0.39 (0.04, 3.93) | 0.38 |
| Gupta | 2020 | 1.51 (1.01, 2.25) | 5.10 |
| Hajifathalian | 2020 | 0.70 (0.33, 1.50) | 2.53 |
| Halasz | 2020 | 3.91 (0.83, 18.43) | 0.79 |
| Hendren | 2021 | 1.03 (0.72, 1.47) | 5.55 |
| Iannelli | 2020 | 1.59 (1.19, 2.12) | 6.28 |
| Ioannou | 2020 | 0.75 (0.56, 1.02) | 6.12 |
| Kabarriti | 2020 | 1.46 (0.98, 2.18) | 5.11 |
| Kim | 2020 | 0.75 (0.41, 1.38) | 3.35 |
| Kim | 2021 | 1.08 (0.82, 1.43) | 6.38 |
| Klang | 2020 | 1.35 (1.08, 1.70) | 6.94 |
| Nakeshbandi | 2020 | 1.30 (1.00, 1.69) | 6.53 |
| Nimkar | 2020 | 1.14 (0.16, 8.13) | 0.51 |
| Olivas-Mart??nez | 2021 | 3.38 (1.63, 7.00) | 2.69 |
| Palaiodimos | 2020 | 1.95 (0.79, 4.80) | 1.97 |
| Petrilli | 2020 | 1.41 (0.98, 2.02) | 5.52 |
| Rottoli | 2020 | 1.72 (0.99, 2.97) | 3.81 |
| Schmidt | 2021 | 0.87 (0.45, 1.67) | 3.10 |
| Shah | 2020 | 2.29 (1.11, 4.71) | 2.73 |
| Smati | 2021 | 1.56 (0.60, 4.04) | 1.81 |
| Tartof | 2020 | 2.31 (1.06, 5.05) | 2.43 |
| Yoshida | 2021 | 1.64 (0.85, 3.17) | 3.07 |
| Overall (Heterogeneity: $I^2$ = 54.2%) | | 1.33 (1.15, 1.53) | 100.00 |

NOTE: Weights are from random effects analysis

.04    .2    1    5    25

**Supplemental Figure S3.** Funnel plot to assess publication bias in studies comparing mortality between highest versus lowest categories of body mass index in COVID-19 patients



Funnel plot with pseudo 95% confidence limits

**Supplemental Figure S4.** The leave-one-out sensitivity analysis of the relative risk of mortality for highest versus lowest categories of body mass index in COVID-19 patients with each study omitted individually one at a time

# Detailed Search Strategies

**PubMed:**

("COVID-19"[tw] OR "COVID 19"[tw] OR "COVID19"[tw] OR "COVID2019"[tw] OR "COVID 2019"[tw] OR "COVID-2019"[tw] OR "novel coronavirus"[tw] OR "new coronavirus"[tw] OR "novel corona virus"[tw] OR "new corona virus"[tw] OR "SARS-CoV-2"[tw] OR "SARSCoV2"[tw] OR "SARS-CoV2"[tw] OR "2019nCoV"[tw] OR "2019-nCoV"[tw] OR "2019 coronavirus"[tw] OR "2019 corona virus"[tw] OR "coronavirus disease 2019"[tw] OR "severe acute respiratory syndrome coronavirus 2"[nm] OR "severe acute respiratory syndrome coronavirus 2"[tw] OR "sars-coronavirus-2"[tw] OR "coronavirus disease 2019"[tw] OR "corona virus disease 2019"[tw] OR "betacoronavirus" [tw] OR "beta-coronavirus" [tw])
AND
("Thinness"[Mesh] OR obesity[mh] OR overweight[mh] OR weight gain[mh] OR weight loss[mh] OR body mass index[mh] OR waist-hip ratio[mh] OR overweight*[tw] OR over weight*[tw] OR obes* OR "body mass index" OR waist-hip ratio* OR "abdominal fat" OR underweight [tw] OR "body weight" [tw])
AND
("mortality"[mh] OR "mortality" OR "fatal outcome"[mh] OR "fatal" OR "fatality" OR "fatalities" OR "death" OR "deaths")
Limit: English

**Embase:**

('covid-19'/exp OR 'covid-19' OR 'covid 19'/exp OR 'covid 19' OR 'covid19' OR 'covid2019' OR 'covid 2019'/exp OR 'covid 2019' OR 'covid-2019'/exp OR 'covid-2019' OR 'novel coronavirus' OR 'new coronavirus' OR 'novel corona virus' OR 'new corona virus' OR 'sars-cov-2'/exp OR 'sars-cov-2' OR 'sarscov2' OR 'sars-cov2' OR '2019ncov' OR '2019-ncov'/exp OR '2019-ncov' OR '2019 coronavirus' OR '2019 corona virus' OR 'severe acute respiratory syndrome coronavirus 2'/exp OR 'severe acute

respiratory syndrome coronavirus 2' OR 'sars-coronavirus-2'/exp OR 'sars-coronavirus-2' OR 'coronavirus disease 2019'/exp OR 'coronavirus disease 2019' OR 'corona virus disease 2019')

AND

('obesity'/exp OR 'underweight'/exp OR 'body weight change'/exp OR 'body mass'/exp OR 'waist hip ratio'/exp OR obes*:ti,ab,kw OR overweight*:ti,ab,kw OR 'over weight*':ti,ab,kw OR 'body mass index':ti,ab,kw OR 'body-mass index':ti,ab,kw OR 'waist hip ratio*':ti,ab,kw OR 'waist-hip ratio*':ti,ab,kw OR 'abdominal fat*':ti,ab,kw OR 'underweight*':ti,ab,kw OR 'body weight*':ti,ab,kw)

AND

('mortality'/exp OR 'mortality' OR 'fatality'/exp OR 'fatal' OR 'fatality' OR 'fatalities' OR 'death' OR 'deaths')

Limit: English


**Cochrane library:**

| Search number | Search | Results |
|---|---|---|
| #1 | "COVID-19" OR "COVID 19" OR "COVID19" OR "COVID2019" OR "COVID 2019" OR "COVID-2019" OR "novel coronavirus" OR "new coronavirus" OR "novel corona virus" OR "new corona virus" OR "SARS-CoV-2" OR "SARSCoV2" OR "SARS-CoV2" OR "2019nCoV" OR "2019-nCoV" OR "2019 coronavirus" OR "2019 corona virus" OR "coronavirus disease 2019" OR "severe acute respiratory syndrome coronavirus 2" OR "severe acute respiratory syndrome coronavirus 2" OR "sars-coronavirus-2" OR "coronavirus disease 2019" OR "corona virus disease 2019" OR "betacoronavirus" OR "beta-coronavirus" | 1119 |
| #2 | MeSH descriptor: [Thinness] explode all trees | 283 |
| #3 | MeSH descriptor: [Obesity] explode all trees | 13544 |

| #4 | MeSH descriptor: [Overweight] explode all trees | 16074 |
| #5 | MeSH descriptor: [Body Weight Changes] explode all trees | 8578 |
| #6 | MeSH descriptor: [Body Mass Index] explode all trees | 9987 |
| #7 | MeSH descriptor: [Waist-Hip Ratio] explode all trees | 255 |
| #8 | "waist hip ratio" OR obes* OR overweight* OR "over weight" OR "body mass index" OR "body-mass index" OR "waist-hip ratio*" OR "abdominal fat*" OR "underweight*" OR "body weight*" | 102474 |
| #9 | #2 or #3 or #4 or #5 or #6 or #7 or #8 | 104326 |
| #10 | #1 and #9 | **35** |

**Cochrane COVID-19 Study Register:**

| | Search | Results |
| #1 | bmi OR obesi* OR overweight* | **388** |

**Web of Science:**

TS=("waist hip ratio"  OR obes*  OR overweight*  OR "over weight"  OR "body mass index"  OR "body-mass index"  OR "waist-hip ratio"  OR "abdominal fat"  OR "underweight"  OR "body weight")

AND

TS=("COVID-19"  OR "COVID 19"  OR "COVID19"  OR "COVID2019"  OR "COVID 2019"  OR "COVID-2019"  OR "novel coronavirus"  OR "new coronavirus"  OR "novel corona virus"  OR "new corona virus"  OR "SARS-CoV-2"  OR "SARSCoV2"  OR "SARS-CoV2"  OR "2019nCoV"  OR "2019-nCoV"  OR "2019 coronavirus"  OR "2019 corona virus"  OR "coronavirus disease 2019"  OR "severe acute respiratory syndrome coronavirus 2"  OR "severe acute respiratory syndrome coronavirus 2"  OR "sars-coronavirus-2"  OR "coronavirus disease 2019"  OR "corona virus disease 2019"  OR "betacoronavirus"  OR "beta-coronavirus")

AND

TS=("mortality" OR "fatal" OR "fatality" OR "fatalities" OR "death" OR "deaths")Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC.

Limit: English


**Scopus:**

TITLE-ABS-KEY ( "waist hip ratio"  OR  obes*  OR  overweight*  OR  "over weight"  OR  "body mass index"  OR  "body-mass index"  OR  "waist-hip ratio"  OR  "abdominal fat"  OR  "underweight"  OR  "body weight" )

AND

TITLE-ABS-KEY ( "COVID-19"  OR  "COVID 19"  OR  "COVID19"  OR  "COVID2019"  OR  "COVID 2019"  OR  "COVID-2019"  OR  "novel coronavirus"  OR  "new coronavirus"  OR  "novel corona virus"  OR  "new corona virus"  OR  "SARS-CoV-2"  OR  "SARSCoV2"  OR  "SARS-CoV2"  OR  "2019nCoV"  OR  "2019-nCoV"  OR  "2019 coronavirus"  OR  "2019 corona virus"  OR  "coronavirus disease 2019"  OR  "severe acute respiratory syndrome coronavirus 2"  OR  "severe acute respiratory syndrome coronavirus 2"  OR  "sars-coronavirus-2"  OR  "coronavirus disease 2019"  OR  "corona virus disease 2019"  OR  "betacoronavirus"  OR  "beta-coronavirus" )

AND

TITLE-ABS-KEY ("mortality" OR "fatal" OR "fatality" OR "fatalities" OR "death" OR "deaths")

Limit: English