Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Cancer is associated with coronavirus disease (COVID-19) severity and mortality: A pooled analysis

Isaac Cheruiyot *, Vincent Kipkorir, Brian Ngure, Musa Misiani, Jeremiah Munguti

School of Medicine, University of Nairobi, Nairobi, Kenya

Abstract

Background: Coronavirus disease 2019 (COVID-19) is a rapidly escalating pandemic that has spread to many parts of the world. As such, there is urgent need to identify predictors of clinical severity in COVID-19 patients. This may be useful for early identification of patients who may require life-saving interventions. In this meta-analysis, we evaluated whether malignancies are associated with a significantly enhanced odds of COVID-19 severity and mortality.

Method: A systematic search of literature was conducted between November 1, 2019, to May 26th, 2020 on PubMed and China National Knowledge Infrastructure (CNKI) to identify studies reporting data on cancers in patients with or without severe COVID-19 were included. The primary outcome of interest was the association between malignancies and COVID-19 severity, while the secondary outcome was the association between malignancies and COVID-19 mortality. Data were pooled into a meta-analysis to estimate pooled odds ratio (OR) with 95% confidence interval (95% CI) for either outcome.

Results: A total of 20 studies (n = 4549 patients) were included. Overall, malignancies were found to be associated with significantly increased odds of COVID-19 severity (OR = 2.17; 95% CI 1.47–3.196; p < 0.001) and mortality (OR = 2.39; 95% CI 1.18–4.85; p = 0.016). No heterogeneity was observed for both outcomes (Cochran’s Q = 6.558, p = 0.922, I² = 0% and Cochran’s Q = 2.91, p = 0.71, I² = 0% respectively).

Conclusion: Malignancies were significantly associated with a 2-fold increase in the odds of developing severe COVID-19 disease, as well as mortality. Larger studies are needed to corroborate these findings. These patients should be closely monitored for any signs of unfavorable disease progression.

© 2020 Elsevier Inc. All rights reserved.

1. Introduction

The coronavirus disease 2019 (COVID-19), which was first reported in Wuhan in December 2019, has achieved a pandemic status. As of 30th July 2020, the disease had spread to over 213 countries and territories, with over 16,812,763 confirmed cases and 662,095 fatalities [1]. Therefore, there is urgent need to identify patient characteristics to enable risk stratification for predicting unfavorable disease progression, and facilitate timely life-saving interventions.

Recently, Zheng and colleagues [2] published a paper on the risk factors of critical and mortal coronavirus disease 2019 (COVID-19) cases in the Journal of Infection. In their analysis, the authors found that the proportion of patients with malignancies was higher in the critical/mortality group “yet without statistical significance” (OR = 1.60; 95% CI 0.81–3.18; p = 0.18). Since the publication of their paper, more data on this subject has been published. We performed an updated meta-analysis of currently available literature to evaluate whether malignancies are associated with increased severity and mortality of COVID-19.

2. Methods

2.1. Study protocol

This systematic review and meta-analysis were conducted in strict conformity with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [3]. The PRISMA checklist is provided in the supplementary material.

2.2. Literature search strategy

A systematic electronic search of literature from November 1, 2019, to May 26th, 2020 was conducted on the electronic databases Medline (PubMed interface) and China National Knowledge Infrastructure (CNKI) to identify studies eligible for inclusion. The electronic search was carried out using the strategy as follows: (1) (((COVID-19) OR (SARS-CoV-2)) OR (2019-nCoV)); (2) ((((Malignancy) OR (Cancer)) OR (Tumor)) OR (Clinical features)) OR (Outcomes)) OR
Fig. 1. PRISMA flow chart for the included studies.

Table 1
Characteristics of the studies included in the severity analysis cohort

| Study               | Country & City          | Sample Size | Severe patients | Non-severe patients |
|---------------------|-------------------------|-------------|-----------------|---------------------|
|                     |                         |             | Age (yrs)       | Age (yrs)           |
|                     |                         |             | Women (%)       | Women (%)           |
|                     |                         |             | Cancer (%)      | Cancer (%)          |
| Guan et al. [5]     | Outside Hubei, China    | 1099        | 173 (15.7%)     | 73 (42%)            |
|                     |                         |             | 52 (40-65)      | 3 (1.7%)            |
|                     |                         |             | 926 (84.3%)     | 45 (34-57)          |
|                     |                         |             | 3 (1.7%)        | 386 (42%)           |
|                     |                         |             | 15 (53.6%)      | 0 (0%)              |
| Huang et al. [6]    | Wuhan, China            | 41          | 13 (31.7%)      | 2 (15%)             |
|                     |                         |             | 49 (41-61)      | 0 (0%)              |
|                     |                         |             | 28 (68.3%)      | 49 (41-57.5)        |
|                     |                         |             | 15 (53.6%)      | 1 (3.6%)            |
| Zhang Guqin et al. 7 | Wuhan, China            | 221         | 55 (24.0%)      | 20 (36.4%)          |
|                     |                         |             | 62 (52-74)      | 4 (7.3%)            |
|                     |                         |             | 166 (75.1%)     | 51 (36-64.3)        |
|                     |                         |             | 93 (56%)        | 5 (3.0%)            |
| Yao et al. [8]      | Dabieshan, China        | 108         | 25 (23.1%)      | 12 (48%)            |
|                     |                         |             | –               | 2 (8%)              |
|                     |                         |             | 83 (76.9%)      | 50.0 (63.9%)        |
|                     |                         |             | 53 (63.9%)      | 0 (0%)              |
| Aggarwal et al. [9] | Iowa, USA               | 16          | 8 (50%)         | 3 (38%)             |
|                     |                         |             | 67 (38-70)      | 2 (25%)             |
|                     |                         |             | 8 (50%)         | 68.5 (41-95)        |
|                     |                         |             | 1 (13%)         | 1 (13%)             |
| Wang D et al. [10]  | Wuhan, China            | 138         | 36 (26.1%)      | 14 (38.9%)          |
|                     |                         |             | 66 (57-78)      | 4 (11.1%)           |
|                     |                         |             | 102 (71.9%)     | 53 (37-62)          |
|                     |                         |             | 49 (48%)        | 6 (5.8%)            |
| Hong et al. [11]    | Daegu, South Korea      | 98          | 13 (13.2%)      | 7 (53.8%)           |
|                     |                         |             | 63.2 ± 10.1     | 1 (7.7%)            |
|                     |                         |             | 85 (86.8%)      | 54.2 ± 17.7         |
|                     |                         |             | 53 (62.4%)      | 3 (3.5%)            |
| Li X et al. [12]    | Wuhan, China            | 548         | 269 (49.3%)     | 116 (43.1%)         |
|                     |                         |             | 65 (54-72)      | 14 (5.2%)           |
|                     |                         |             | 279 (50.7%)     | 56 (44-66)          |
|                     |                         |             | 153 (54.8%)     | 10 (3.5%)           |
| Wang Z et al. [13]  | Wuhan, China            | 69          | 14 (20.9%)      | 7 (30%)             |
|                     |                         |             | 70.5 (62-77)    | 1 (7.1%)            |
|                     |                         |             | 55 (79.1%)      | 73 (32-51)          |
|                     |                         |             | 30 (55%)        | 5 (3.4%)            |
| Wan S et al. [14]   | Chongqing China         | 135         | 40 (29.6%)      | 19 (47.5%)          |
|                     |                         |             | 56 (52-73)      | 3 (7.5%)            |
|                     |                         |             | 95 (70.4%)      | 44 (33-49)          |
|                     |                         |             | 43 (45.3%)      | 1 (1%)              |
| Goyal et al. [15]   | New York, USA           | 393         | 130 (33.1%)     | 38 (29.2%)          |
|                     |                         |             | 64.5 (51.7-73.6) | 10 (7.6%)          |
|                     |                         |             | 263 (66.9%)     | 61.5 (47-75)        |
|                     |                         |             | 117 (45.5%)     | 13 (4.9%)           |
| Feng et al. [16]    | Wuhan, Shanghai and Anhui | 476      | 124 (26.1%)     | 43 (34.7%)          |
|                     |                         |             | 58 (48-67)      | 7 (5.6%)            |
|                     |                         |             | 352 (73.9%)     | 51 (37-61)          |
|                     |                         |             | 162 (46%)       | 5 (1.4%)            |
| Colaneri et al. [17] | Pavia, Italy           | 44          | 17 (38.6%)      | 4 (23.5%)           |
|                     |                         |             | –               | 27 (61.4%)          |
|                     |                         |             | 4 (23.5%)       | 12 (44.4%)          |
| Zhu et al. [18]     | Ningbo, China           | 127         | 16 (12.5%)      | 7 (43.8%)           |
|                     |                         |             | 57.50 ± 11.70   | 111 (87.5%)         |
|                     |                         |             | 49.95 ± 15.52   | 38 (34.2%)          |

(Risk factors)); (3) 1 AND 2. No language restriction was made. When the articles were published by the same study group and there was an overlap of the search period, only the most recent article was included to avoid duplication of data. The PubMed function “related articles” was used to extend the search. Also, we searched major infectious disease (Lancet Infectious Disease, Journal of Medical Virology, Journal of Infection, International Journal of Infectious Diseases), oncology (Journal of Clinical Oncology, Lancet Oncology), and general medicine journals (The Lancet, New England Journal of Medicine, British Medical Journal) reporting articles about COVID-19 infection to look for additional
studies. We then hand-searched the bibliographies of included studies to detect other potentially eligible investigations.

2.3. Eligibility criteria

All studies were screened and assessed for eligibility by three independent reviewers (I·C, B·N and V·K). The search results were screened by title and abstract, with those of potential relevance evaluated by full text. Studies were deemed eligible for inclusion if they fulfilled the following criteria: (1) observational cohort or case-control studies reporting malignancy frequency data in COVID-19 patients (>18 years old), (2) used appropriate definition of severe disease or compared survivors to non-survivors, (3) disease severity was monitored throughout the study, (4) clearly outlined the definition of “severe disease” and (5) sample size >10. A clinically valid definition of ‘severe disease’ (i.e. a composite of (1) respiratory distress, respiratory rate ≥ 30 per min; (2) oxygen saturation on room air at rest ≤93%; (3) partial pressure of oxygen in arterial blood/fraction of inspired oxygen ≤300 mmHg; (4) patients requiring mechanical ventilation/vital life support/intensive care unit admission (ICU); (5) death/mortality) was required for a study to be included. Reviews and studies with incomplete or irrelevant data were excluded. Any disagreements between reviewers arising during the eligibility assessment were settled through consensus.

2.4. Data extraction & quality assessment

Data extraction and quality assessment were conducted by three independent reviewers (I·C, B·N and V·K). For each study, the following
2.5. Outcomes of interest

The primary outcome of interest was the association between malignancies and COVID-19 severity, while the secondary outcome was the association between malignancies and COVID-19 mortality.

2.6. Statistical analysis

The statistical analysis was carried out using MetaXL (software version 5.3, EpiGear International Pty Ltd., Sunrise Beach, Australia) and Meta-Analyst (software version 5.26.14, Center for Evidence-Based Medicine, Brown University, Providence, USA). The strength of association between malignancies and COVID-19 severity and mortality was estimated using the odds ratio (OR). A random-effects model was applied. The magnitude of heterogeneity among the included studies was assessed using the chi-squared test (Chi [2]) and I-squared statistic ($I^2$). For the Chi [2] test, a Cochrane's Q p-value of <0.10 was considered significant. The values of the $I^2$ statistic were interpreted as follows at a 95% confidence interval: Thresholds of 25%, 50%, and 75% to designate low, moderate, and high heterogeneity were applied [4]. Random-effects meta-regression using log OR was performed to evaluate the impact of baseline characteristics (age and sex) on the study outcomes. Publication bias was assessed using funnel plots. Additionally, a leave-one-out sensitivity analysis was performed to assess the robustness of the results and to further probe the sources of inter-study heterogeneity.

3. Results

3.1. Study identification and characteristics of the included studies

The initial search produced 2986 potentially relevant articles. Following the removal of duplicates and primary screening, 54 articles were assessed by full text for eligibility in the meta-analysis. Of these, 34 were excluded because the primary and secondary outcomes of the study did not match that of this review. Thus, a total of 20 studies ($n = 4549$ patients) were included in this systematic review and meta-analysis (Fig. 1). Most of the studies were from China (15 studies), while the rest were from the United States (2 studies), Italy (2 studies) and South Korea (1 study). Fourteen studies reported data on malignancies in severe vs non-severe COVID-19 patients, while the rest reported data in COVID-19 survivors vs non-survivors. The characteristics of the included are summarized in Tables 1 and 2.
3.2. Primary outcome: meta-analysis of association of malignancies with COVID-19 severity

A total of 14 studies (n = 3513 patients [933 severe & 2580 non-severe]) reported data on the association between malignancies and COVID-19 severity. In the pooled analysis, malignancies were found to be associated with significantly increased odds of severe COVID-19 (OR = 2.17; 95% CI 1.47–3.196; p < 0.001), with no evidence of inter-study heterogeneity being observed for this outcome (Cochran’s Q = 6.558, p = 0.922, I² = 0%) (Fig. 2). No significant changes in the OR could be seen in the leave-one-out sensitivity analysis. In the meta-regression analysis, neither age (co-efficient = −0.040; 95% CI -0.125-0.044; p = 0.351) nor sex (co-efficient = 0.007; 95% CI -0.045-0.058; p = 0.797) of patients in the severe group had significant influence on association of malignancies and severity of COVID-19 (Figs. 3 and 4). Funnel plot revealed only mild asymmetry (Fig. 5).

3.3. Secondary outcome: meta-analysis of association of malignancies with COVID-19 mortality

A total of 6 studies (n = 1036 patients [590 survivors & 446 non-survivors]) reported data on the association between malignancies and mortality in COVID-19 patients. In the pooled analysis, malignancies were found to be associated with significantly increased odds of mortality in COVID-19 patients (OR = 2.39; 95% CI 1.18–4.85; p = 0.016). No evidence of inter-study heterogeneity was observed for this outcome (Cochran’s Q = 2.91, p = 0.71, I² = 0%) (Fig. 6). No significant changes in the OR could be seen in the leave-one-out sensitivity analysis. In the meta-regression analysis, neither age (co-efficient = 0.217; 95% CI -0.395–0.829; p = 0.487) nor sex (co-efficient = −0.084; 95% CI -0.411-0.243; p = 0.615) had significant influence on the association of malignancies and mortality in COVID-19 patients (Figs. 7 and 8). Due to the small number of studies, analysis for publication bias was not performed for this outcome.

4. Discussion

The results of this meta-analysis demonstrate that malignancies are associated with a worse prognosis in COVID-19 patients, with a 2-fold increase in the odds of severity and mortality.

Generally, cancer patients are known to have a higher susceptibility to life-threatening infections and sepsis from many pathogens, including viruses [25]. Williams and colleagues in 2004 demonstrated that compared to the general population, cancer patients are much more likely to be with severe sepsis (relative risk, 3.96; 95% confidence interval, 3.94–3.99) [26]. Mortality rates for these patients are also higher [25,26]. These observations are consistent with the findings of the current study. Similar findings have also been reported in previous epidemics such as the Middle-East Respiratory Syndrome Coronavirus (MERS-CoV) [27].

The increased risk of a severe form of COVID-19, as well as mortality in cancer patients could be a function of their immnosuppressed status, either due to the malignancy itself or treatment [28]. Further, cancer patients tend to be older and have more co-morbid conditions, both of which are established risk factors for poor outcomes in COVID-19 [29]. Recent studies have demonstrated a high level of expression of angiotensin converting enzyme 2 (ACE2) receptor, the transmembrane
receptor used by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) for entry into cells, in various types of cancers [30–32]. This could also partly explain the higher susceptibility of cancer patients to COVID-19, as well as the poor outcomes.

Our meta-analysis was limited by several factors, such as the small sample sizes of the studies included, particularly in the analysis of the secondary outcome (mortality). We could not perform a sub-group analysis to determine which cancers carried the highest odds of severe form of COVID-19 due to lack of adequate data. Further, most of the studies were from China, hence there is a possibility of patient overlap. Nonetheless, our study was strengthened by the lack of inter-study heterogeneity, robust analysis including leave-one out sensitivity analysis, meta-regression and analysis for potential publication bias. Larger studies are needed to confirm the findings of the current study.

5. Conclusion

The findings of this updated meta-analysis suggest that malignancies may be associated with a 2-fold increase in the odds of developing severe COVID-19 disease, as well as mortality. These patients should be closely monitored for any signs of unfavorable disease progression.

Funding

No funding was sought for this study.

Declaration of Competing Interest

None of the authors have any conflicts of interests with regard to this publication.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajem.2020.08.025.

References

[1] World Health Organization (WHO). Coronavirus disease 2019 (COVID-19) Situation Report – 192. Accessed 31st July 2020 https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200730-covid-19-sitrep-192.pdf?sfvrsn=5e52901f_8, 2020.
[2] Zheng Z, Peng F, Xu B, Zhao J, Liu H, Peng J, et al. Risk factors of critical & mortal COVID-19 cases: a systematic literature review and meta-analysis. J Infect; 2020 Apr;23.
[3] Moher D, Liberati A, Tetzlaff J, Altman DG, Prisma Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009 Jul 21;6(7):e1000097.
[4] Higgins JP, Green S. Cochrane handbook for systematic reviews of interventions 4.2. 6 [updated September 2006]. Cochrane Libr. 2006:4.
[5] Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, et al. Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med. 2020;382:1708–20.
[6] Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 2020;395:497–506.
[7] Zhang G, Hu C, Luo L, Fang F, Chen Y, Li J, et al. Clinical features and short-term outcomes of 221 patients with COVID-19 in Wuhan, China. J Clin Virol. 2020 Apr;5:104364.
[8] Yao Q, Wang P, Wang X, Qie G, Meng M, Tong X, et al. Retrospective study of risk factors for severe SARS-Cov-2 infections in hospitalized adult patients. Polish Arch Intern Med. 2020 Apr;24.
[9] Aggarwal S, Garcia-Telles N, Aggarwal G, Lavie C, Lippi G, Henry BM. Clinical features, laboratory characteristics, and outcomes of patients hospitalized with coronavirus disease 2019 (COVID-19): early report from the United States. Diagnosis. 2020 May 26;7(2):91–6.
[10] Wang D, Hu B, Hu C, et al. Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel coronavirus-infect ed pneumonia in Wuhan, China. JAMA 2020.
[11] Hong KS, Lee KH, Chung JH, Shin KC, Choi EY, Jin HJ, et al. Clinical features and outcomes of 98 patients hospitalized with SARS-CoV-2 infection in Daegu, South Korea: a brief descriptive study. Yonsei Med J. 2020 May;61(5):431–7.
[12] Li X, Xu S, Yu M, Wang K, Tao Y, Zhou Y, et al. Risk factors for severity and mortality in adult COVID-19 inpatients in Wuhan. J Allergy Clin Immunol. 2020 Apr;12.
[13] Wang Z, Yang B, Li Q, Wen L, Zhang R. Clinical features of 69 cases with coronavirus disease 2019 in Wuhan. Clinical Infectious Diseases; China: 2020 Mar 16.
[14] Wan S, Xiang Y, Fang W, Zheng Y, Li B, Hu Y, et al. Clinical features and treatment of COVID-19 patients in Northeast Chongqing. J Med Virol. 2020 Mar;21.
[15] Goyal P, Choi JJ, Pinheiro LC, Schenck EJ, Chen R, Jabi A, et al. Clinical characteristics of COVID-19 in New York City. New England J Med. 2020 Apr;17.
[16] Peng Y, Ling Y, Bai T, Xie Y, Huang J, Li J, et al. COVID-19 with different severity: a multi-center study of clinical features. Am J Respir Crit Care Med. 2020 Apr;10 ja.
[17] Colaneri M, Sacchi P, Zuccarini V, Biscarini S, Sachs M, Roda S, et al. Clinical characteristics of coronavirus disease (COVID-19) early findings from a teaching hospital in Pavia, Northern Italy, 21 to 28 February 2020. Eurosurveillance. 2020 Apr 23;25(16):2000460.
[18] Zhu Z, Cai T, Fan L, Lou K, Hua X, Huang Z, et al. Clinical value of immune-inflammatory parameters to assess the severity of coronavirus disease 2019. Int J Infect Dis. 2020 Apr;22.
[19] Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet [Internet]. 2020;395:1054–62 Available from: https://doi.org/10.1016/S0140-6736(20)30566-3.
[20] Chen T, Wu D, Chen H, Yan W, Yang D, Chen G, et al. Clinical characteristics of 113 deceased patients with coronavirus disease 2019: Retrospective study. BMJ [Internet]. 2020;2020;368(March):1–14 Available from: https://doi.org/10.1136/bmj.m1091.
[21] Yang X, Yu Y, Xu J, Shu H, Xia J, Liu H, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. Lancet Respir Med [Internet]. 2020;8(5):475–81 Available from: https://doi.org/10.1016/S2213-2600(20)30079-5.
[22] Deng Y, Liu W, Liu K, et al. Clinical characteristics of fatal and recovered cases of coronavirus disease 2019 (COVID-19) in Wuhan, China: a retrospective study. Chin Med J (Engl). 2020;133(1):1261–7. https://doi.org/10.1097/CM9.0000000000000824.
[23] Ruan Q, Yang K, Wang W, Jiang L, Song J, Clinical predictors of mortality due to COVID-19 based on an analysis of data of 150 patients from Wuhan. Intensive Care Med; China: 2020.
[24] Bonetti M, Manelli F, Patrini A, Bettinardi A, Borrelli G, Fiordalisi G, et al. Laboratory predictors of death from coronavirus disease 2019 (COVID-19) in the area of Valcamonica, Italy. Clinical Chemistry and Laboratory Medicine (CCLM): . 2020 Apr 28;1 ahead-of-print.
[25] Rosolem MM, Rabello LS, Lisboa T, Caruso P, Costa RT, Leaf JV, et al. Critically ill patients with cancer and sepsis: clinical course and prognostic factors J Crit Care. 2012 Jun 1;27(3):301–7.
[26] Williams MD, Braun LA, Cooper LM, Johnston J, Weiss RV, Quayle RL, et al. Hospitalized cancer patients with severe sepsis: analysis of incidence, mortality, and associated costs of care. Crit Care. 2004 Oct;7(4):R291.
[27] Park JE, Jung S, Kim A. MERS transmission and risk factors: a systematic review. BMC Public Health. 2018 Dec 1;18(1):574.
[28] Sidaway P. COVID-19 and cancer: what we know so far. Nat Rev Clin Oncol. 2020 Apr;7:1.
[29] Al-Quteimat OM, Amer AM. The impact of the COVID-19 pandemic on cancer patients. Am J Clin Oncol. 2020 Apr;16.
[30] Cai C, Ahmed OA, Shen H, Zeng S. Which cancer type has the highest risk of COVID-19 infection? J Infect. 2020 May;19.
[31] Dai YJ, Hu F, Li H, Huang HY, Wang DW, Liang Y. A profiling analysis on the receptor ACE2 expression reveals the potential risk of different type of cancers vulnerable to SARS-CoV-2 infection. Ann Transl Med. 2020 Apr;8(7).
[32] Zhang L, Han X, Shi Y. Comparative analysis of SARS-CoV-2 receptor ACE2 expression in multiple solid tumors and matched non-diseased tissues. Infect Genet Evol. 2020 Jun 18;104428.