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SYNOPSIS

12/09/2020

COVID-19 Infection Fatality Rates Reported in Two Studies by Ioannidis et al.

This synopsis gives an overview of relevant evidence in relation to two publications for which article citations follow:

1. Ioannidis JPA, Axfors C, Contopoulos-Ioannidis DG. Population-level COVID-19 mortality risk for non-elderly individuals overall and for non-elderly individuals without underlying diseases in pandemic epicenters. Environ Res. 2020;188:109890. Available from: https://doi.org/10.1016/j.envres.2020.109890

2. Ioannidis JPA. Infection fatality rate of COVID-19 inferred from seroprevalence data. Bull World Health Organ. 2020 Oct 14 [Epub ahead of print]. Available from: https://www.who.int/bulletin/online_first/BLT.20.265892.pdf

Key Findings

- Ioannidis et al. provide evidence of the previously known and well-documented age-dependent gradient in Coronavirus Disease 2019 (COVID-19)-associated mortality:
    - In a cross-sectional study of publicly reported data on COVID-19 deaths, the risk of death from COVID-19 in patients <65 years of age was 30 to 100-fold lower than that for patients ≥65 years of age in Canada and 11 European countries, and 16 to 52-fold lower in 13 United States (US) states.[1]
    - In an article reviewing seroprevalence and mortality data of COVID-19 from 51 locations, the median infection fatality rate of COVID-19 was estimated at 0.27% (range 0.00%–1.63%) overall, and at 0.05% (range 0.00%–0.31%) for people <70 years of age.[2]
- Ioannidis et al. speculate that a preventive approach of shielding vulnerable elderly could be used without a broad lockdown. They did not include in their analyses; however, consideration for the body of evidence that protection of the more vulnerable elderly population cannot be achieved by public health measures targeting this group in isolation, as transmission (and outbreaks) occur within households, institutions and the community where different age groups are present or interact.[3-13]
- The reviewed papers by Ioannidis et al. do not provide evidence to support the lead author's public statements against restrictive public health measures such as lockdowns.[14,15]

Current Status

- In response to rising cases and reduced health system capacity in Ontario, and in accordance with the recently launched framework for Keeping Ontario Safe and Open,[16] the Ontario government moved Toronto and Peel Region into the grey "lockdown" level of restrictions as of November 23, 2020.[17]

- The approach in Ontario is consistent with other jurisdictions which have re-implemented restrictive 'lockdown' measures to various degrees after witnessing a rise in COVID-19 incidence, hospitalization, and/or intensive care unit (ICU) admissions due to COVID-19. These countries include Belgium;[18] England;[19] France;[20] Israel;[21] Italy;[22] Northern Ireland;[23] Spain;[24] State of Victoria, Australia.[25] Further details on approaches to restrictive and lockdown public health measures in other jurisdictions can be found in the recent Public Health Ontario (PHO) scan on this topic.[26]

- During the first wave of the pandemic, lockdowns were effective at reducing the spread of, hospitalization rates and deaths from COVID-19,[27-29] and earlier adoption of lockdowns and accompanying measures was associated with an overall decreased burden of COVID-19.[30-34] However, evidence regarding the necessary stringency level of lockdown measures was mixed, and the stringency of second wave lockdowns, while still an evolving situation, appears more varied in recognition of the societal impacts of pandemic interventions.[35]

Article 1

Ioannidis JPA, Axfors C, Contopoulos-Ioannidis DG. Population-level COVID-19 mortality risk for non-elderly individuals overall and for non-elderly individuals without underlying diseases in pandemic epicenters. Environ Res. 2020;188:109890. Available from: https://doi.org/10.1016/j.envres.2020.1098901

Summary

- In the cross-sectional study by Ioannidis et al., publicly reported data on COVID-19 deaths from 14 countries and 13 US states with at least 800 COVID-19 deaths as of April 24 were reviewed:

    - Individuals <65 years accounted for 4.5%–11.2% of all COVID-19 deaths in Canada and 11 European countries, and 8.3%–22.7% in the US locations. The risk of dying from COVID-19 was 30 to 100-fold lower in the younger age group than that for people >64 years in Canada and 11 European countries, and 16 to 52-fold lower than that of people >64 years in US locations.

    - The absolute risk of COVID-19 death per million as of June 17, 2020 for people <65 years old in high-income countries ranged from 10 (Germany) to 349 (New Jersey).

    - The absolute risk of COVID-19 death per thousand for people >79 years old ranged from 0.6 (Florida) to 17.5 (Connecticut).

PHO Reviewer Comments

- Deaths in many of the jurisdictions are now more than double those reported in the article (e.g., Illinois had 4,800 COVID-19 associated deaths as of June 2020, compared with over 12,000 in November 2020).

- The authors report an *absolute risk* of mortality in the population with data on deaths up to June 17; as such, their denominator is the full population in each age group, not individuals with COVID-19 (i.e., case fatality was not estimated). As noted, the results can only be interpreted as a cross-sectional viewpoint representing the first wave and are not reflective of the size of the epidemic.

- It is important to note that the absolute risk of death is conditioned on becoming a case and this risk was reduced in the first wave due to large-scale lockdowns.

- The authors limited their studies to jurisdictions with >800 deaths as of April 24 and examined mortality data as of June 17 to account for the lag from infection to death. Given the epidemic curve of infections in Canada, there were likely to have been additional deaths after June 17 that were part of the first wave but were not captured in this analysis, thereby underestimating the absolute risk. The authors provide estimates of the timing of the death data used in their analysis relative to the peak of the first wave by jurisdiction. In Canada, this peak was estimated at 4-7 weeks prior whereas the majority of European jurisdictions had peaked more than 9 weeks ago (and therefore may have better capture of mortality data).

- The COVID-19 mortality reported does not account for undetected COVID-19 associated deaths.[36]

- Testing criteria varied widely by country, and also likely changed over the included time frame within a jurisdiction. Regardless, there was likely substantial under-detection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) related deaths, particularly in certain jurisdictions.

- The comparison of absolute risk of COVID-19 mortality to absolute risk from driving a motor vehicle is misleading, and not comparable across countries with relatively safe versus dangerous road infrastructure. In addition, many of the jurisdiction-specific ratios presented have more than doubled since the first wave.

- The authors acknowledge that their focus on mortality risk does not include impacts of hospitalization morbidity from COVID-19. Further, the authors do not consider or discuss other health outcome impacts by age group that contribute to societal impacts.

- The authors also acknowledge that morbidity may vary across countries due to effects of deprivation, access to health services and undiagnosed conditions, and that different patterns of morbidity in the non-elderly may be due to the socioeconomic profile of the jurisdiction. While age may be the major driver of differential mortality risk, there are important equity-based considerations in understanding risk of dying from COVID-19 in non-elderly populations if public health measures were to focus on the risk to the elderly only.[37]

Article 2

Ioannidis JPA. Infection fatality rate of COVID-19 inferred from seroprevalence data. Bull World Health Organ. 2020 Oct 14 [Epub ahead of print]. Available from: https://www.who.int/bulletin/online_first/BLT.20.265892.pdf[2]

Summary

- In the review article on seroprevalence and mortality data published as of September 9, 2020 from 51 different locations:
    - Seroprevalence varied widely (range = 0.02%–53.40%) due to varied methodologies in adjusting for test performance, sampling strategies, clustering, etc.
    - The median infection fatality rates of COVID-19, after adjusting for variations in sample size, was estimated at 0.23% overall (range = 0.00%–1.54%); and at 0.05% for people <70 years of age (from 40 locations with data).

PHO Reviewer Comments

- The author combined all seroprevalence estimates into one analysis, and this is a central limitation of this study. Stratifying the estimates into various groups would have resulted in more meaningful estimates for the following reasons:
    - The populations sampled vary greatly (ranging from slums in Mumbai, to New York City, to the Faroe Islands). Conceptually speaking, there are many differences between these populations rendering it inappropriate to analyze them together.
    - The type of serology testing methods varies greatly between studies. This is important because the choice of laboratory methods for seroprevalence studies can directly affect the results.
    - Results of different antibody isotypes (IgG, IgM, IgA) should not be analyzed together, as each has its own role within the immune response to COVID-19. While IgM and IgA are acute markers of infection, IgG responses are made later in infection and last longer.
    - There is great variability in the quality of studies performed. A quality assessment of each study would have been beneficial to ensure that the included studies were of adequate quality for inclusion, and so that any bias was characterized.
- The author applies statistical adjustments to the estimates that are not necessarily warranted. For example, seroprevalence estimates have been corrected upwards by one tenth if a study did not measure IgM or IgA.
- Although acknowledged in the discussion section, the author does not correct estimates to account for the fact that not all COVID-19-infected individuals mount an antibody response, and that antibody levels can decline over time.
- Of note, a study reporting Ontario COVID-19 infection fatality rates using seroprevalence data was recently published, using seroprevalence estimates from the Canadian Blood Services

seroprevalence survey. The study estimates the overall infection fatality rate in Ontario to be 0.8% (95% confidence interval, 0.75 to 0.85).

Conclusions

- The strong age-gradient for COVID-19–associated mortality is not controversial and was accurately estimated in March 2020.[38] However, the infection fatality rate estimates by Ioannidis et al. are lower than those reported in multiple other studies.[38-40]

- The articles by Ioannidis et al. speculate that 'shielding' the elderly or at-risk individuals, while minimizing measures used for other population groups who are less likely to experience severe illness, can be a public health strategy. There is currently little evidence that such shielding approaches can be effectively implemented across an entire jurisdiction, despite efforts.

- Although COVID-19 infections tend to be less severe in younger patients, cardiovascular, pulmonary and other neurological sequelae may be expected based on the pathophysiology of COVID-19, what is known about other infectious diseases,[41] and what is being learned about SARS-CoV-2 specifically.[42,43] Furthermore, factors at individual, biological and societal levels that increase the risk of infection and severe outcomes are still being understood.[44,45] It would not be possible to equitably shield non-elderly individuals who might be at risk.

- Public health agencies globally have supported the use of physical distancing measures and lockdowns to control community transmission of COVID-19, recognizing that high community transmission renders protection or shielding of higher-risk populations virtually impossible due to the connections within the broader community in which they live. Further, an approach to strict isolation of at-risk populations can also be considered inhumane and unethical.[47]

References

1. Ioannidis JPA, Axfors C, Contopoulos-Ioannidis DG. Population-level COVID-19 mortality risk for non-elderly individuals overall and for non-elderly individuals without underlying diseases in pandemic epicenters. Environ Res. 2020;188:109890. Available from: https://doi.org/10.1016/j.envres.2020.109890

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3. Schwartz NG, Moorman AC, Makaretz A, Chang KT, Chu VT, Szablewski CM, et al. Adolescent with COVID-19 as the source of an outbreak at a 3-week family gathering - four states, June-July 2020. MMWR Morb Mortal Wkly Rep. 2020;69(40):1457-9. Available from: https://doi.org/10.15585/mmwr.mm6940e2

4. Grijalva CG, Rolfes MA, Zhu Y, McLean HQ, Hanson KE, Belongia EA, et al. Transmission of SARS-CoV-2 infections in households - Tennessee and Wisconsin, April-September 2020. MMWR Morb Mortal Wkly Rep. 2020;69(44):1631-4. Available from: https://doi.org/10.15585/mmwr.mm6944e1

5. Lei H, Xu X, Xiao S, Wu X, Shu Y. Household transmission of COVID-19-a systematic review and meta-analysis. J Infect. 2020;81(6):979-97. Available from: https://doi.org/10.1016/j.jinf.2020.08.033

6. Jing QL, Liu MJ, Zhang ZB, Fang LQ, Yuan J, Zhang AR, et al. Household secondary attack rate of COVID-19 and associated determinants in Guangzhou, China: a retrospective cohort study. Lancet Infect Dis. 2020;20(10):1141-50. Available from: https://doi.org/10.1016/s1473-3099(20)30471-0

7. Blackman C, Farber S, Feifer RA, Mor V, White EM. An illustration of SARS-CoV-2 dissemination within a skilled nursing facility using heat maps. J Am Geriatr Soc. 2020;68(10):2174-8. Available from: https://doi.org/10.1111/jgs.16642

8. McMichael TM, Currie DW, Clark S, Pogosjans S, Kay M, Schwartz NG, et al. Epidemiology of COVID-19 in a long-term care facility in King County, Washington. N Engl J Med. 2020;382(21):2005-11. Available from: https://doi.org/10.1056/NEJMoa2005412

9. Graham NSN, Junghans C, Downes R, Sendall C, Lai H, McKirdy A, et al. SARS-CoV-2 infection, clinical features and outcome of COVID-19 in United Kingdom nursing homes. J Infect. 2020;81(3):411-9. Available from: https://doi.org/10.1016/j.jinf.2020.05.073

10. Ladhani SN, Chow JY, Janarthanan R, Fok J, Crawley-Boevey E, Vusirikala A, et al. Investigation of SARS-CoV-2 outbreaks in six care homes in London, April 2020. EClinicalMedicine. 2020;26:100533. Available from: https://doi.org/10.1016/j.eclinm.2020.100533

11. Taylor J, Carter RJ, Lehnertz N, Kazazian L, Sullivan M, Wang X, et al. Serial testing for SARS-CoV-2 and virus whole genome sequencing inform infection risk at two skilled nursing facilities with COVID-19 outbreaks - Minnesota, April - June 2020. MMWR Morb Mortal Wkly Rep. 2020;69(37):1288-95. Available from: https://doi.org/10.15585/mmwr.mm6937a3

12. Escobar DJ, Lanzi M, Saberi P, Love R, Linkin DR, Kelly JJ, et al. Mitigation of a coronavirus disease 2019 outbreak in a nursing home through serial testing of residents and staff. Clin Infect Dis. 2020 Jul 20 [Epub ahead of print]. Available from: https://doi.org/10.1093/cid/ciaa1021

13. Kim JJ, Coffey KC, Morgan DJ, Roghmann M-C. Lessons learned – outbreaks of COVID-19 in nursing homes. Am J Infect Control. 2020;48(10):1279-80. Available from: https://doi.org/10.1016/j.ajic.2020.07.028

14. Ioannidis J. John Ioannidis: another shutdown would do more harm than good. National Post [Internet], 2020 Aug 13 [cited 2020 Nov 27]; Full Comment. Available from: https://nationalpost.com/opinion/john-ioannidis-another-shutdown-would-do-more-harm-than-good

15. Shaban B, Campos R, Rutanashoodech A, Villarreal M, Carroll J. Stanford professor warns COVID shelter-in-place orders are 'killing people'. NBC Bay Area [Internet], 2020 Oct 07 [modified 2020 Oct 19; cited 2020 Nov 27]; Investigative. Available from: https://www.nbcbayarea.com/investigations/stanford-professor-warns-covid-shelter-in-place-orders-are-killing-people/2376796/

16. Government of Ontario. COVID-19 response framework: keeping Ontario safe and open [Internet]. Toronto, ON: Queen's Printer for Ontario; 2020 [modified 2020 Nov 13; cited 2020 Nov 26]. Available from: https://files.ontario.ca/moh-covid-19-response-framework-keeping-ontario-safe-and-open-en-2020-11-13.pdf

17. Government of Ontario, Office of the Premier. News release: Ontario taking further action ot stop the spread of COVID-19 [Internet]. Toronto, ON: Queen's Printer for Ontario; 2020 [cited 2020 Nov 25]. Available from: https://news.ontario.ca/en/release/59305/ontario-taking-further-action-to-stop-the-spread-of-covid-19

18. EPISTAT. COVID-19: historical datasets [Internet]. Brussels: Sciensano; 2020 [modified 2020 Nov 03; cited 2020 Nov 03]. Available from: https://epistat.sciensano.be/covid/covid19_historicaldata.html

19. Public Health England. Coronavirus (COVID-19) in the UK [Internet]. London: Crown copyright; 2020 [modified 2020 Nov 17; cited 2020 Nov 17]. Available from: https://coronavirus.data.gov.uk/details/cases

20. Ellyatt H. Paris put on 'maximum alert' as more COVID-19 restrictions are imposed. CNBC News [Internet], 2020 Oct 05 [cited 2020 Nov 05]; Europe Economy. Available from: https://www.cnbc.com/2020/10/05/paris-to-be-put-on-maximum-alert-with-more-covid-19-restrictions-.html

21. Government of Israel. Joint PMO - Health Ministry - Finance Ministry statement. Jerusalem: Government of Israel; 2020 [cited 2020 Nov 17]. Available from: https://www.gov.il/BlobFolder/news/foreign-workers-lockdown/he/Regulations-eng-17-9.pdf

22. Paterlini M. COVID:19: Italy has wasted the sacrifices of the first wave, say experts. BMJ. 2020;371:m4279. Available from: https://doi.org/10.1136/bmj.m4279

23. Blevins D. COVID-19: Northern Ireland 'circuit-breaker' extended after confusion over deadline. Sky News [Internet], 2020 Nov 13 [cited 2020 Nov 17]; UK. Available from:

https://news.sky.com/story/covid-19-northern-ireland-circuit-breaker-extended-after-confusion-over-deadline-12131304

24. Gobierno de España. Government decrees state of emergency to provide full constitutional coverage to measures necessary to tackle pandemic in regions [Internet]. Madrid: Gobierno de España; 2020 [cited 2020 Nov 17]. Available from: https://www.lamoncloa.gob.es/lang/en/presidente/news/paginas/2020/20201025state-emergency.aspx

25. Australia. Premier of Victoria. Statement on changes to Melbourne's restrictions [Internet]. Melbourne: State Government of Victoria; 2020 [cited 2020 Nov 17]. Available from: https://www.premier.vic.gov.au/statement-changes-melbournes-restrictions

26. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Environmental scan: 'lockdown' public health measures during the COVID-19 pandemic [Internet]. Toronto, ON: Queen's Printer for Ontario; 2020 [cited 2020 Nov 27]. Available from: https://www.publichealthontario.ca/-/media/documents/ncov/main/2020/11/covid-19-lockdown-public-health-measures.pdf?la=en

27. Santamaría L, Hortal J. COVID-19 effective reproduction number dropped during Spain's nationwide dropdown, then spiked at lower-incidence regions. Sci Total Environ. 2021;751:142257. Available from: https://doi.org/10.1016/j.scitotenv.2020.142257

28. Edelstein M, Obi C, Chand M, Hopkins S, Brown K, Ramsay M. SARS-CoV-2 infection in London, England: impact of lockdown on community point-prevalence, March-May 2020. medRxiv 20109017 [Preprint]. 2020 May 25 [cited 2020 Nov 17]. Available from: https://doi.org/10.1101/2020.05.21.20109017

29. Keshet A, Gavrieli A, Rossman H, Shilo S, Meir T, Karady T, et al. The effect of a national lockdown in response to COVID-19 pandemic on the prevalence of clinical symptoms in the population. medRxiv 20076000 [Preprint]. 2020 Jun 17 [cited 2020 Nov 17]. Available from: https://doi.org/10.1101/2020.04.27.20076000

30. Ghosal S, Bhattacharyya R, Majumder M. Impact of complete lock-down on total infection and death rates: a hierarchical cluster analysis. Diabetes Metab Syndr. 2020;14(4):707-11. Available from: https://doi.org/10.1016/j.dsx.2020.05.026

31. Hooper VJ. Global determinants of COVID-19 deaths: lockdown dates and social distancing measures mattered. medRxiv 20163394 [Preprint]. 2020 Jul 29 [cited 2020 Nov 17]. Available from: https://doi.org/10.1101/2020.07.28.20163394

32. Loewenthal G, Abadi S, Avram O, Halabi K, Ecker N, Nagar N, et al. COVID-19 pandemic-related lockdown: response time is more important than its strictness. EMBO Mol Med. 2020;12(11):e13171. Available from: https://doi.org/10.15252/emmm.202013171

33. Medline A, Hayes L, Vahedi F, Valdes K, Sonnenberg J, Capell W, et al. Evaluating the efficacy of stay-at-home orders: does timing matter? medRxiv 20117853 [Preprint]. 2020 Jun 04 [cited 2020 Nov 17]. Available from: https://doi.org/10.1101/2020.05.30.20117853

34. Islam N, Sharp SJ, Chowell G, Shanam S, Kawachi I, Lacey B, et al. Physical distancing interventions and incidence of coronavirus disease 2019: natural experiment in 149 countries. BMJ. 2020;370:m2743. Available from: https://doi.org/10.1136/bmj.m2743

35. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Negative impact of community-based public health measures during a pandemic (e.g., COVID-19) on children and families [Internet]. Toronto, ON: Queen's Printer for Ontario; 2020 [cited 2020 Nov 18]. Available from: https://www.publichealthontario.ca/-/media/documents/ncov/cong/2020/06/covid-19-negative-impacts-public-health-pandemic-families.pdf?la=en

36. Statistics Canada. Provisional death counts and excess mortality, January to August 2020 [Internet]. Ottawa, ON: Government of Canada; 2020 [modified 2020 Nov 19; cited 2020 Nov 27]. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/201028/dq201028b-eng.htm

37. Subedi R, Greenberg L, Turcotte M; Statistics Canada. StatCan COVID-19: data to insights for a better Canada: COVID-19 mortality rates in Canada's ethno-cultural neighbourhoods [Internet]. Ottawa, ON: Government of Canada; 2020 [modified 2020 Oct 28; cited 2020 Nov 27]. Available from: https://www150.statcan.gc.ca/n1/pub/45-28-0001/2020001/article/00079-eng.htm

38. Verity R, Okell LC, Dorigatti I, Winskill P, Whittaker C, Imai N, et al. Estimates of the severity of coronavirus disease 2019: a model-based analysis. Lancet Infect Dis. 2020;20(6):669-77. Available from: https://doi.org/10.1016/S1473-3099(20)30243-7

39. Meyerowitz-Katz G, Merone L. A systematic review and meta-analysis of published research data on COVID-19 infection fatality rates. Int J Infect Dis. 2020;101:138-48. Available from: https://doi.org/10.1016/j.ijid.2020.09.1464

40. O'Driscoll M, Dos Santos GR, Wang L, Cummings DAT, Azman AS, Paireau J, et al. Age-specific mortality and immunity patterns of SARS-CoV-2. Nature. 2020 Nov 02 [Epub ahead of print]. Available from: https://doi.org/10.1038/s41586-020-2918-0

41. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Long-term sequelae and COVID-19 - what we know so far [Internet]. Toronto, ON: Queen's Printer for Ontario; 2020 [cited 2020 Nov 26]. Available from: https://www.publichealthontario.ca/-/media/documents/ncov/covid-wwksf/2020/07/what-we-know-covid-19-long-term-sequelae.pdf?la=en

42. Datta SD, Talwar A, Lee JT. A proposed framework and timeline of the spectrum of disease due to SARS-CoV-2 infection: illness beyond acute infection and public health implications. JAMA. 2020;324(22):2251-2. Available from: https://doi.org/10.1001/jama.2020.22717

43. Centers for Disease Control and Prevention. Multisystem inflammatory syndrome (MIS-C) [Internet]. Atlanta, GA: Centers for Disease Control and Prevention; 2020 [cited 2020 Nov 27]. Available from: https://www.cdc.gov/mis-c/

44. Muñoz-Price LS, Nattinger AB, Rivera F, Hanson R, Gmehlin CG, Perez A, et al. Racial disparities in incidence and outcomes among patients with COVID-19. JAMA Netw Open. 2020;3(9):e2021892. Available from: https://doi.org/10.1001/jamanetworkopen.2020.21892

45. Ontario Agency for Health Protection and Promotion (Public Health Ontario). COVID-19 - What we know so far about... social determinants of health [Internet]. Toronto, ON: Queen's Printer for

Ontario; 2020 [cited 2020 Nov 27]. Available from: https://www.publichealthontario.ca/-/media/documents/ncov/covid-wwksf/2020/05/what-we-know-social-determinants-health.pdf?la=en

46. Bhattacharya J, Gupta S, Kulldorff M. Great Barrington Declaration [Internet]. Great Barrington, MA: Great Barrington Declaration; 2020 [cited 2020 Nov 27]. Available from: https://gbdeclaration.org/

47. Alwan NA, Burgess RA, Ashworth S, Beale R, Bhadelia N, Bogaert D, et al. Scientific consensus on the COVID-19 pandemic: we need to act now. Lancet. 2020;396(10260):e71-2. Available from: https://doi.org/10.1016/s0140-6736(20)32153-x Erratum in: Lancet. 2020;396(10261):1490.

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