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ORIGINAL RESEARCH

Health Inequality in the Global Burden of Chronic Obstructive Pulmonary Disease: Findings from the Global Burden of Disease Study 2019

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Background: This study assessed health inequality in the global burden of chronic obstructive pulmonary disease (COPD) between 1990 and 2019 using data extracted from the Global Burden of Diseases (GBD 2019) study.

Methods: Data were extracted from the GBD 2019 study. A series of comparative and descriptive analyses of the disease burden between women and men in countries with different socioeconomic development (SDI) status were performed. The slope index of inequality (SII), relative index of inequality (RII), and concentration index (CI) were calculated to measure the socioeconomic-related cross-national health inequity between 1990 and 2019.

Results: The global health burden caused by COPD increased by 25.7% in terms of disability-adjusted life years (DALY) from 59.2 million years in 1990 to 74.4 million years in 2019. Global age-standardized DALY rate (ASDR) associated with COPD decreased by 40.0%, from 1537.7 per 100,000 population in 1990 to 926.1 per 100,000 population in 2019. The highest sex-specific DALY number was at age 70–74 in male and female, and female is lower than male. However, after controlling for population size, the burden of COPD is more concentrated in the population living in low SDI countries, relative health inequality indicators (RII and CI) supported this conclusion.

Conclusion: The health inequalities caused by the disparity of socioeconomic status are increasing, and the increasing concentration of wealth worldwide is likely to aggravate health inequalities associated with COPD.

Keywords: chronic obstructive pulmonary disease, disease burden, health inequality

Introduction

Chronic Obstructive Pulmonary Disease (COPD), which is characterized by progressive, partially irreversible airflow limitation, is a progressive inflammatory disease.[1] It is one of the leading causes of death and disability globally, accounting for 41.9 deaths per 100,000 individuals and a total of 1068.02 DALY rate per 100,000 in 2017.[2] This may be aggravated by global population growth and the increase in the aging population in the coming decades.[3] The global health burden caused by COPD is not homogeneous, but differs according to region and gender, which can be affected by demographic characteristics,[4,5] air pollution,[6,7] and the prevalence of smoking in different countries or territories.[8] These factors reflect the health burden gap in the socioeconomic dimension between developed and non-developed countries.

In the past decades, the rapid global industrialization resulted in a transfer of air pollution sources as well as the prevalence of smoking.[7–9] The continuously increasing disparities in infrastructure and accessibility to health resources between developed and non-developed countries may further increase the inequality in the COPD burden with respect to

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socioeconomic status.[10–12] Despite this, the literature is not up-to-date on this topic. Here, we measured the health inequality in the COPD burden by focusing on poorer countries and women. For this purpose, we performed a second analysis of the Global Burden of Diseases study (GBD 2019) to identify challenges and opportunities for reducing the disease burden and to provide evidence for policy making.

Methods

Data Sources

The annual global, regional and national disability-adjusted life years (DALY) related to COPD, and population and socio-demographic index (SDI) data were downloaded from GBD 2019 for a second analysis.[13–15] DALY is a comprehensive measure of the quantity and quality of life in terms of time; it was first jointly proposed by Harvard University and the World Health Organization (WHO) in 1988 and successfully used in the estimation of disease burden in the updated GBD study.[16] It quantifies the burden of disease by calculating the loss of total healthy life years, including the loss of healthy life years caused by premature death (YLLs) and the loss of healthy life years due to disability (YLDs). The overall estimation of COPD-related DALY in the GBD 2017 study is based on an extensive literature search including 2361 data sources to provide estimates of prevalence, death from the disease based on the DisMod-MR model, and the calculation of YLL and YLD according to the prevalence and death data, which are added to obtain the DALY value.[14] Additional information about the estimation of DALY is available in the supplementary materials of the GBD 2019 study.[16] SDI is a composite indicator of the developmental status of countries and territories. It is the geometric mean of the indices of total fertility rates under the age of 25 (TFU25), mean education for those aged 15 and older (EDU15+), and lag distributed income (LDI) per capita. SDI ranges from 0 to 1, and a higher SDI value indicates a better socioeconomic and demographic development of a country. In this study, SDI was used as the basis for ranking countries and territories.[13]

Measures of Cross-National Health Inequality

We used methods recommended by the WHO to measure the socioeconomic-related cross-national health inequity in COPD burden by calculating the slope index of inequality (SII), relative index of inequality (RII), and concentration index (CI).[17] To quantify cross-national health inequality in the socioeconomic dimension, countries or territories (195) were first ranked from the most disadvantaged (rank zero) to the most advantaged (rank 1) according to SDI values. This ranking is weighted to account for the proportional distribution of the population within each country, and the weighted rank of each country is the midpoint of the country's cumulative proportional population. SII is the slope of the regression line between national age-standardized DALY rates (ASDR) related to COPD and the weighted rank of each country. To eliminate the influence of burden values, the SII was divided by the global ASDR to obtain the RII. The CI was used to measure the relative inequity of COPD burden among countries by fitting a Lorenz concentration curve between the cumulative DALY number and the cumulative population. CI is the result of the numerical integration of the area under the curve, which ranges from −1 to 1. A negative CI value indicates that the burden from COPD is more concentrated in the population living in a low SDI country. To focus on the analysis of women, we estimated sex-specific SII, RII, and CI.

Results

Overall Status

The global health burden caused by COPD increased by 25.7% in the past 28 years in terms of the DALY number, from 59.2 million years in 1990 to 74.4 million years in 2019. However, the development trends varied among regions. Most WHO regions showed an apparent increase in the same period, and the largest increase was observed in the Eastern Mediterranean region and regions of the America, which showed growth rates of 80.0% and 87.2%, respectively. One of six WHO regions showed a decreasing trend in DALY number, the Western Pacific Region (−16.9%). The significant increase in global COPD burden may be the consequence of global population growth and population aging. As estimated in the GBD 2019 study, after removing the effect of population size and age structure, the ASDR among all

WHO regions decreased, although the extent of the decline varies from region to region. As a result, the global ASDR caused by COPD decreased by 40.0%: from 1537.7 per 100,000 population in 1990 to 926.1 per 100,000 population in 2019. A total of 195 countries and territories around the world were divided into high, high-middle, middle, low-middle, and low SDI regions according to the SDI value reported in the GBD 2019 study, and the magnitude and temporal trends of the COPD burden in different SDI regions were estimated. The high-middle SDI region was the only one that showed a decreasing trend in DALY number between 1990 and 2019; however, regarding ASDR values, all SDI regions showed a decreasing trend, with patterns similar to the WHO regions (Table 1).

In general, men bear a larger COPD burden than women whether from the perspective of DALY number or ASDR. In 2019, the global male-specific DALY number was estimated at 42 million years, with is 29.9% higher than the 32 million years for females. The male-specific ASDR was 1149.1 (95% UI 1050.1, 1257.3) per 100,000 population, which is 54.4% higher than the 744.1 (95% UI 652.2, 822.2) for women in the same year (Table 2). The constitution of the DALY value differs between men and women, with years of life lost (YLL) accounting for a higher proportion of the DALY in men than in women. The highest sex-specific DALY number was at age 70–74 in male and female, and female is lower than male; however, after controlling for population size, there was a difference in the age range of the highest burden between men and women (95 plus in women vs 85–89 in men) (Figure 1).

As shown in Figure 2, for DALYs, Nepal (3318.4 per 100,000 population), and India (2000.6 per 100,000 population) were the 2 countries with the greatest COPD burdens worldwide in 2019. United Arab Emirates (917.2), and Qatar (537.4%) were the top 2 countries with the largest increase change in COPD cases, Ukraine (−50.7%) and Belarus (−38.6%) were the top 2 countries with the largest decrease change in COPD cases.

Cross-National Health Inequality

The DALY number due to COPD was disproportionately concentrated in populations living in low SDI countries (or territories), and between 1990 and 2019, the socioeconomic related cross-national health inequality increased, whereas the global ASDR due to COPD decreased. As shown in Table 2, the increase in the health inequality in COPD burden occurred regardless of the absolute health inequality or the relative health inequality. In 1990, the global ASDR was 1537.7 (1330.7 to 1647.5) per 100,000 population and SII was −735.16 (−959.39 to −510.94), suggesting that the DALY number is 1537.7 per 100,000 population lower in countries with the highest socioeconomic developmental levels than in countries with the lowest socioeconomic development. Global ASDR decreased to 926.1 (848.8 to 997.7) per 100,000 population, and SII increased to −451.78 (−568.56 to −334.99) in 2019. The relative health inequality indicators (RII and CI) showed a similar pattern. Comparison of the health inequality due to COPD between men and women showed that the absolute cross-national health inequality was slightly higher in men than in women in 2019, whereas the relative cross-national inequality was slightly higher in women (Table 2).

Discussion

The present second analysis of the GBD 2019 study data provided a global description of the health burden caused by COPD worldwide, especially the population-based cross-national health inequality due to socioeconomic disparities. We found that the DALY number related to COPD was unevenly concentrated in poor and underdeveloped countries (or women), and the situation was aggravated as global age-standardized DALY rates decreased. These findings provided evidence supporting the need for a health system reform to ensure that more attention is paid to disadvantaged groups of people regarding economic and social status.

The present study confirmed that the increase of global DALY number related to COPD was the result of global population growth and aging. After controlling for these factors, the age-standardized DALY rates reflected the global, regional, and national COPD burden development trend between 1990 and 2019, which showed that a steep and continuous decrease in the average COPD burden (after age-standardization) occurred in the past 28 years.

There are several possible explanations for these results. First, global economic improvement as a whole and continuous medical reform increased the accessibility to medical resources, and proper clinical management of COPD can greatly reduce the mortality from the disease. Second, an increasing number of individuals are becoming aware of the damage that air pollution can cause to people's health. Governments are currently willing to take measures to improve air

Table 1 Global and WHO Regional DALY Number, Crude DALY Rates, Age-Standardized DALY Rates Due to COPD in 1990 and 2019, and Percentage Change from 1990 to 2019

Location	All Ages DALY Number (Millions)			All Ages DALY Rates (Per 100,000 Population)			Age-Standardized DALY Rates (Per 100,000 Population)		
	1990	2019	Percentage Change	1990	2019	Percentage Change	1990	2019	Percentage Change
Global	59.2 (51.2–63.6)	74.4 (68.2–80.2)	25.7%	1107.4 (957.2–1188.7)	962 (881.5–1036.4)	−13.1%	1537.7 (1330.7–1647.5)	926.1 (848.8–997.7)	−40.0%
High SDI	6.5 (6.1–6.9)	10.3 (9.5–11.1)	58.5%	794.4 (740–844.8)	1019 (933–1094.1)	28.3%	622.9 (580–662.2)	543.5 (499.2–582.9)	−12.8%
High-middle SDI	14.3 (11.9–15.5)	12.3 (11.2–14.1)	−14.0%	1242.8 (1034.5–1346.8)	859.6 (783.7–989.2)	−30.8%	1405.3 (1161.5–1521.7)	617.7 (562.8–708.9)	−56.0%
Middle SDI	20.6 (16.6–22.6)	22.9 (20.9–25.2)	11.2%	1200.5 (966.8–1317.6)	956.1 (871.5–1052.8)	−20.4%	2207.6 (1778.7–2412)	1007.2 (915.7–1112.4)	−54.4%
Low-middle SDI	14 (12.1–15.5)	22.1 (19–24.6)	57.9%	1235.2 (1075.5–1370.2)	1255.6 (1078.8–1395.6)	1.7%	2505 (2177.4–2776.7)	1728.6 (1488.8–1923.7)	−31.0%
Low SDI	3.8 (3.3–4.4)	6.7 (5.9–7.5)	76.3%	725.9 (621.5–826.8)	595.2 (526–662)	−18.1%	1666.9 (1378–1894.3)	1364.1 (1201.6–1522.6)	−18.2%
African Region	2.1 (1.8–2.4)	3.5 (3.1–3.9)	66.7%	402.7 (350.2–464.2)	322.2 (285.8–359)	−20.0%	868.3 (761–1003.9)	694.5 (616–771.7)	−20.0%
Eastern Mediterranean Region	2 (1.7–2.4)	3.6 (3.2–4.1)	80.0%	527.5 (454.7–623.9)	502.5 (447–567.7)	−4.7%	1110.6 (935.9–1342.8)	876.4 (781.1–986.9)	−21.1%
European Region	7.2 (6.7–7.6)	7.7 (7.1–8.3)	7.0%	839.9 (780.2–881.5)	825.5 (761.2–889)	−1.7%	679.7 (631–713.8)	481 (442.9–518)	−29.2%
Region of the America	4.7 (4.4–5)	8.8 (8.1–9.4)	87.2%	652.1 (610.4–691.7)	873.6 (801.9–932.1)	34.0%	759 (710.6–805.2)	691.1 (635.7–737.4)	−9.0%
South-East Asia Region	15.3 (13.3–17.1)	27.4 (23.3–30.7)	79.1%	1168.7 (1014.6–1307.8)	1359.7 (1155.7–1525.6)	16.3%	2439.9 (2123.8–2740.2)	1705.2 (1451.7–1918.7)	−30.1%
Western Pacific Region	27.9 (21.2–31.2)	23.2 (20.6–26.9)	−16.9%	1785.8 (1357.8–1996.6)	1199.1 (1067–1392.6)	−32.9%	2634.3 (2002.4–2928.1)	887.7 (789–1029.6)	−66.3%

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Table 2 Sex-Specific Population-Based Cross-National Healthy Inequality, Compare 1990 with 2019. ASDR = Age-Standardized DALY Rates (per 100,000 Population)

	Year	Male	Female	Both Sexes
Global ASDR	**1990**	1972.4 (1736.8 to 2154.3)	1202.4 (958.0 to 1348.1)	1537.7 (1330.7 to 1647.5)
SII		−864.86 (−1190.99 to −538.72)	−596.48 (−763.11 to −429.85)	−735.16 (−959.39 to −510.94)
RII		−0.43 (−0.69 to 0.25)	−0.50 (−0.77 to −0.32)	−0.48 (−0.72 to −0.31)
CI		−0.2681 ± 0.0175 (p = 0.0000)	−0.3269±0.0220 (p = 0.0000)	−0.2984±0.0193 (p = 0.0000)
Global ASDR	**2019**	1149.1 (1050.1 to 1257.3)	744.1 (652.2 to 822.2)	926.1 (848.8 to 997.7)
SII		−552.39 (−700.95 to −403.83)	−377.97 (−476.03 to −279.92)	−451.78 (−568.56 to −334.99)
RII		−0.48 (−0.67 to −0.32)	−0.51 (−0.73 to −0.34)	−0.49 (−0.67 to −0.34)
CI		−0.1345 ± 0.0190 (p = 0.0000)	− 0.1461 ± 0.0232 (p = 0.0000)	−0.1453 ± 0.0207 (p = 0.0000)

Abbreviations: SII, slope index of inequality; RII, relative index of inequality; CI, concentration index.

quality, such as by promoting the development of vehicles powered by clean energy and by controlling the exhaust emissions of polluting enterprises. However, the 2018 Environmental Performance Index (EPI) showed that air quality remains the leading environmental threat to public health, and significant challenges still exist at the global level despite improvements in air conditions achieved by some countries.[18] Controlling tobacco use, which is the leading cause of COPD,[19] plays a vital role in reducing the prevalence of COPD. The age-standardized tobacco use prevalence rates for men and women have declined across all income groups over the period from 2000 to 2015 (from 33.3% in 2000 to 24.9% in 2015).[19] The proportion of men using tobacco was three-fold higher than that of women in 2000, whereas the rate for men was more than four-fold higher in 2015.[20] This is one of the reasons why the COPD burden is consistently higher in men than in women, as determined by the GBD respiratory studies.[21–23] In addition, a greater under diagnosis of COPD in women has been reported.[10]

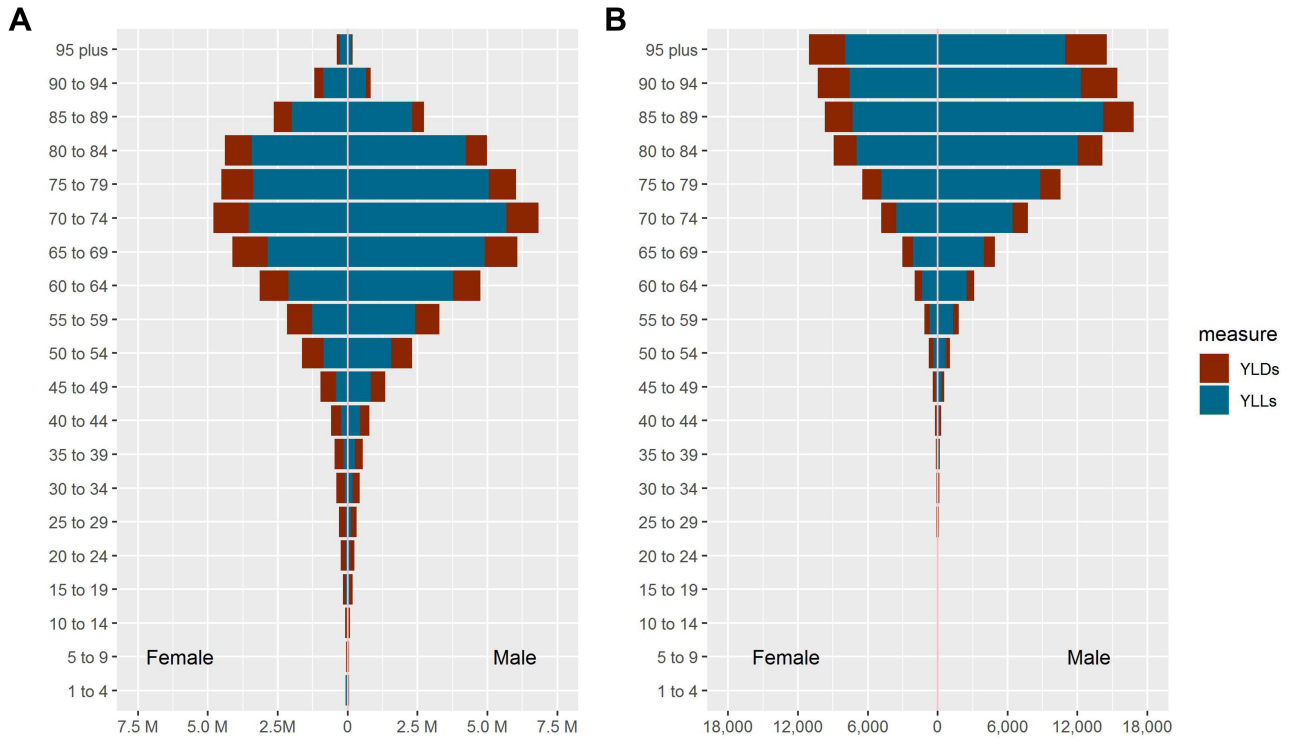

Figure 1 Age distribution of global sex-specific DALY number (**A**) and DALY rate (**B**) in 2019. DALY =YLLs +YLDs.
Abbreviations: DALY, disability-adjusted life years; YLLs, year of life lost due to premature death; YLDs, years lived with disability; M, million.

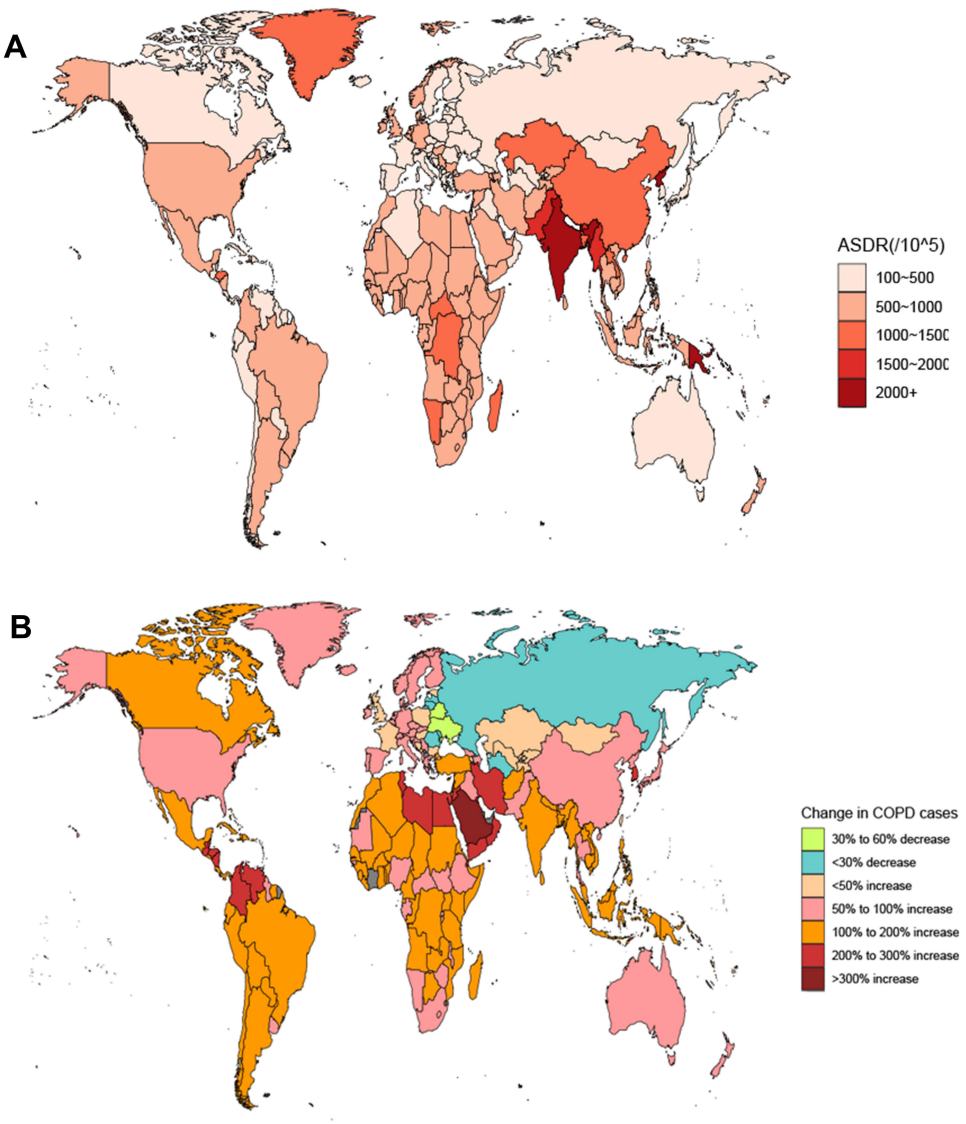

Figure 2 Global distribution of COPD burden in terms of age-standardized DALY rates in 2019 (**A**) and the relative change in incidence cases of COPD between 1990 and 2019 (**B**).
Abbreviation: ASDR, age-standardized DALY rate.

The present findings indicated that the health inequalities caused by the disparity of socioeconomic status are increasing, and the increasing concentration of wealth worldwide is likely to aggravate the health inequalities related to COPD. This phenomenon may be related to several factors in low SDI countries or regions, such as failure to implement prevention and control measures, including less effective laws regarding tobacco consumption and environment improvement; lack of financial and medical resources; other health priorities, such as communicable, maternal, neonatal, and nutritional diseases; and the unhealthy consequences of global economic growth associated with industrial transfer.[24,25] Therefore, the utilization and allocation of health resources should be performed in a more rational way, and the WHO should implement targeted strategies to reduce global inequality due to the disparity of socioeconomic levels.

The present study had several limitations. First, the study only included COPD burden data at the global (WHO partition) level; COPD mortality and DALY values in specific countries and the role of specific risk factors were not analyzed. Second, the GBD results relied mainly on estimated data obtained by combining the system dynamics model and the statistical model, which did not constitute real observation data; therefore, the estimated results could be

inaccurate. Furthermore, the prevalence of COPD may be underestimated in low income countries with poor health supervision systems.

Conclusions

The present study revealed the health inequalities caused by the disparity of socioeconomic status are increasing, and the increasing concentration of wealth worldwide is likely to aggravate health inequalities associated with COPD. The utilization and allocation of health resources should be performed in a more rational way to reduce global inequality due to the disparity of socioeconomic levels.

Ethics Statement

This study was approved by the Ethics Committee of the Seventh Affiliated Hospital, Sun Yat-sen University in line with the Declaration of Helsinki.

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Disclosure

The authors declare that they have no competing interests.

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