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Changes and trends in mortality, disability-adjusted life years, life expectancy, and healthy life expectancy in China from 1990 to 2021: a secondary analysis of the global burden of disease 2021

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Abstract

Background The aging population in China is increasingly evident, leading to a shift in the patterns of disease burden. This study aims to investigate changes and trends in mortality, disability-adjusted life years (DALYs), life expectancy (LE), and health-adjusted life expectancy (HALE) in China from 1990 to 2021.

Methods This study presents a secondary analysis of data from the Global Burden of Disease Study 2021, with a focus on mortality, DALYs, LE, and HALE. We examined changes in these indicators in China from 1990 to 2021, comparing them with global averages and across five SDI regions. Using Joinpoint Regression Software, we analyzed trends in the top ten cause-specific DALY rates in 2021. Furthermore, we employed the Bayesian Age-Period-Cohort model to forecast age-standardized rates (ASR) of mortality for the next decade.

Results China witnessed a decrease in the ASRs of mortality (1198.16/100,000 [1098.61–1294.10] to 644.68/100,000 [555.12–735.51]) and DALYs (43085.42/100,000 [39330.62–47273.39] to 22717.19/100,000 [19748.18–25903.34]) from 1990 to 2021. During the COVID-19 pandemic, the ASRs of mortality and DALY declined in China (23009.47/100,000 [19661.21–26495.58] in 2019), but global rates and those across the five SDI (Socio-demographic Index) regions increased. Projections indicate a continued decline in the ASRs of mortality over the next decade, from 2019 to 2035 and 2021 to 2035. Notably, DALY rates for the top 10 level 2 causes in 2021 decreased over the past three decades, except for musculoskeletal disorders (AAPC% 95%CI, 0.10 [0.07–0.14], men; 0.05 [-0.02–0.13], women) and sense organ diseases (AAPC% 95%CI, 0.38 [0.33–0.43], men; 0.35 [0.30–0.41], women). LE and HALE increased across all age groups in China over the same period, although there was no significant change in the HALE/LE ratio.

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Conclusion Effective policy implementation and technological advancements could play a crucial role in alleviating disease burdens associated with aging in China, thereby reducing the country's all-cause mortality rate and enhancing the quality of life for its residents.

Keywords Population aging, Disability-adjusted life year, Life expectancy, Healthy life expectancy

Text box 1. Contributions to the literature

1.Effective public health policies in China can help increase life expectancy and reduce the disability-adjusted life years (DALYs) associated with chronic diseases.

2.The mortality rate in China may increase over the next 10 years due to COVID-19.

3.Life expectancy in China increased between 1990 and 2021, but the quality of life associated with this extended longevity did not show a comparable improvement.

Introduction

China, as the world's top two most populous country [1], has undergone profound demographic shifts due to its economic development and advancements in education. The implementation of the one-child family planning policy in the 1970s further accelerated these changes [2], leading to significant alterations in the age structure of Chinese society. As a result, the challenge of an aging population has become increasingly prominent. The number of people aged 65 and over is gradually increasing worldwide, with China now accounting for 13.5% of the elderly population [3]. As the elderly population continues to grow, the prevalence of chronic non-communicable diseases has also increased in China [4], posing a significant threat to the health of older adults. Conditions such as cardiovascular and cerebrovascular diseases, diabetes mellitus, and chronic respiratory diseases, are often closely linked to the lifestyles, dietary habits, and genetic predispositions. While life expectancy in China is expected to continue rising, the impact of these diseases on the quality of life for the elderly still needs further research [5].

While mortality and life expectancy (LE) are essential indicators, they provide only partial understanding of an individual's overall well-being, health, and disease status. Therefore, it is important to explore more comprehensive indicators that account for various factors such as gender, age, disease prevalence, and socio-economic conditions. Metrics like mortality, disability-adjusted life years (DALYs), LE, and health-adjusted life expectancy (HALE) play a crucial role in assessing the health and socio-economic landscape of a population. Among these, DALYs and HALE, are particularly important, as they not only capture mortality but also reflect the loss of function resulting from illness [6, 7]. SDI stands for Sociodemographic Index, which is a composite measure for the position of a country or geographic area within the development spectrum [8].

This study aimed to explore the impact of sex, age, sociodemographic factors, the COVID-19 pandemic, and other specific causes on the shifts and disparities in mortality, DALYs, LE, and HALE in China from 1990 to 2021. The findings have the potential to provide valuable insights to inform policy-making regarding health system planning and resource allocation.

Methods

Data resource

The data used in this study were obtained from the Global Burden of Disease Study 2021 (GBD 2021), which includes information on mortality, DALYs, LE, and HALE. The GBD data were compiled through rigorous process of identification and extraction from multiple sources, including official and international websites, scholarly articles, and key data contributors. Each information was uniquely tagged and recorded in the Global Health Data Exchange (GHDx), creating a precise and reliable system for global health data analysis [9]. This dataset provides both all-age and age-standardized metrics for China, as well as global data and breakdowns across five SDI regions(high SDI, high-middle SDI, middle SDI, low-middle SDI, and low SDI regions). It covers all age groups (0–6 days, 7–27 days, 1–5 months, 6–11 months, 12–23 months, 2–4 years, and every 5-year age group up to 94 years, and 94 years and older). The original dataset can be accessed via the official website: https://www.healthdata.org/.

Variables and measurement

DALYs represent years of healthy life lost, accounting for both mortality and disability. In this study, we analyzed all-cause mortality and all-cause DALYs, and provided a separate analysis focus on cause-specific DALYs (level 2 causes). LE indicates the expected lifespan at a specific age, while HALE reflects the expected years of healthy life at a given age. In this study, LE and HALE within the

0–6 days age group were treated as equivalent to those at birth.

In the GBD study, causes of diseases and injuries are categorized into four levels; they are: three Level 1 causes, 22 Level 2 causes, 174 Level 3 causes, and 301 Level 4 causes [10]. Level 2 causes serve as a mid-level categorization, offering a balance between the broad scope of Level 1 causes and the more specific details of Level 3 and Level 4 causes. This level of categorization provides policymakers and researchers with a practical perspective that is neither too general nor overly detailed.

The SDI serves as a composite measure of development status, closely associated with health outcomes, and ranges from 0 to 1. A score of 0 reflects the lowest per capita income, minimal educational attainment, and the highest total fertility rate, while a score of 1 represents the opposite, indicating higher affluence and development [11].

Statistical analysis

We conducted a comparative analysis of mortality, DALYs, LE, and HALE in China, globally, and across various SDI regions, spanning from 1990 to 2021. The analysis took into account gender, age groups, and specific Level 2 causes. To assess trends in cause-specific DALY rates, we used Joinpoint Regression software (version 4.9.1.0; NCI). Trends were classified as increasing or decreasing only when the average annual percent change (AAPC) was statistically significant (P-value < 0.05); otherwise, they were considered stable. Additionally, we performed the Bayesian age-period-cohort (BAPC) model fitted with integrated nested Laplace approximation (INLA) to project age-standardized mortality rates from 2019 or 2020 to 2035 for China and globally with the R program (version 4.3.1).

Results

Mortality from 1990 to 2021

Over the past three decades, China has witnessed a notable increase in the total number of all-cause mortality, rising from 8,469,131.30 (95% UI 7704601.36–9223988.09) in 1990 to 11,696,257.67 (9,988,541.96–13,439,384.57) in 2021. However, the age-standardized rate (ASR) of all-cause mortality has steadily decreased, from 1,198.16 per 100,000 (1,098.61–1,294.10) in 1990 to 644.68 per 100,000 (555.12–735.51) in 2021. These trends are consistent across both genders.

On a global scale, the total number of all-cause deaths has also experienced a significant increase from 1990 to 2021, rising from 46,097,968.74 (44,939,984.95–47,306,002.08) to 67,871,076.62 (65,111,321.62–70,624,188.63). However, the trajectory of ASRs of mortality has taken a different path. Initially, global ASRs of all-cause mortality exhibited a consistent decline from 1990 (1,107.03 per 100,000, 1,082.61–1,133.36) to 2019 (735.30 per 100,000 [706.59–767.87]). However, from 2019 to 2021 this trend reversed, with ASRs rising to 835.27 per 100,000 (800.83–870.33) in 2021.

The number of all-cause deaths increased from 1990 to 2021 in high SDI, high-middle SDI, middle SDI, and low-middle SDI regions. In contrast, the number of all-cause deaths in low SDI regions increased from 1990 to 2000 and from 2019 to 2021, but decreased from 2000 to 2019. The ASRs of mortality in all five different SDI regions decreased from 1990 to 2019, however, the course was reversed to an increase from 2019 to 2021. Further details are provided in Table 1.

DALYs from 1990 to 2021

The number of DALYs in China and globally fluctuated for both males and females. The ASRs of DALYs in China decreased for both sexes from 1990 to 2021 (43,085.42 per 100,000 [39,330.62–47,273.39] to 22,717.19 per 100,000 [19,748.18–25,903.34]). Similarly, global ASRs of DALYs declined from 1990 to 2019 (50,765.95 per 100,000 [47,546.03–54,275.24] to 33,759.61 per 100,000 [30,669.84–37,223.12]). However, the global ASRs of DALYs exhibited an annual increase from 2019 to 2021 (33,759.61 per 100,000 [30,669.84–37,223.12] to 36,203.13 [33,062.44–39,613.73]).

The number of DALYs increased from 1990 to 2019 in high-SDI, high-middle SDI, and middle-SDI regions, while it decreased in the low-middle SDI and low-SDI regions. However, the number DALYs increased across all SDI regions from 2019 to 2021. The ASRs of DALYs decreased from 1990 to 2019 in all five different SDI regions and increased from 2019 to 2021. Further details are provided in Table 1.

Changes in mortality and DALYs from 2019 to 2021

Between 2019 and 2021, both all-cause mortality and DALYs experienced an increase in China, across the five SDI regions, and globally. Notably, the ASRs of all-cause mortality and DALYs in China decreased from 2019 to 2021 (23,009.47 per 100,000 [19,661.21–26,495.58] to 22,717.19 per 100,000 [19748.18–25903.34]), while these rates increased in the five SDI regions and worldwide.

Predictions of ASRs of mortality, 2020–2035 and 2022–2035

Based on the global ASRs of mortality from 1990 to 2019, the ASRs of mortality are projected to decrease

Table 1 Mortality and DALYs in China, the world, and five SDI Regions

China/Global/ Regions	Mortality (95% UI)					
	Number			Age-standardized rate (/100, 000)		
	Male	Female	Both sexes	Male	Female	Both sexes
China						
1990	4693890.03 (4066733.04, 5390210.51)	3775241.26 (3312389.58, 4297265.13)	8469131.30 (7704601.36, 9223988.09)	1424.26 (1258.62, 1603.00)	1030.53 (911.58, 1161.27)	1198.16 (1098.61, 1294.10)
2000	5081444.69 (4649497.05, 5543177.42)	3815669.88 (3516638.87, 4163579.51)	8897114.57 (8338715.85, 9469450.51)	1281.78 (1194.47, 1375.22)	843.56 (782.94, 912.72)	1029.57 (972.58, 1086.10)
2010	5779455.86 (5150100.69, 6431645.73)	3951513.93 (3599298.25, 4313367.32)	9730969.79 (9037844.79, 10513839.68)	1095.55 (993.07, 1198.57)	629.90 (577.14, 684.58)	825.44 (772.57, 883.65)
2019	6516214.43 (5328905.81, 7933768.45)	4562806.70 (3793854.22, 5464674.14)	11079021.12 (9652774.17, 12622705.19)	876.95 (733.40, 1043.66)	493.11 (413.45, 587.12)	656.65 (577.63, 741.29)
2020	6705426.79 (5417976.53, 8179899.52)	4725126.35 (3949228.99, 5667859.74)	11430553.15 (9918412.74, 13130924.54)	873.52 (721.80, 1040.63)	490.87 (412.61, 584.39)	653.79 (572.66, 742.31)
2021	6838612.03 (5527684.64, 8342957.77)	4857645.65 (4020841.66, 5881941.09)	11696257.67 (9988541.96, 13439384.57)	861.73 (711.64, 1027.74)	484.20 (403.15, 582.32)	644.68 (555.12, 735.51)
Global						
1990	24810216.48 (24074669.77, 25698867.38)	21287752.25 (20703911.99, 21884614.28)	46097968.74 (44939984.95, 47306002.08)	1296.47 (1259.24, 1339.59)	952.43 (927.01, 978.93)	1107.03 (1082.61, 1133.36)
2000	27218431.84 (26566482.10, 27950828.61)	23071414.24 (22540500.78, 23600479.59)	50289846.08 (49236596.15, 51358303.15)	1191.43 (1165.24, 1220.37)	864.93 (846.14, 884.38)	1012.84 (993.34, 1032.81)
2010	29040076.62 (28164580.04, 29967007.89)	24030662.20 (23478405.62, 24651657.41)	53070738.82 (51850694.67, 54354374.55)	1019.90 (990.72, 1050.09)	716.35 (699.93, 734.74)	854.44 (835.89, 874.18)
2019	31037271.52 (29452417.25, 32729755.03)	25939799.47 (24762145.49, 27228772.45)	56977071.00 (54733865.85, 59507264.98)	877.61 (834.59, 922.92)	614.41 (584.94, 644.61)	735.30 (706.59, 767.87)
2020	34868925.40 (33120784.80, 36901685.16)	28252414.43 (27051736.14, 29588318.58)	63121339.84 (60658141.99, 65803168.12)	963.33 (916.46, 1017.69)	651.74 (624.07, 683.86)	794.46 (762.49, 828.19)
2021	37679080.72 (35838818.42, 39694551.33)	30191995.90 (28820490.73, 31583358.23)	67871076.62 (65111321.62, 70624188.63)	1018.59 (970.28, 1070.85)	680.61 (649.17, 713.60)	835.27 (800.83, 870.33)
High SDI						
1990	3832282.27 (3808305.78, 3860888.67)	3577872.84 (3558569.31, 3599156.45)	7410155.11 (7377334.33, 7444162.59)	899.66 (894.35, 906.07)	543.90 (540.72, 547.48)	693.24 (689.91, 696.75)
2000	3955849.25 (3933167.60, 3978872.70)	3856156.96 (3839417.33, 3875875.99)	7812006.21 (7780857.54, 7844169.89)	753.17 (749.06, 757.51)	468.14 (465.79, 470.81)	590.13 (587.49, 592.66)
2010	4211515.18 (4183828.89, 4245417.31)	4012462.38 (3995441.69, 4033143.51)	8223977.56 (8190347.09, 8264494.55)	612.74 (608.82, 617.70)	384.95 (383.13, 387.20)	486.04 (483.89, 488.66)
2019	4811296.95 (4754746.93, 4875546.15)	4522284.70 (4481243.69, 4571704.75)	9333581.65 (9254282.92, 9423230.73)	548.47 (541.56, 555.55)	349.62 (345.88, 354.08)	440.31 (436.00, 445.00)
2020	5325048.19 (5265672.54, 5394350.67)	4904442.09 (4858159.59, 4952703.90)	10229490.28 (10153119.45, 10319662.92)	592.81 (585.86, 601.14)	372.06 (368.13, 376.30)	473.06 (468.67, 477.80)

Table 1 (continued)

China/Global/ Regions	Mortality (95% UI)					
	Number			Age-standardized rate (/100, 000)		
	Male	Female	Both sexes	Male	Female	Both sexes
2021	5511206.92 (5432123.60, 5585566.52)	5041105.84 (4987135.77, 5095324.96)	10552312.76 (10452709.30, 10654695.16)	600.24 (591.58, 608.55)	376.33 (372.06, 381.15)	478.96 (473.75, 484.23)
High-middle SDI						
1990	4610318.66 (4373688.28, 4882077.61)	4023634.61 (3835403.94, 4220721.75)	8633953.27 (8323440.54, 8960785.29)	1218.91 (1163.08, 1281.84)	790.25 (755.71, 825.98)	972.83 (941.14, 1005.83)
2000	5493958.42 (5294292.11, 5703577.61)	4597384.26 (4461100.28, 4750957.24)	10091342.67 (9849328.07, 10358603.84)	1171.42 (1133.21, 1211.94)	735.50 (714.53, 758.10)	926.06 (905.42, 947.59)
2010	5722238.88 (5461989.28, 5997637.68)	4758760.01 (4608281.93, 4932083.30)	10480998.89 (10175340.08, 10808268.12)	966.29 (925.06, 1008.44)	586.99 (569.14, 608.03)	751.86 (730.79, 774.00)
2019	5946456.18 (5448504.53, 6530541.89)	5098609.41 (4741973.67, 5474667.32)	11045065.60 (10423272.82, 11725493.14)	790.41 (728.11, 862.56)	486.66 (453.01, 522.59)	620.63 (586.86, 657.38)
2020	6518394.80 (5984293.21, 7144083.17)	5588107.31 (5202222.81, 6037571.12)	12106502.10 (11477193.93, 12791890.32)	844.96 (779.93, 921.60)	518.92 (482.92, 560.64)	662.29 (629.26, 698.10)
2021	6905519.26 (6318921.11, 7562817.12)	6024496.15 (5622164.58, 6434990.19)	12930015.41 (12187716.48, 13670074.59)	871.25 (802.11, 948.75)	546.38 (509.93, 583.61)	689.97 (651.35, 728.56)
Middle SDI						
1990	6509347.84 (6131650.77, 6956333.32)	5199758.85 (4906675.66, 5515925.78)	11709106.69 (11237034.07, 12249406.93)	1255.15 (1182.81, 1339.74)	969.95 (914.64, 1028.75)	1106.28 (1061.03, 1154.49)
2000	7059802.35 (6788946.02, 7346116.76)	5394687.17 (5197829.05, 5603938.73)	12454489.52 (12097189.24, 12819659.30)	1137.24 (1094.48, 1182.16)	820.59 (791.33, 852.04)	969.29 (942.35, 996.64)
2010	8119029.23 (7749320.08, 8502202.39)	5988393.22 (5778905.90, 6193506.79)	14107422.45 (13695568.36, 14553658.88)	1014.40 (969.56, 1059.79)	682.95 (659.68, 705.52)	836.68 (813.50, 861.92)
2019	9205380.20 (8486426.01, 10027400.59)	6932236.04 (6501250.10, 7478717.25)	16137616.25 (15284497.21, 17122913.90)	879.54 (813.51, 955.35)	580.83 (544.89, 626.31)	718.61 (681.72, 761.61)
2020	10302734.56(9472303.59, 11122412.35)	7586080.83 (7097444.95, 8131313.63)	17888815.40 (16900383.89, 18919836.87)	956.18 (881.49, 1028.94)	612.59 (574.41, 655.51)	770.19 (729.20, 813.91)
2021	11310040.91 (10507349.31, 12331012.57)	8273036.17 (7741674.10, 8861355.94)	19583077.08 (18449982.93, 20749900.04)	1024.21 (954.02, 1111.64)	646.47 (605.24, 691.14)	818.71 (772.65, 866.84)
Low-middle SDI						
1990	6008389.02 (5797453.68, 6229042.55)	5152267.36 (4981593.70, 5321434.67)	11160656.38 (10817933.81, 11536671.13)	1468.95 (1422.52, 1515.69)	1284.33 (1244.52, 1323.12)	1378.27 (1338.96, 1416.64)
2000	6363512.41 (6139704.16, 6610762.49)	5404132.08 (5223424.76, 5603306.31)	11767644.49 (11379107.56, 12200322.10)	1344.77 (1304.13, 1386.92)	1134.67 (1101.96, 1169.39)	1239.38 (1208.13, 1273.42)
2010	6698760.52 (6407366.74, 6971087.34)	5502978.11 (5273312.32, 5733756.47)	12201738.63 (11722664.09, 12688098.41)	1208.96 (1163.26, 1250.70)	958.83 (924.47, 995.27)	1080.39 (1044.87, 1115.36)
2019	6960474.44 (6548021.54, 7377888.92)	5900254.88 (5564747.31, 6228174.59)	12860729.32 (12184749.25, 13550110.66)	1067.52 (1010.60, 1127.29)	857.75 (813.44, 903.20)	958.77 (913.90, 1005.23)

Table 1 (continued)

China/Global/ Regions	Mortality (95% UI)					
	Number			Age-standardized rate (/100, 000)		
	Male	Female	Both sexes	Male	Female	Both sexes
2020	8088262.13 (7660380.37, 8564483.98)	6443944.15 (6102020.11, 6820729.54)	14532206.28 (13829279.42, 15293830.61)	1237.83 (1176.28, 1303.89)	923.99 (878.56, 973.99)	1073.50 (1026.72, 1124.73)
2021	8881572.35 (8371147.57, 9404915.18)	6886948.78 (6459155.95, 7326480.67)	15768521.13 (14951036.51, 16597874.22)	1350.58 (1276.51, 1424.28)	971.78 (915.24, 1030.72)	1150.92 (1095.09, 1207.33)
Low SDI						
1990	3825387.88 (3646482.44, 3999955.07)	3313252.60 (3191147.52, 3442955.87)	7138640.48 (6850974.25, 7433524.89)	1937.39 (1852.83, 2026.83)	1697.57 (1632.57, 1771.05)	1819.24 (1744.59, 1892.64)
2000	4320454.45 (4120372.42, 4534892.96)	3797172.98 (3637047.09, 3962229.77)	8117627.44 (7765580.72, 8471279.98)	1819.74 (1740.71, 1899.36)	1590.79 (1518.36, 1661.67)	1705.41 (1634.25, 1774.27)
2010	4259574.01 (3985276.60, 4523807.99)	3740360.46 (3546258.47, 3936323.01)	7999934.47 (7535888.67, 8456170.90)	1502.09 (1417.10, 1581.25)	1301.08 (1237.00, 1363.50)	1401.00 (1329.76, 1464.98)
2019	4085810.55 (3698254.12, 4532018.12)	3461810.81 (3155794.92, 3804663.44)	7547621.35 (6884437.32, 8323079.60)	1283.75 (1188.20, 1388.31)	1081.83 (999.88, 1167.97)	1180.64 (1097.61, 1276.05)
2020	4603322.76 (4211887.77, 5122018.63)	3703067.22 (3385552.89, 4094490.46)	8306389.98 (7595140.06, 9198982.19)	1516.65 (1421.44, 1644.78)	1182.30 (1095.11, 1281.97)	1344.29 (1255.05, 1458.00)
2021	5035041.91 (4597649.96, 5565875.43)	3936361.60 (3611362.10, 4329934.96)	8971403.51 (8244880.22, 9891043.19)	1694.99 (1569.34, 1829.11)	1275.18 (1182.40, 1373.71)	1477.77 (1375.02, 1581.91)
China/Global/ Regions	**DALYs (95% UI)**					
	Number			**Age-standardized rate(/100, 000)**		
	Male	Female	Both sexes	Male	Female	Both sexes
China						
1990	229799146.13 (206284905.40, 257225296.59)	187385174.26 (167409167.99, 209108757.75)	417184320.39 (380103440.46, 461229692.36)	47445.82 (42524.56, 52879.61)	39161.45 (35074.22, 43653.14)	43085.42 (39330.62, 47273.39)
2000	211610237.54 (193133785.15, 230997549.50)	166544733.80 (149176364.84, 184885267.21)	378154971.34 (345362767.92, 413663959.06)	40327.55 (37304.23, 43534.58)	31579.45 (28649.06, 34653.33)	35712.58 (33082.74, 38669.77)
2010	210920354.86 (189148358.10, 232617477.09)	158504822.10 (138697108.25, 179911903.46)	369425176.96 (334736296.88, 407578097.46)	32262.84 (29368.93, 35260.22)	23387.53 (20721.60, 26299.60)	27526.45 (25200.57, 30086.73)
2019	220646619.76 (185267000.19, 261675295.30)	170803283.10 (142719464.59, 199629719.28)	391449902.85 (333393958.73, 452413919.78)	26796.81 (22827.90, 31336.12)	19696.58 (16467.27, 22956.03)	23009.47 (19661.21, 26495.58)
2020	223995405.76 (187129481.64, 267848755.34)	174294229.82 (145381746.56, 206013414.53)	398289635.58 (342497220.27, 460985288.16)	26701.13 (22650.70, 31464.28)	19673.81 (16504.72, 23207.94)	22950.12 (19880.76, 26391.49)
2021	225714127.08 (187417865.61, 263385094.36)	176915302.58 (147050278.86, 206725156.65)	402629429.66 (348086367.56, 461086597.50)	26375.84 (22247.81, 30440.73)	19531.87 (16349.88, 22872.71)	22717.19 (19748.18, 25903.34)
Global						
1990	1379352505.69 (1305261603.34, 1456474875.56)	1207082415.35 (1120770206.02, 1307265670.77)	2586434921.05 (2430092558.12, 2759398669.26)	55202.99 (52168.45, 58298.38)	46748.75 (43312.29, 50816.34)	50765.95 (47546.03, 54275.24)
2000	1413236394.96 (1335306181.34, 1500417352.98)	1237021939.44 (1150667485.66, 1349346035.84)	2650258334.40 (2488045111.72, 2845762572.10)	50593.14 (47859.94, 53642.70)	42899.67 (39950.15, 46695.15)	46571.75 (43747.52, 49883.07)

Table 1 (continued)

China/Global/ Regions	Mortality (95% UI)					
	Number			Age-standardized rate (/100, 000)		
	Male	Female	Both sexes	Male	Female	Both sexes
2010	1403151070.64 (1310853639.28, 1503325571.72)	1225893324.51 (1121638316.14, 1353907955.16)	2629044395.15 (2434864800.18, 2857177251.09)	42896.15 (40170.69, 45867.91)	36124.23 (33132.60, 39815.58)	39355.32 (36524.23, 42674.86)
2019	1382941751.27 (1267559299.04, 1519814566.81)	1222085900.97 (1090996345.45, 1371973373.82)	2605027652.24 (2363268602.86, 2879261819.87)	36687.79 (33693.28, 40154.97)	31069.83 (27787.35, 34864.90)	33759.61 (30669.84, 37223.12)
2020	1478183244.48 (1360892158.64, 1611276139.41)	1277670561.57 (1137204878.09, 1435010956.43)	2755853806.05 (2500315851.96, 3037650641.25)	38649.66 (35622.67, 42086.96)	31920.38 (28448.02, 35876.39)	35137.09 (32058.43, 38672.04)
2021	1553509065.03 (1432529441.22, 1688168028.93)	1329545261.36 (1191421255.41, 1476297637.40)	2883054326.39 (2635339087.27, 3147689598.01)	40043.82 (36910.36, 43463.85)	32690.87 (29265.25, 36269.68)	36203.13 (33062.44, 39613.73)
High SDI						
1990	145405280.82 (133941740.91, 158840533.26)	130395743.32 (115561016.81, 147749465.45)	275801024.14 (249367011.37, 306631335.78)	32434.59 (29960.38, 35363.05)	24321.80 (21355.90, 27790.08)	27975.61 (25239.93, 31147.43)
2000	146438511.56 (133685179.12, 161038486.49)	136641337.22 (120263565.91, 155856371.91)	283079848.79 (254227096.37, 317354779.30)	28006.89 (25557.37, 30835.47)	22192.32 (19254.31, 25643.77)	24828.04 (22158.16, 27999.97)
2010	154058728.45 (139135598.48, 171000780.58)	143962746.53 (125257239.45, 165935274.49)	298021474.99 (264645057.97, 337193052.53)	24530.49 (22070.60, 27381.94)	20254.31 (17244.75, 23760.23)	22230.25 (19508.87, 25422.05)
2019	168235435.45 (151000181.08, 187705953.76)	157757884.62 (137203020.66, 182203204.94)	325993320.07 (288397199.50, 370075979.46)	23148.60 (20581.39, 26088.54)	19720.64 (16726.28, 23295.63)	21326.26 (18604.05, 24584.07)
2020	180749051.19 (163431046.31, 200843673.48)	166416977.84 (145475625.70, 191074395.85)	347166029.03 (308988903.48, 391762661.14)	24474.95 (21913.93, 27466.59)	20548.53 (17467.46, 24202.63)	22396.41 (19639.55, 25706.01)
2021	184932461.91 (167889493.77, 205364173.21)	169922191.92 (148896303.62, 195120014.03)	354854653.83 (317053631.80, 400110693.70)	24692.96 (22216.07, 27709.59)	20742.90 (17685.97, 24374.23)	22603.08 (19870.53, 25892.34)
High-middle SDI						
1990	202503004.54 (187376941.94, 218138307.67)	168914949.91 (152295627.41, 188654272.83)	371417954.45 (340111656.04, 404666030.37)	43521.00 (40504.33, 46676.42)	32244.36 (29249.75, 35865.01)	37437.86 (34491.64, 40584.58)
2000	220121452.59 (204724782.56, 236569494.55)	176278372.55 (158910321.90, 196334620.55)	396399825.14 (364210184.15, 431492840.53)	40975.53 (38359.44, 43800.93)	29296.17 (26478.79, 32485.00)	34774.71 (32156.62, 37649.27)
2010	213465384.91 (197487787.79, 231291794.46)	175400349.36 (155528273.33, 198408216.20)	388865734.27 (354307243.41, 429216590.91)	33129.56 (30753.89, 35811.32)	24116.04 (21395.46, 27362.88)	28314.11 (25837.21, 31162.16)
2019	209473733.54 (187185267.75, 233340273.76)	180005967.83 (155374413.15, 206146857.68)	389479701.37 (345165024.11, 439118640.95)	27567.92 (24692.14, 30655.84)	21086.68 (18094.22, 24310.53)	24109.44 (21259.32, 27186.28)
2020	221947501.00 (198602791.85, 245440888.83)	190127480.68 (166535011.08, 216732644.47)	412074981.67 (368938384.96, 462928986.43)	28624.70 (25708.32, 31630.06)	21810.88 (18888.69, 25104.27)	24978.41 (22249.42, 28209.09)
2021	232146396.60 (209619344.92, 256306051.91)	200589318.83 (177245816.67, 227758981.90)	432735715.43 (389941657.38, 482066525.43)	29412.14 (26636.34, 32421.13)	22595.92 (19777.27, 25954.97)	25775.28 (23139.18, 28836.99)
Middle SDI						
1990	369495153.45 (344530228.78, 395346605.50)	306262122.11 (280898722.82, 335669151.99)	675757275.56 (628918525.77, 728459045.68)	49673.65 (46271.37, 53134.06)	41847.43 (38408.38, 45914.69)	45737.57 (42630.94, 49335.33)

Table 1 (continued)

China/Global/ Regions	Mortality (95% UI)					
	Number			Age-standardized rate (/100, 000)		
	Male	Female	Both sexes	Male	Female	Both sexes
2000	358515956.84 (335376727.56, 383913668.71)	294233456.92 (267934743.53, 325736596.17)	652749413.75 (603897377.72, 707612141.52)	43537.78 (40922.57, 46417.00)	35692.90 (32770.29, 39168.62)	39544.04 (36813.75, 42497.67)
2010	371528471.77 (345164134.27, 401988305.62)	303556300.60 (272829478.82, 340349338.20)	675084772.37 (618332063.17, 740559668.15)	37720.96 (35156.15, 40617.74)	30130.38 (27332.22, 33522.86)	33806.78 (31208.38, 36885.21)
2019	385092390.22 (348834238.40, 424953111.96)	321416807.72 (281374285.26, 366402192.04)	706509197.94 (633323775.20, 795536073.11)	32755.31 (29793.59, 35988.93)	26326.28 (23153.62, 29865.91)	29419.90 (26520.50, 33008.83)
2020	412467298.89 (373761241.62, 453007183.21)	338841442.23 (298672185.35, 388269442.56)	751308741.13 (675366766.27, 836495414.89)	34407.81 (31311.84, 37630.32)	27105.25 (24025.13, 30992.27)	30605.40 (27611.29, 33967.64)
2021	439023718.86 (400607913.71, 480089575.63)	357409883.58 (316225701.79, 403781396.65)	796433602.44 (717782248.64, 879880170.70)	35957.40 (32937.89, 39173.26)	27985.77 (24824.26, 31502.83)	31792.21 (28844.65, 35014.39)
Low-middle SDI						
1990	388536542.38 (368814784.42, 410418760.64)	355074400.55 (333576388.08, 377422805.01)	743610942.94 (704698411.65, 786972418.91)	65915.54 (62561.50, 69714.95)	61982.00 (58157.42, 66304.12)	64006.08 (60440.23, 67831.81)
2000	385253776.41 (363257270.53, 410027667.11)	353403994.13 (331300688.99, 381386480.48)	738657770.53 (694240320.57, 789684744.03)	59010.79 (55613.94, 62635.94)	54833.08 (51307.93, 59393.00)	56944.92 (53494.46, 60935.25)
2010	371185941.58 (347312560.36, 400744923.56)	333649900.87 (308238631.27, 365467850.71)	704835842.45 (655537561.06, 764944467.07)	50490.20 (47387.74, 54234.15)	45099.78 (41755.61, 49406.68)	47763.08 (44609.02, 51654.27)
2019	351511101.15 (322063399.17, 385115963.72)	321930691.41 (290772852.77, 358430270.02)	673441792.56 (612442567.80, 743155928.95)	42981.87 (39674.07, 46752.06)	38663.67 (35092.90, 42798.56)	40777.62 (37356.73, 44778.78)
2020	380224808.75 (350239346.57, 414339260.88)	334973979.43 (302722680.00, 372267935.70)	715198788.18 (655528721.18, 784540783.18)	46596.77 (43183.72, 50521.29)	39893.00 (36292.40, 44105.40)	43152.63 (39814.35, 47044.44)
2021	401454516.01 (370422019.40, 437609400.21)	347298507.10 (313523878.19, 385916091.20)	748753023.11 (688071523.80, 821906084.89)	49014.94 (45372.39, 53080.01)	40890.38 (37173.51, 45167.95)	44818.65 (41445.76, 48965.52)
Low SDI						
1990	272250211.68 (259087038.64, 286240347.97)	245445469.28 (235083320.39, 256831959.52)	517695680.96 (494751216.48, 543069367.18)	90969.47 (86225.60, 95678.52)	84466.27 (79932.21, 89505.72)	87819.62 (83111.88, 92538.40)
2000	301764759.98 (286252230.59, 320284056.08)	275464185.08 (262625452.53, 291418146.27)	577228945.05 (549540987.56, 609266667.94)	83391.45 (78814.53, 88777.13)	78331.77 (73873.93, 83925.14)	80930.98 (76486.36, 86084.18)
2010	291579973.05 (269612221.64, 314119925.13)	268004336.55 (251650526.34, 287503597.35)	559584309.60 (522327231.11, 600271019.69)	66705.72 (62263.24, 71675.18)	62407.11 (58502.34, 67429.54)	64593.89 (60508.66, 69586.50)
2019	267473993.91 (241221977.75, 300913947.98)	239953724.22 (214890803.29, 267274099.41)	507427718.12 (456299924.76, 568513340.08)	54437.55 (49644.34, 60669.80)	49450.15 (44671.94, 54865.79)	51946.96 (47341.44, 57808.66)
2020	281569106.90 (252330018.14, 317345807.44)	246245230.37 (220993690.56, 276058630.12)	527814337.26 (473941025.11, 591085034.95)	59181.98 (54112.17, 65419.83)	51241.60 (46473.38, 56956.96)	55176.58 (50240.71, 61163.68)
2021	294606111.86 (263097259.97, 331646070.50)	253178120.12 (227479838.87, 283698441.53)	547784231.99 (492427163.74, 615038728.77)	63011.45 (57386.86, 69535.24)	52912.81 (48251.83, 58409.68)	57891.94 (52791.85, 63937.08)

DALYs Disability-adjusted life years, *SDI* Socio-demographic Index, *UI* uncertainty interval

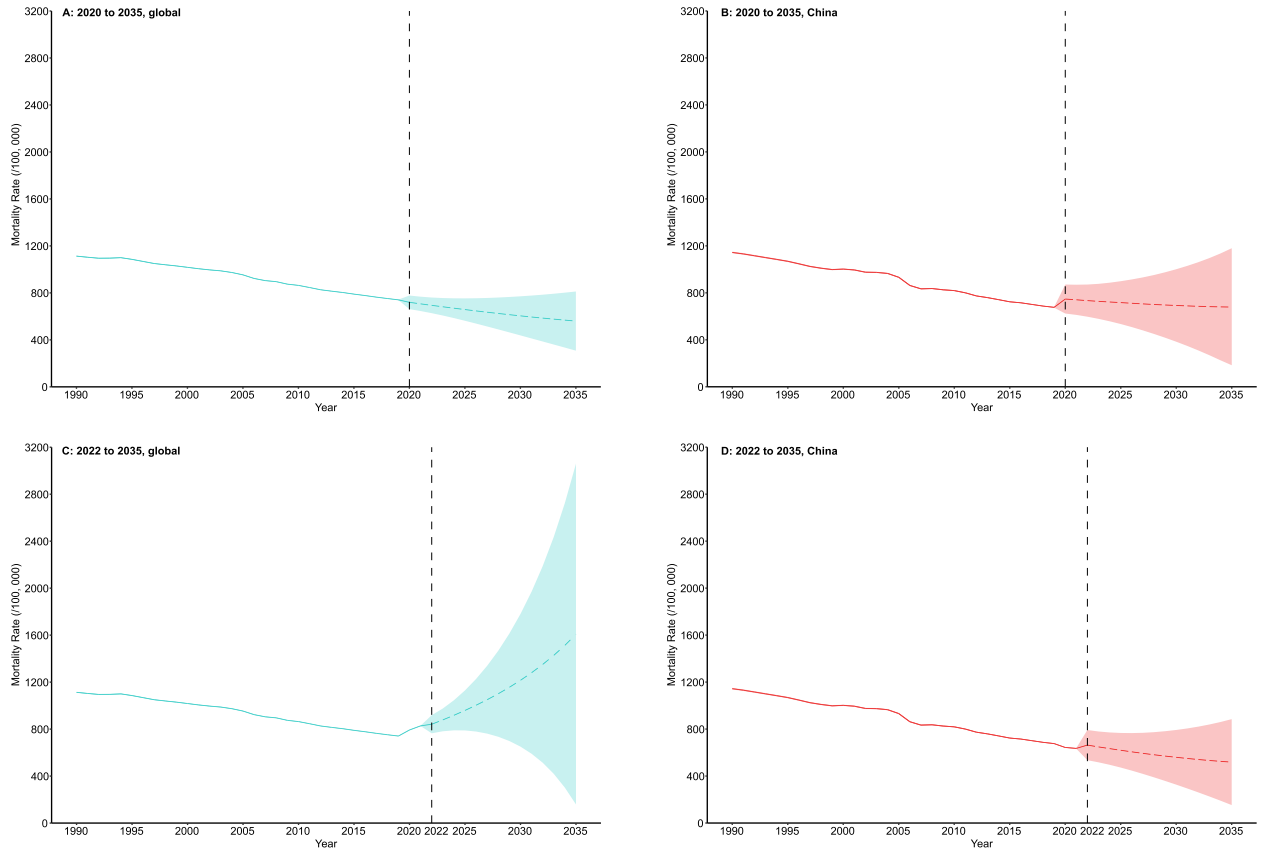

Fig. 1 Projections of China's and global age-standardized mortality rates, 2019–2035, and 2021 to 2035. **A** projection of global ASR of mortality, 2019–2035; **B** projection of China's ASR of mortality, 2019–2035; **C** projection of global ASR of mortality, 2021–2035; **D** projection of China's ASR of mortality, 2021–2035. ASR, Age-standardized rate

from 719.71(662.00, 777.43) per 100,000 in 2020 to 560.05(308.34, 811.75) per 100,000 in 2035. However, based on the data from 1990 to 2021, the ASRs of global mortality showed an upward trend, from 841.49 (764.34, 918.64) per 100,00 in 2022 to 1607.53 (158.46, 3059.46) per 100,00. In contrast, the ASRs of mortality in China are expected to show downward trends over the next 10 years. The ASRs of mortality in China are projected to decline from 747.09 [623.79, 870.38] per 100,00 in 2020 to 678.83 [183.55, 1179.73] per 100,00 in 2035, according to the 1990–2019 dataset; and from 663.61 [535.14, 792.07] per 100,00 in 2022 to 518.57 [152.96, 884.41] in 2035, according to the 1990–2021 dataset (Fig. 1).

The top 10 level 2 causes of DALYs rates in 2021

In 2021, the top 10 causes of DALYs rates among Chinese men, at level 2, were cardiovascular diseases (CVD), neoplasms, chronic respiratory disease, unintentional injury, mental disorders, musculoskeletal disorders, transport injuries, neurological disorders, sense organ diseases and diabetes and kidney diseases. Among Chinese women, the top 10 causes were CVD, neoplasms, musculoskeletal disorders, mental disorders, other non-communicable diseases, neurological disorders, chronic respiratory diseases, sense organ diseases, diabetes and kidney diseases, and unintentional injury (as illustrated in Fig. 2).

Trends of the cause-specific DALY rates

The ASRs of DALY for most of the top 10 causes in China decreased from 1990 to 2021 for both men and women. This trend was observed for conditions such as CVD, neoplasms, chronic respiratory disease, unintentional injury, mental disorders, transport injuries, neurological disorders, and diabetes and kidney diseases. However, the ASRs of DALYs for musculoskeletal disorders (AAPC% 95%CI, 0.10 [0.07–0.14] in men; 0.05 [−0.02–0.13] in women) and sense organ diseases (AAPC% 95%CI, 0.38 [0.33–0.43] in men; 0.35 [0.30–0.41] in women) showed either upward or stable trends for both genders during the same period.

Except for musculoskeletal disorders and diabetes and kidney diseases, Global DALY rates for CVD, respiratory infections and tuberculosis, maternal and neonatal

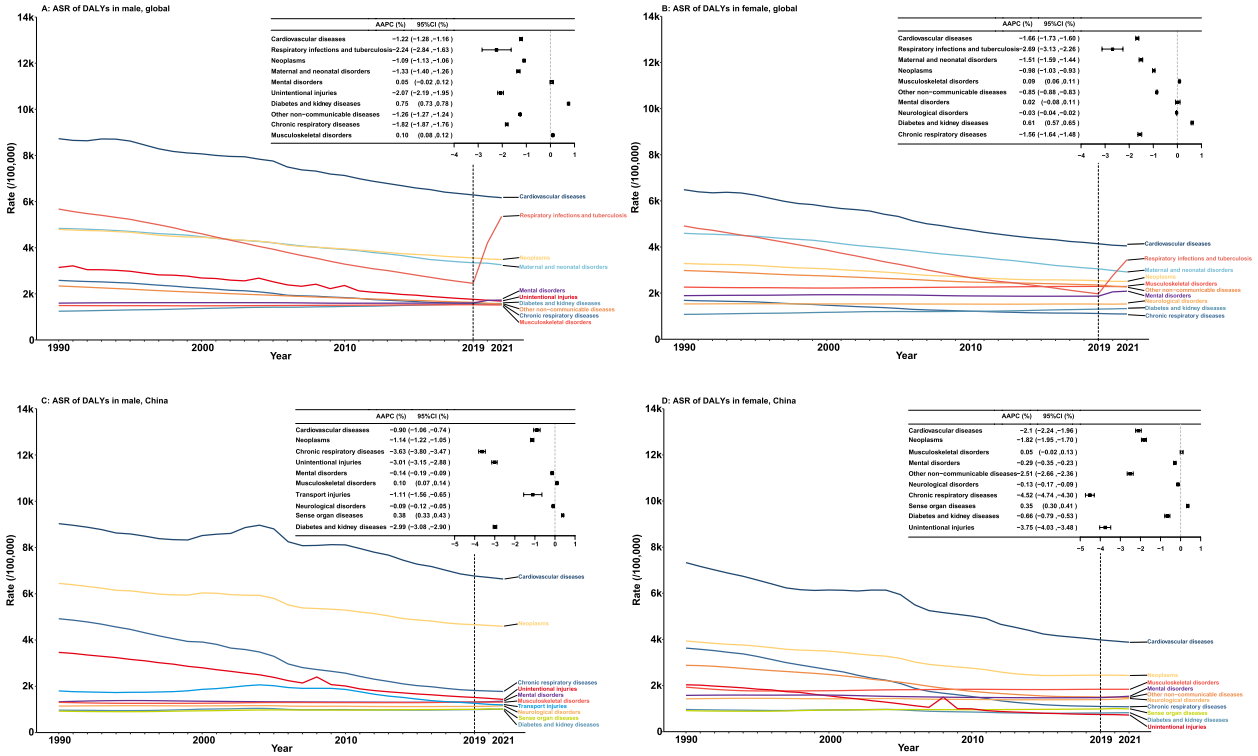

Fig. 2 Trends of age-standardized DALY rates in the world and China. **A** ASR (/100,000) of DALYs in male, global; **B** ASR (/100,000) of DALYs in female, global; **C** ASR (/100,000) of DALYs in male, China; **D** ASR (/100,000) of DALYs in female, China. DALY, Disability-adjusted life year; ASR, Age-standardized rate

disorders, neoplasms, other non-communicable diseases, neurological disorders, and chronic respiratory diseases presented downward trends in both men and women, The global DALY rates for mental disorders remained stable from 1990 to 2019. However, there was a notable increase from 2019 to 2021 (Fig. 2).

The LE and HALE at birth in China and across SDI regions

In 1990, China's LE and HALE were 67.67 and 60.32 years, respectively, both were closest to the figures in the middle SDI region. In 2019, China's LE and HALE reached 77.33 and 68.46 years, respectively, which were closest to the high-middle SDI region. The LEs in 2020 and 2021 were 77.41 and 77.58 years, and both were closest to the high-middle SDI. However, the HALEs in these two years were more in line with those l in the high SDI region (68.46 years in 2020; 68.56 years in 2021). More details can be found in Table 2.

Changes in LE, HALE, and HALE/LE in China from 1990 to 2021

China's LE and HALE have steadily increased from 1990 to 2021, particularly among younger age groups (Fig. 3). However, the ratio of HALE to LE has remained stable in younger age groups and even declined in the old age groups. In the 1–5 months and 7–27 days age groups, both LE and HALE were longer than those in the 0–6 days age group. However, the latter group exhibited a higher HALE-to-LE ratio compared to the former two. Over the past three decades, the ratio has remained at approximately 90.0% for men at birth and 87.5% for women at birth. In the same age group, the HALE-to-LE ratio in men was higher than that in women. Additionally, the LE and HALE at birth for women were higher than for men, and both measures increased by SDI (Fig. 4).

Discussion

In this study, we examined the trends in all-cause mortality, Level 2 cause-specific DALYs, LE, and HALE in China from 1990 to 2021. We also conducted comparative analyses among China, global trends, and different SDI regions. Our findings revealed a consistent decline in ASRs of all-cause mortality and all-cause DALYs in China, despite the challenges posed by the COVID-19 pandemic. At the meanwhile, both LE and HALE have shown significant increases. These trends reflect the progress of China's socio-economic development,, advancements in public health, and the effectiveness of relevant policies and interventions.

Table 2 LE and HALE at birth in China, globally, and SDI regions in 1990, 2019, 2020, and 2021

China/ Global/ Regions	In 1990				In 2019				In 2020				In 2021			
	LE	δLE	HALE	δHALE	LE	δLE	HALE	δHALE	LE	δLE	HALE	δHALE	LE	δLE	HALE	δHALE
	Years (95%UI)	Years	Years (95%UI)	Years	Years (95%UI)	Years	Years (95%UI)	Years	Years (95%UI)	Years	Years (95%UI)	Years	Years (95%UI)	Years	Years (95%UI)	Years
China	67.67 (66.41,68.95)	Ref	60.32 (57.96,62.5)	Ref	77.33 (75.8,78.79)	Ref	68.46 (65.51,71.21)	Ref	77.41 (75.93,78.89)	Ref	68.46 (65.53,71.15)	Ref	77.58 (75.99,79.15)	Ref	68.56 (65.8,71.18)	Ref
Global	65.49 (64.98,65.99)	−2.18	57.05 (54.52,59.27)	−3.27	73.34 (72.56,74.01)	−3.99	63.61 (60.66,66.2)	−4.85	72.4 (71.6,73.1)	−5.01	62.78 (59.9,65.3)	−5.68	71.74 (70.9,72.49)	−5.84	62.20 (59.42,64.67)	−6.36
High SDI	75.59 (75.5,75.67)	7.92	65.60 (62.68,68.12)	5.28	81.17 (81.04,81.29)	3.84	69.48 (66.13,72.36)	1.02	80.36 (80.21,80.48)	2.95	68.70 (65.37,71.55)	0.24	80.22 (80.07,80.36)	2.64	68.53 (65.17,71.32)	−0.03
High-middle SDI	70.37 (69.81,70.89)	2.70	61.79 (59.22,64.15)	1.47	77.36 (76.6,78.03)	0.03	67.74 (64.85,70.39)	−0.72	76.73 (76.05,77.39)	−0.68	67.17 (64.26,69.56)	−1.29	76.2 (75.46,76.89)	−1.38	66.67 (63.94,69.05)	−1.89
Middle SDI	66.99 (66.29,67.68)	−0.68	58.81 (56.28,61.03)	−1.51	74.71 (73.97,75.41)	−2.62	65.22 (62.3,67.78)	−3.24	73.93 (73.15,74.66)	−3.48	64.51 (61.61,66.95)	−3.95	73.22 (72.44,74.01)	−4.36	63.88 (61.14,66.27)	−4.68
Low-middle SDI	60.61 (59.9,61.24)	−7.06	52.36 (49.89,54.44)	−7.96	69.42 (68.46,70.27)	−7.91	60.14 (57.35,62.55)	−8.32	68.19 (67.21,69.03)	−9.22	59.09 (56.48,61.48)	−9.37	67.43 (66.42,68.3)	−10.15	58.43 (55.77,60.77)	−10.13
Low SDI	53.05 (52.11,54.03)	−14.62	45.79 (43.54,47.79)	−14.53	64.88 (63.19,66.35)	−12.45	56.26 (53.55,58.65)	−12.20	63.53 (61.78,64.97)	−13.88	55.17 (52.37,57.56)	−13.29	62.57 (60.9,63.94)	−15.01	54.36 (51.59,56.71)	−14.20

LE life expectancy, *HALE* health-adjusted life expectancy, *SDI* Socio-demographic Index, *UI* uncertainty interval

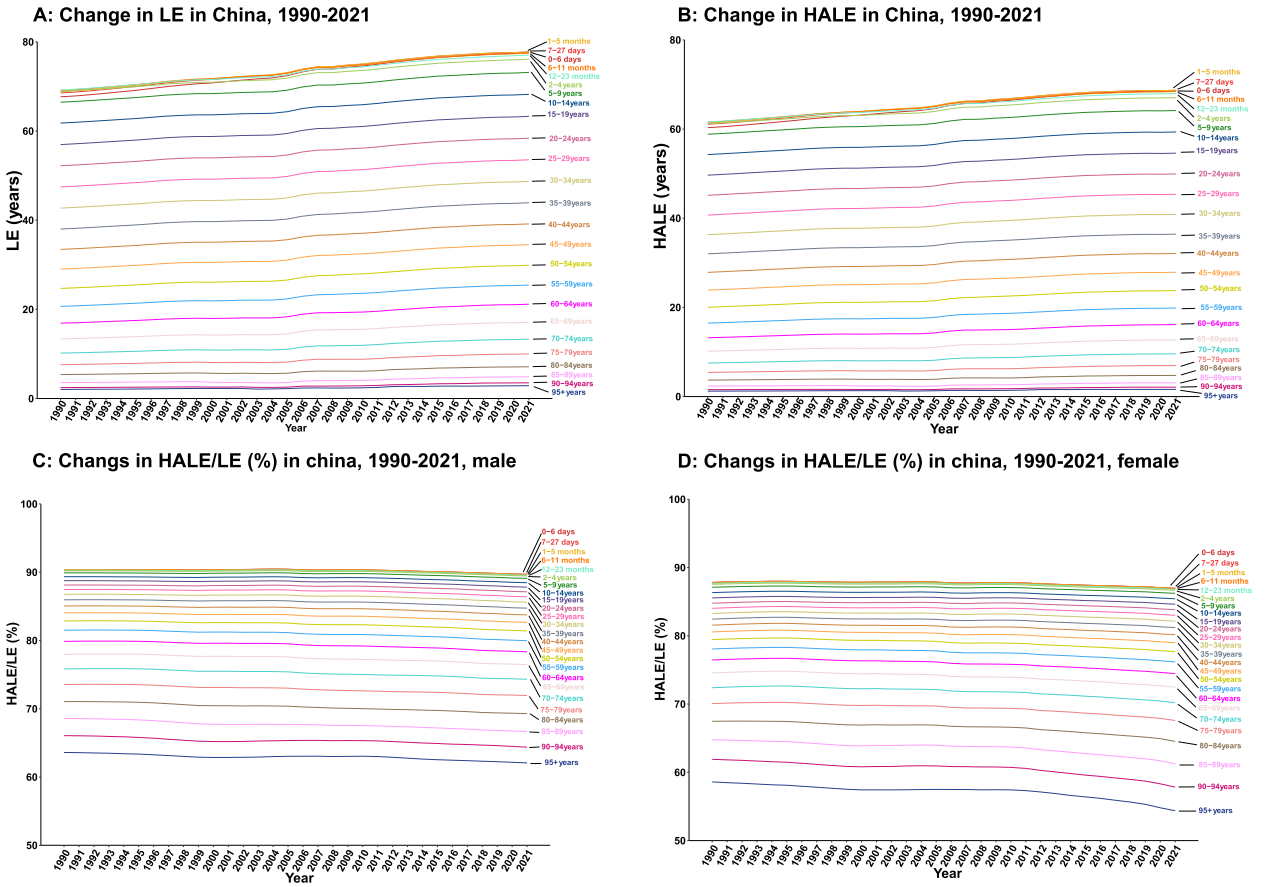

Fig. 3 Changes in LE, HALE, and HALE/LE% in different age groups in China, 1990- 2021. **A** change in LE (years) in China, 1990–2021; **B** change in HALE (years) in China, 1990–2021; **C** change in HALE/LE (%) in China, 1990–2021, male; **D** change in HALE/LE (%) in China, 1990–2021, female.LE, life expectancy; HALE, health-adjusted life expectancy

While LE and HALE have both increased, we did not observe an apparent increase in HALE-to-LE ratios. This suggests that although people are living longer, a considerable portion of the extended lifespan may be spent in an unhealthy state, potentially compromising overall quality of life. Moreover, age-related conditions such as cardiovascular diseases, metabolic disorders, and cancers tend to develop and progress as an individual age [12, 13]. Therefore, actively managing the health of the aging population and slowing down the aging process of the population could effectively alleviate the burden of disease in society [14].

Additionally, as people age, they often experience loss of muscle mass and increased risks of osteoporosis [15, 16]. These contribute significantly to fall-related injuries among the elderly, which can severely impact their quality of life. To address this, it is crucial to strengthen care services for the elderly, in order to mitigate the occurrence of such accidents and improve the overall well-being of this group [17].

Over the past three decades, the ASRs of DALYs for most of the top ten cause-specific diseases have declined, except for musculoskeletal disorders and sensory organ diseases. Musculoskeletal disorders include a spectrum of conditions, such as rheumatoid arthritis, osteoarthritis, low back pain, neck pain, and gout [18]. Notably, musculoskeletal disorders have become the third leading cause of DALYs among young adults globally [19]. Women of childbearing age with MSK disorders are at an increased risk of pregnancy-related complications [20]. Moreover, these disorders strongly associated with certain occupations, particularly in sectors such as manufacturing, construction workers, and nurses [21–23], where they are classified as work-related musculoskeletal disorders (WMSDs) [24]. Occupations that involve high physical demands and poor ergonomic practices are particularly susceptible to WMSDs. Nevertheless, the adverse impacts of WMSDs can be mitigated through improved rehabilitative aids and widespread adoption of standardized ergonomic knowledge [25, 26].

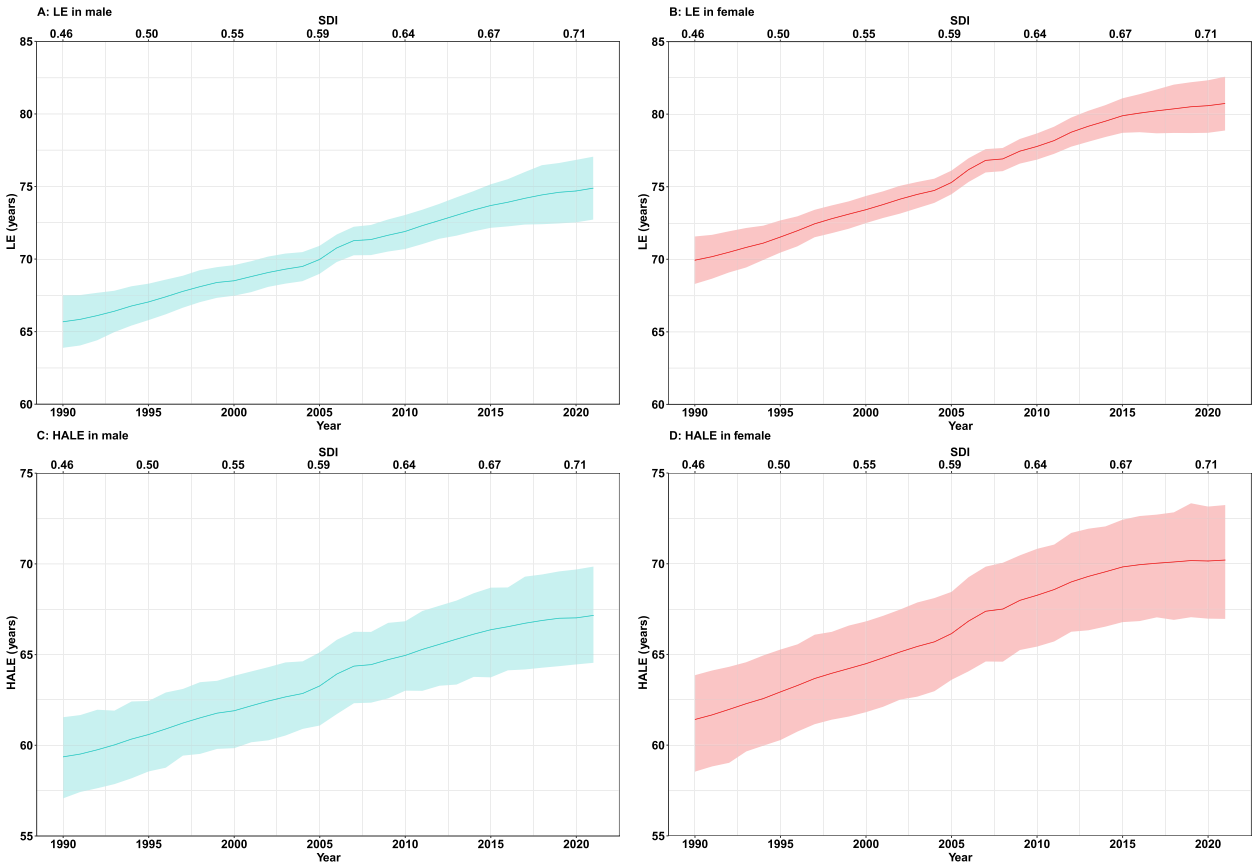

Fig. 4 Changes in LE and HALE in China with SDI, 1990–2021. LE, life expectancy; HALE, health-adjusted life expectancy. SDI, Socio-demographic Index

Throughout the 30 years spanning from 1990 to 2021, both LE and HALE levels in China have shown a consistent upward trend. Despite the challenges posed by the COVID-19 pandemic, HALE in China has approached levels similar to those observed in high SDI regions, in parallel with a notable increase in China's SDI from 0.46 to 0.71. The diseases that reduce HALE are mainly cancer, cardiovascular diseases, chronic respiratory diseases, and diabetes mellitus [27]. The leading causes of the reduced HALE in Chongqing, China, are cerebrovascular diseases, cancer, and injuries [28]. During the pandemic, China implemented a range of proactive measures, including swift deployment of non-pharmacological interventions, extensive nucleic acid testing, meticulous tracing and isolation of close contacts, and the provision of free vaccination with the novel coronavirus vaccine [29–31]. These efforts played an important role in curtailing the mortality rate associated with respiratory infections, with reported new cases accounting for a mere 0.05% of the global total [32]. This success underscored the importance of strategic policy interventions and technological advancements in reducing disease burden. As China's disease profile gradually shifts from that of a developing country to that of a developed one, it is essential to draw from the successful policies and project experiences of Western countries [33], particularly in areas such as preventive measures, healthcare policy, and elderly care [34, 35]. Given that the impact of a policy may take a long process to demonstrate, it is a future direction for subsequent studies to evaluate and refine these strategies.

Furthermore, the prevalence of mental disorders over the past three decades warrants attention. During the COVID-19 pandemic, the global burden of mental disorders increased significantly. In contrast, the change in the epidemiological burden of mental disorders in China was less pronounced. This discrepancy may be attributable to limited resources for mental health care in China, especially for vulnerable populations such as the elderly, adolescents, and pregnant women [36–38]. Physical illnesses often exacerbate mental health conditions as the two being interlinked in a harmful cycle [39]. This underscores the importance of addressing physical health concerns while simultaneously improving mental health care

and support for those suffering from mental disorders [40, 41].

This study is subject to several limitations. First, it relies on secondary data from the GBD study 2021, which imposes certain inherent constraints. Second, the absence of detailed data on specific causes affecting HALE limited our ability to fully explore the factors contributing to the decline in HALE in China over the past three decades. U We hope future research, utilizing China's public health data, will provide a more detailed analysis of population aging across different regions and cities. Finally, the COVID-19 pandemic, which altered the global mortality landscape between 2019 and 2021, highlights the needs for a more comprehensive assessment of the current burden of disease in China and the world.

Conclusions

The aging process is associated with an increased prevalence of various health conditions. Effective public health policies and advancements in medical technology are crucial for enhancing the quality of life among the elderly. While drawing lessons from good experiences and advanced technologies of Western countries, it is essential to tailor these strategies to fit the specific conditions of China in order to address the challenges posed by population aging and reduce the associated disease burden.

Abbreviations

DALYs	Disability-adjusted life years
LE	Life expectancy
HALE	Health-adjusted life expectancy
SDI	Socio-demographic Index
ASR	Age-standardized rates
AAPC	Average annual percent change
BAPC	Bayesian age-period-cohort
INLA	Integrated nested Laplace approximation
CVD	Cardiovascular diseases
WMSDs	Work-related musculoskeletal disorders

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Authors' contributions

XC, WJ, JZ, YX, XL, ML, SJ: Conceptualization, Methodology, Software. XC, WJ, JZ: Data curation, Writing- Original draft preparation. XC, WJ, JZ: Visualization, Investigation. XL, ML, SJ: Supervision. XC, WJ, JZ, YX, XL, ML, SJ: Writing-Reviewing and Editing. Sunfang Jiang: Funding acquisition.

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Data availability

The data were available in the GBD website.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

The authors give consent for publication of this paper in Archives of Public Health.

Competing interests

The authors declare no competing interests.

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