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Original Research Article

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The global, regional, and national burden and quality of care index of kidney cancer; a global burden of disease systematic analysis 1990–2019

Mohamad Mehdi Khadembashiri[1,‡], Erfan Ghasemi[1,‡], Mohammad Amin Khadembashiri[1], Sina Azadnajafabad[1], Sahar Saeedi Moghaddam[1,2], Mohamad Eslami[1], Mohammad-Mahdi Rashidi[1], Mohammadreza Naderian[1,3], Zahra Esfahani[1,4], Naser Ahmadi[1], Nazila Rezaei[1], Sahar Mohammadi Fateh[1], Farzad Kompani[5], Bagher Larijani[6], Farshad Farzadfar[1,6,*]

[1]Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Jalal-AL-Ahmad St., Chmaran HWY., Tehran, Tehran, Iran 1411713119, Iran
[2]Global Cooperation and Social Cohesion, The Global Health Economy, Kiel Institute for the World Economy, Hindenburgufer 66 24105 Kiel Germany, Kiel 24148, Germany
[3]Tehran Heart Center, Cardiovascular Diseases Research Institute, Tehran University of Medical Sciences, North Kargar-Ave, Tehran, Tehran, Iran 1995614331, Iran
[4]Department of Biostatistics, University of Social Welfare and Rehabilitation Sciences, kodakyar Ave., daneshjo Blvd.,Evin, Tehran, Tehran, Iran 1985713871, Iran
[5]Division of Hematology and Oncology, Children's Medical Center, Pediatrics Center of Excellence, Tehran University of Medical Sciences, Children's Medical Center, Dr Gharib St, Keshavarz Blvd, Tehran, Iran, Tehran, Tehran, Iran 1419733151, Iran
[6]Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, NO 10, Jalal-AL-Ahmad St., Chmaran HWY., Tehran, Iran, Tehran 1411713137, Iran

[*]Corresponding author. Non-Communicable Diseases Research Center (NCDRC), Non-Communicable Diseases Research Center (NCDRC), Second Floor, No.10, Jalal Al-e-Ahmad Highway, Tehran, Tehran 1411713136, Iran,
E-mail: f-farzadfar@tums.ac.ir
[‡]Mohamad Mehdi khadembashiri and Erfan Ghasemi are equally first authors.
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Abstract

Kidney cancer (KC) is a prevalent cancer worldwide. The incidence and mortality rates of KC have risen in recent decades. The quality of care provided to KC patients is a concern for public health. Considering the importance of KC, in this study, we aim to assess the burden of the disease, gender and age disparities globally, regionally, and nationally to evaluate the quality and inequities of KC care. The 2019 Global Burden of Disease study provides data on the burden of the KC. The secondary indices, including mortality-to-incidence ratio, disability-adjusted life years -to-prevalence ratio, prevalence-to-incidence ratio, and years of life lost-to-years lived with disability ratio, were utilized. These four newly merged indices were converted to the quality-of-care index (QCI) as a summary measure using principal component analysis. QCI ranged between 0 and 100, and higher amounts of QCI indicate higher quality of care. Gender disparity ratio was calculated by dividing QCI for females by males to show gender inequity. The global age-standardized incidence and mortality rates of KC increased by 29.1% (95% uncertainty interval 18.7–40.7) and 11.6% (4.6–20.0) between 1990 and 2019, respectively. Globally, the QCI score for KC increased by 14.6% during 30 years, from 71.3 to 81.6. From 1990 to 2019, the QCI score has increased in all socio-demographic index (SDI) quintiles. By 2019, the highest QCI score was in regions with a high SDI (93.0), and the lowest was in low SDI quintiles (38.2). Based on the World Health Organization regions, the QCI score was highest in the region of America, with Canada having the highest score (99.6) and the lowest in the African Region, where the Central African Republic scored the lowest (17.2). In 1990, the gender disparity ratio was 0.98, and in 2019, it was 0.97 showing an almost similar QCI score for females and males. Although the quality of care for KC has improved from 1990 to 2019, there is a significant gap between nations and different socioeconomic levels. This study provides clinicians and health authorities with a global perspective on the quality of care for KC and identifies the existing disparities.

Keywords: kidney cancer; epidemiology; quality of health care; mortality; disability-adjusted life years; global burden of disease

Introduction

In 2020, kidney cancer (KC) was the fourteenth most prevalent cancer worldwide. There are various forms of KC, with renal cell carcinoma being the most prevalent [1]. In 2020, KC global incidence was 431 288 (2.2% of all new cancer cases) and accounted for 179 368 deaths (1.8% of all deaths caused by cancers), also 271 249 of all KC cases were males, and 160 039 were females [2]. Males had nearly two times

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the age-standardized incidence and mortality rates of KC [3]. The incidence rate and mortality rate of KC patients are projected to rise by 2030 [4]; therefore, it should be taken into consideration [5].

The World Health Organization (WHO) defines the quality of care as 'the extent of which healthcare services are provided to individuals and populations to improve desired health outcomes' [6]. In general, the quality of healthcare is improving over time, however, it has not uniformly improved [7, 8]. Possible inequities based on age, gender, race, and socioeconomic disparities in the incidence and mortality of KC may be due to a variety of risk factors, such as smoking, obesity, and past medical histories like hypertension. Access to diagnostic and treatment facilities can also contribute to the variation inequity of care for KC between countries [9, 10]. Consequently, it is crucial to be aware of the disparities, as this provides pertinent information about KC to policymakers in countries with a lower level of care quality.

Some indicators, such as the concentration index and horizontal inequity, have been developed to analyze inequities in health systems [11]; however, no all-inclusive and objective index exists to compare the quality of care and inequities. We introduce the previously developed Quality of Care Index (QCI), for KC in this study, which evaluates the distinct components of quality of care across age groups, genders, and world regions. This study aimed to assess the burden and quality of care of KC across countries and regions for both sexes from 1990 to 2019 using the Global Burden of Disease (GBD) 2019 [12] data using the QCI.

Methods

Data collection

Data were collected from the GBD 2019, which contain data on 369 diseases and 87 risk factors for 204 nations and territories from the Institute for Health Metrics and Evaluation (IHME) [12]. The IHME coordinates the GBD study, which provides mortality, incidence, prevalence, years of life lost (YLLs), years lived with disability (YLDs), and disability-adjusted life years (DALYs). In this study, the 10th revision of the International Classification of Diseases (ICD-10) codes of 'C64-C64.2, C64.9-C65.9, Z80.51, Z85.52-Z85.54' and 'C64-C65.9, D30.0- D30.1, D41.0-D41.1' were utilized to identify malignant neoplasms of the kidney in the claim and cause of death data, respectively. Data included all epidemiological measures and metrics for KC (GBD code: B.1.20) [13, 14].

Quality of Care Index

Epidemiological parameters including incidence, prevalence, mortality, DALYs, YLLs, and YLDs are used to quantify the epidemiologic status of certain diseases. The secondary indices included the following: mortality-to-incidence ratio, DALYs-to-prevalence ratio, prevalence-to-incidence ratio [4], and YLLs-to YLDs ratio, which are all proxies of quality of care as following. Considering a steady incidence of KC, the mortality-to-incidence ratio indicates that a higher mortality rate suggests worse conditions. The prevalence-to-incidence ratio indicates that, for a given incidence rate, a higher prevalence indicates better management that prevents death. The DALYs-to-prevalence ratio suggests that a higher DALYs indicates a lower quality of treatment for regions with the same prevalence. Lastly, the YLLs-to-YLDs ratio demonstrates the impact of the health system in delaying fatalities, with higher values indicating poorer health conditions. These four newly merged indices were converted to the QCI as a summary measure using principal component analysis (PCA) [15]. It ultimately combines all four indices into a single index representing most the combined data points. Calculations for the four secondary indices were as follows [16]:

$$\textit{Mortality to incidence ratio} = \frac{\#\ Age - standardizaed\ Mortality}{\#\ Age - standardizaed\ Incidence}$$

$$\text{DALY to prevalence ratio} = \frac{\#\ \text{Age} - \text{standardizaed DALY}}{\#\ Age - \text{standardizaedPrevalence}}$$

$$\text{Prevalence to incidence ratio} = \frac{\#\ \text{Age} - \text{standardizaed Prevalence}}{\#\ Age - \text{standardizaedIncidence}}$$

$$\text{YLL to YLD ratio} = \frac{\#\ \text{Age} - \text{standardizaed YLL}}{\#\ Age - \text{standardizaed YLD}}$$

QCI calculated as follow:

$$QCI\ (x) = \frac{[PCA_{score}(x) - min\ PCA_{score}]}{[max\ PCA_{score}(x) - min\ PCA_{score}]}$$

x represents a data point. Higher amount of QCI indicate higher quality of care.

Formerly, we evaluated the quality of care for other cancers such as thyroid, liver, and pancreas using the present index [17, 18].

QCI validation

We validated the QCI for KC by two previously introduced and validated indices by IHME and GBD data named healthcare access and quality index (HAQI) and universal health coverage (UHC) [19, 20]. The Healthcare Access and Quality (HAQ) Index is calculated on a scale ranging from 0 to 100 based on death rates from 32 causes of death that might be prevented with timely and adequate medical care. Using countries as random effects, a mixed-effect regression model with QCI as the dependent variable and inpatient healthcare utilization, outpatient healthcare utilization, mortality, prevalence, and attributed death rates to all KC risk factors as independent variables was implemented. Pearson's correlation coefficient of the fitted-dependent variable and the HAQ Index was about 0.77.

We also analyzed the correlation between QCI and the UHC Effective Coverage Index, which measures the extent to which high-quality healthcare services are made available to all those in need without financial barriers. We employed a mixed-effect regression model using QCI as the dependent variable and inpatient and outpatient healthcare utilization, mortality, prevalence, and attributed death rates to all KC risk factors as independent factors. Countries were taken into account as random effects. Using this model, we estimated a Pearson's correlation coefficient of around 0.75.

Gender Disparity Ratio

The gender disparity ratio (GDR) was calculated by dividing the QCI scores of females by those of males. The values closer to one indicate less inequity between men and women. Values greater than one indicated the higher quality of care for females, while values less than one indicated the higher quality of care for males.

$$GDR = \frac{QCI\ for\ females}{QCI\ for\ males}$$

Age disparity

This study utilized age groupings with 5-year intervals (i.e. under 5, 5–9, 10–14, ..., 85–89, 90–94, 95+). Age-standardized rates were calculated using the GBD world population standard [13].

Geographic and socioeconomic classification

We used WHO regions, which are grouped into six areas: African Region (AFR), Region of the America (AMR), South-East Asian Region (SEAR), European Region (EUR), Eastern Mediterranean Region (EMR), and Western Pacific Region (WPR) [21]. Sociodemographic Index (SDI) is an index based on per capita income, average educational attainment, and total fertility rate in females <25 years of age. This study used SDI quintiles to organize the world's areas into five distinct groups: High SDI, High-middle SDI, Middle SDI, Low-middle SDI, and Low SDI quintile regions [22]. Additionally, we evaluated KC QCI according to World Bank Income level (WBIL). The World Bank divides the world's economies into four income groups based on the preceding year's gross national income) per capita in current US dollars: low, lower-middle, upper-middle, and high-income countries [23].

Statistical analysis

The R version 3.6.0 and R studio statistical software for Windows (http://www.r-project.org/, RRID: SCR 001905, Vienna, Austria) was utilized to run analyses and generate tables and figures. Reporting the primary indices in this manuscript, the 95% UI [24] was calculated by obtaining 1000 samples from the posterior distribution and noting the 25th and 975th values. The present study's analysis and procedures were conducted in accordance with the publicly available QCI protocol [16]. The age-standardization technique was employed to make the results of the primary measures comparable across locations and the provided rates in this study refer to age-standardized rates of the epidemiologic measures.

Results

The burden of kidney cancer

The global age-standardized incidence rate of KC in 1990 and 2019 was 3.5 (95% UI: 3.4–3.6) and 4.6 (4.2–4.9) per 100 000, respectively. It shows a 29.1% (18.7 to 40.7) increase between 1990 and 2019. The age-standardized death rate increased by 11.6% (4.6–20.0) between 1990 and 2019 from 1.9 (1.8–1.9) to 2.1 (1.9–2.2) per 100 000. Also, the age-standardized DALYs rate per 100 000 was 47.3 (45.2–49.4) in 1990 and 49.6 (46.5–52.9) in 2019 (Table 1).

The age-standardized incidence and death rates per 100 000 were highest in high SDI quintiles in 1990 and 2019, and the lower the SDI quintiles, the lower the age-standardized incidence and death rate. Age-standardized DALYs rate have increased in all SDI quintiles from 1990 to 2019 except in High SDI quintiles, which decreased by 4.2% (−8.2 to −0.3). Also, similar results were derived from WBIL compared to SDI quintiles for age-standardized DALYs, incidence, and death rates in 1990 and 2019. For instance, DALYs decreased by 0.6% (−4.5 to 3.4) in 2019 compared to 1990 only in High-income WBILs, whereas DALYs increased in other WBILs. (Table 1 and Supplementary Table 1)

Quality of Care Index

Globally, the age-standardized QCI score for KC increased by 14.6% between 1990 and 2019, from 71.3 to 81.6 (ΔQCI= 10.3). In addition, the age-standardized QCI score for females was 75.8, and for males, it was 78.1 in 2019, compared to 66.2 and 67.6 for females and males, respectively, in 1990,

Table 1. Primary epidemiological features of KC, at global, WHO regions, WBILs, and SDI in 1990 and 2019.

		Age-standardized rate per 100 000 (Mean)							
		1990				2019			
Location		Incidence	Prevalence	Death	DALYs	Incidence	Prevalence	Death	DALYs
Global		3.5	15.4	1.9	47.3	4.6	22.7	2.1	49.6
WHO Regions	African region	1	2.7	0.8	23.7	1.5	4.7	1.1	29.3
	Region of America	7.3	38	3.1	81.5	7.9	43.3	3	75
	South-east Asian Region	0.8	2.6	0.6	16.4	1.4	5.6	0.9	23.2
	European region	6.4	28.7	3.2	84.8	9	46.8	3.9	92.9
	Eastern Mediterranean region	1.1	4.3	0.7	20.6	2.5	11.4	1.3	33.4
	Western Pacific Region	1.7	6.8	1	26.7	3.6	19.1	1.5	37.6
World bank Income levels	High income	7.1	35.9	3.1	78.3	9.1	51.5	3.4	77.9
	Upper middle income	2.4	9.5	1.4	40.8	4	20.3	1.8	47.3
	Lower middle income	1.2	4.2	0.8	22.7	1.8	7.3	1.1	29.4
	Low income	1.1	3.1	0.8	24	1.5	4.5	1.1	29.1
SDI quintiles	High SDI	7.3	37	3.2	78.1	9	51.5	3.3	74.8
	High-middle SDI	4.3	18.4	2.3	62.5	6.1	31.1	2.7	66.5
	Middle SDI	1.3	4.9	0.8	24.6	2.5	12.6	1.3	34.5
	Low-middle SDI	0.9	2.6	0.6	18.3	1.5	5.8	1	26.4
	Low SDI	0.8	2	0.7	20.3	1.1	3.6	0.9	25.5

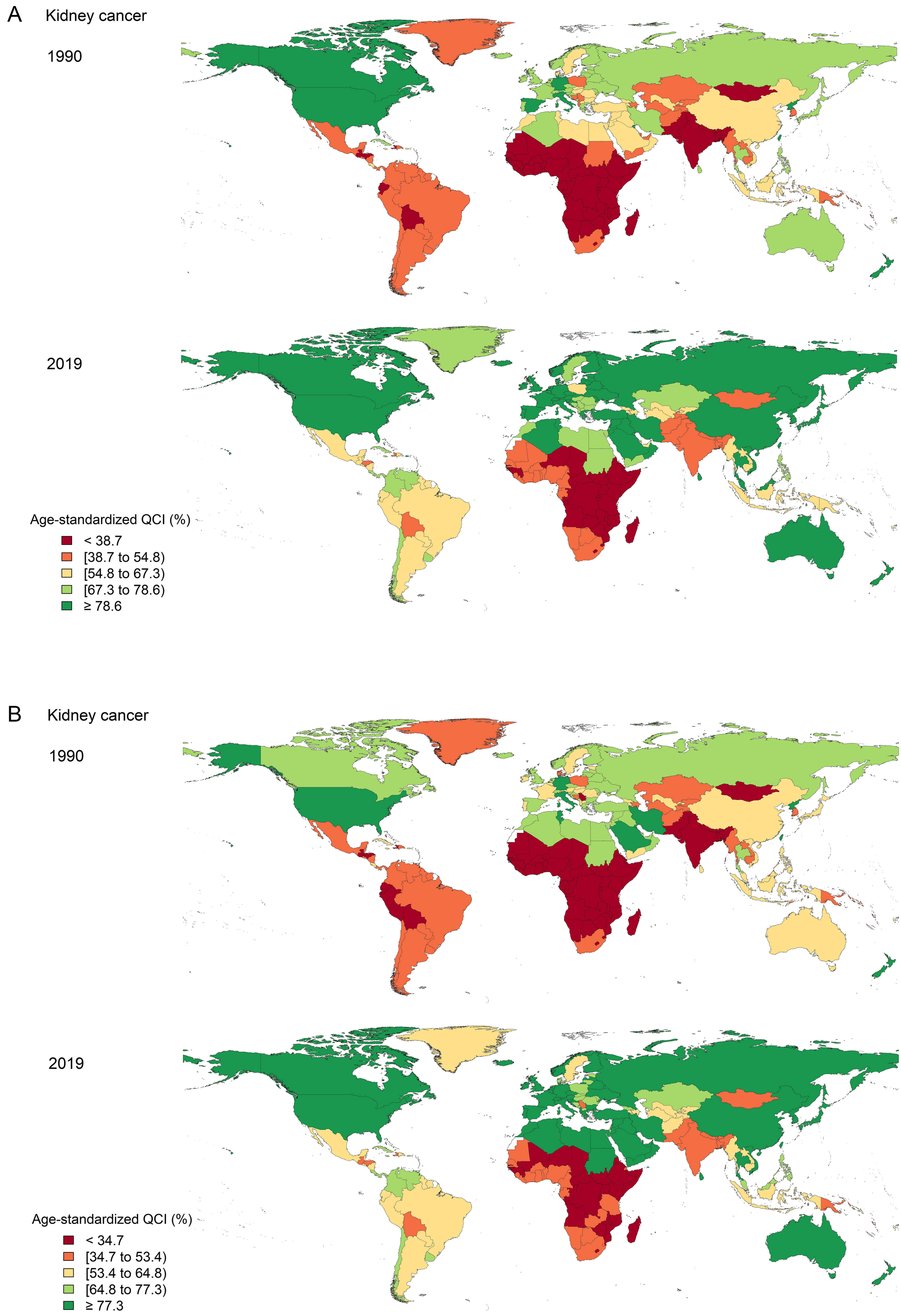

Figure 1 The age-standardized QCI pattern for KC by countries in 1990 and 2019 for both sexes. 1A in both genders, 1B in females and 1C in males.

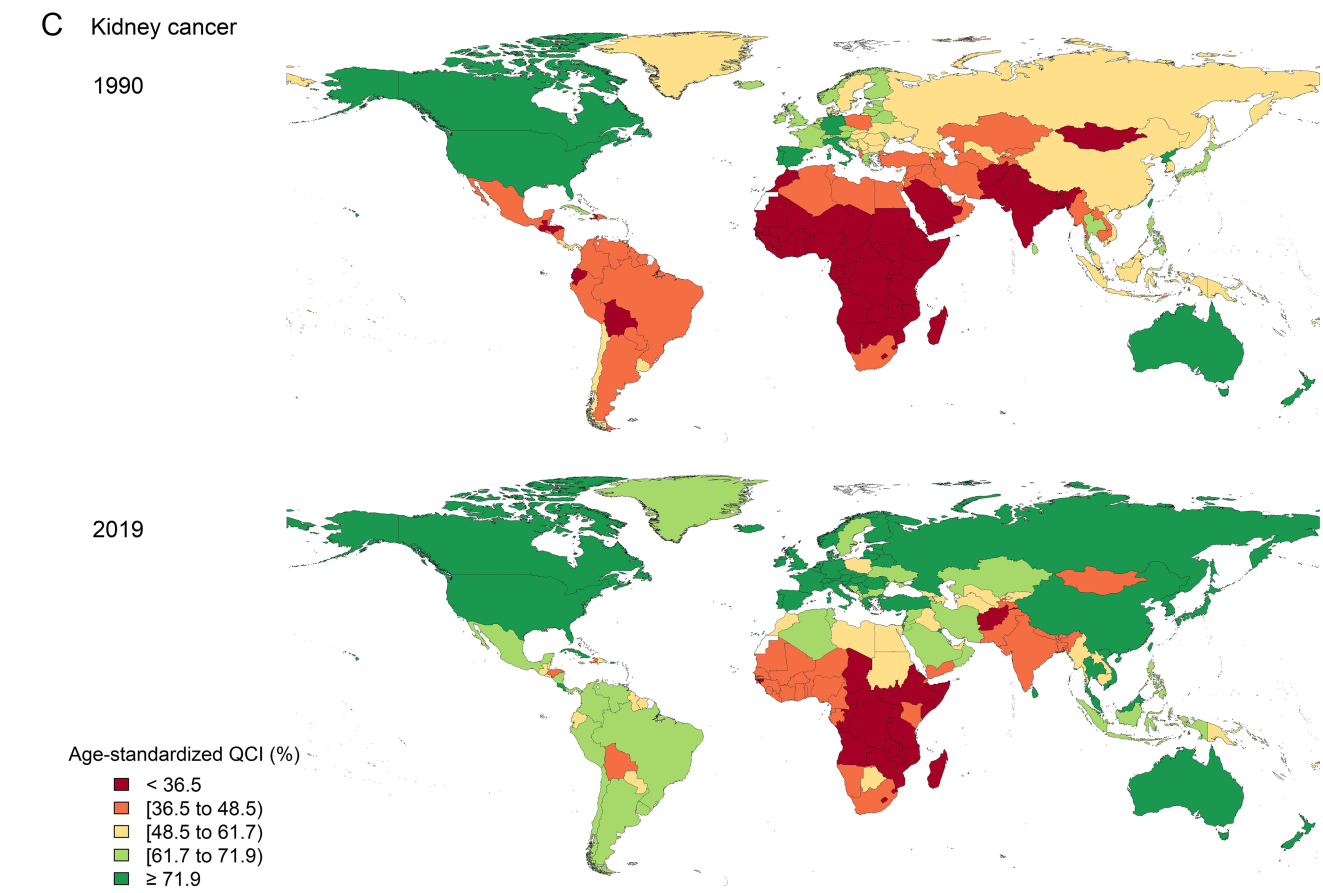

Figure 1 (Continued)

Table 2. Age-standardized QCI for KC in 1990 and 2019 by gender with GDR.

Location		QCI 1990 Both	QCI 1990 Female	QCI 1990 Male	QCI 2019 Both	QCI 2019 Female	QCI 2019 Male	GDR 1990	GDR 2019
Global		71.3	66.2	67.6	81.6	75.8	78.1	0.98	0.97
WHO Regions	African region	28.5	27.1	26.9	44.0	42.5	40.6	1.01	1.05
	Region of America	55.6	67.7	36.9	74.0	83.8	59.3	1.84	1.41
	South-east Asian Region	73.3	71.2	67.1	84.8	80.9	79.6	1.06	1.02
	European region	84.3	75.0	82.5	89.5	81.2	86.9	0.91	0.93
	Eastern Mediterranean Region	44.2	42.0	41.2	60.6	57.4	57.5	1.02	1.00
	Western Pacific Region	63.6	56.8	61.3	86.1	78.5	82.6	0.93	0.95
World bank Income Levels	High income	82.6	76.8	78.4	92.0	85.1	88.3	0.98	0.96
	Upper middle income	61.0	59.0	55.0	81.7	77.4	77.2	1.07	1.00
	Lower middle income	51.1	52.3	44.6	62.7	62.9	57.2	1.17	1.10
	Low income	34.5	31.8	33	42.8	39.3	40.7	0.96	0.97
SDI Quintiles	High SDI	83.5	77.6	79.3	93.0	85.9	89.3	0.98	0.96
	High-middle SDI	68.9	66.3	63.2	83.2	79.2	78.2	1.05	1.01
	Middle SDI	54.9	52.6	50.0	77.1	73.1	72.7	1.05	1.01
	Low-middle SDI	38.5	36.9	35.3	57.9	55.5	54.3	1.05	1.02
	Low SDI	21.2	18.0	21.6	38.2	37.2	35.0	0.83	1.06

QCI= Quality of Care Index; GDR= Gender Disparity Ratio; WHO= World Health Organization; SDI= Socio demographic Index

indicating that males had a slightly higher QCI score in both 1990 and 2019. (Fig. 1 and Table 2) From 1990 to 2019, the age-standardized QCI score has increased in all SDI quintiles. By 2019, the highest value was in regions with a high SDI (93.0), and the lowest was in low SDI quintiles (38.2). Despite a wide gap in age-standardized QCI score between high and low SDI quintiles, the increase in QCI score was higher in lower SDI quintiles by 2019 compared to 1990. For instance, the growth of age-standardized QCI score in low and low-middle SDI was 79.7% from 21.2 to 38.2 and 50.2% from 38.5 to 57.9, while it was 11.4% in high SDI quintiles, which QCI score changed from 83.5 to 93.0 (Fig. 2).

The age-standardized QCI score was consistently highest in the Region of the America and lowest in the African Region,

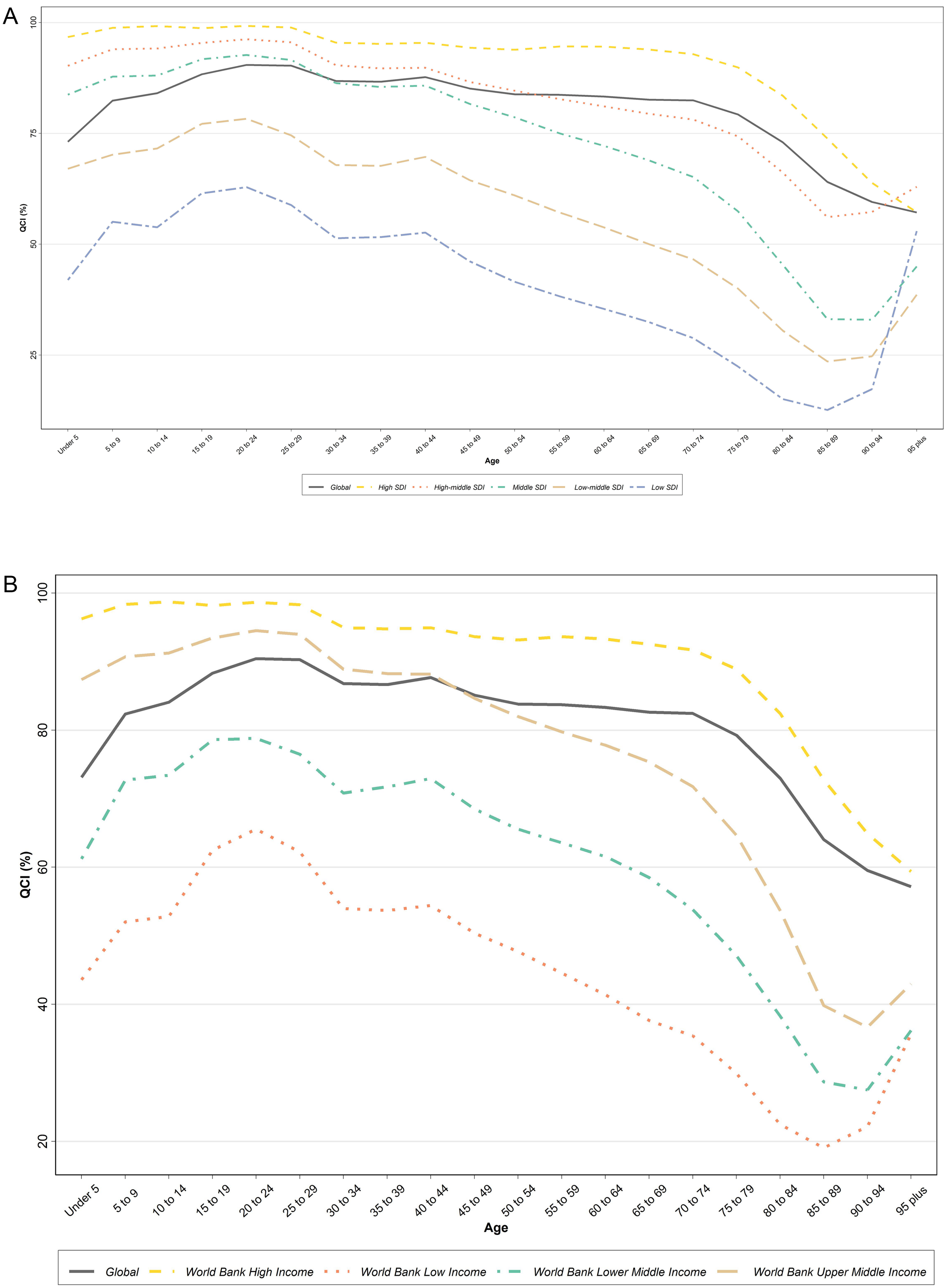

Figure 2 Age pattern of QCI for KC in 2019; 2A based on different SDI quintiles regions and 2B based on different WBIL regions.

given the WHO regions. In the American region, the age-standardized QCI score was 84.3 in 1990 and 89.5 in 2019, whereas in the African region, it was 28.5 in 1990 and 44.0 in 2019. The difference in QCI between the highest and lowest WHO regions decreased from 55.8 in 1990 to 45.5 in 2019.

At national levels, Canada (QCI = 99.6), the USA (99.5), and Italy (99.0) owned the highest age-standardized QCI scores, and Central African Republic (17.2), Somalia (19.7), and South Sudan (24.9) owned the lowest score in 2019. Equatorial Guinea (304.6%) and Eritrea (244.4%) had the highest increase in QCI between 1990 and 2019. Only the Democratic People's Republic of Korea experienced a fall in its QCI score (3.2%) (Supplementary Table 2).

Inequity patterns

❖ Age disparity

In 2019, assessing the global QCI scores for KC in various age groups, we found disparities on a global scale between various age groups, with the highest score in the age group of 20–29 years (QCI = 90.4) and the lowest over 80 years. Within different SDI quintiles, countries with low and low-middle SDI primarily ranked below the global average for all age groups. Contrarily, the QCI scores for KC across all ages in countries with a high SDI were higher than the global average. QCI scores in the middle and high-middle SDI were higher than the global average score <30–35 and 55–59 years, respectively. While QCI scores were lowest in the 85–89 age group, they began to rise in all SDI quintiles except for High SDI. This pattern was almost similar in WBIL. Except for ages <9 and >74 years, where the score begins to decline modestly, the global QCI score for various age patterns nearly remains constant for all ages. Although this reduction occurs at younger ages in middle- and low-SDI quintiles, this pattern is consistent across all SDI quintiles. Additionally, barring high-SDI quintiles, the score increases once more at ages over 94. The QCI score for various WBIL exhibits a remarkably similar trend. Only the QCI score for high-income countries is higher than the global QCI score at ages higher than 44 (Fig. 2).

❖ Gender disparity ratio

In 1990, the global age-standardized GDR was 0.98, and in 2019, it was 0.97, indicating a slight decline. It showed that males received slightly better care for KC in both years. Globally, the GDR scores across various age groups ranges from 0.87 for >95 years to 1.26 in <5 years in 2019, also the ratio was mainly between 0.92 (>95 years) to 1.29 (<5 years) in 1990. In 2019, GDR was more than 1 in all SDI quintiles except High SDI (0.96). Considering the various age groups and SDI quintiles, GDR got the maximum value in the age group of 85–89 years in all SDI quintiles as the highest GDR was reported in the Low SDI (2.50). (Fig. 3) Figure 4 depicts a map comparing GDR in 1990 and 2019 globally (Fig. 4).

Discussion

Principle findings

The main findings of this study highlighted many of the epidemiologic features of KC in different scales. The age-standardized incidence, death, and DALYs rates of KC have increased from 1990 to 2019. Also, the age-standardized incidence and mortality rates were highest among high SDI quintiles and lowest among low SDI quintiles in 1990 and 2019. DALYs increased in all SDI quintiles except high SDI quintiles, which slightly decreased. Global age-standardized QCI score rose from 1990 to 2019, and in all SDI quintiles, it also increased; additionally, the growth of the age-standardized QCI score was higher in lower SDI quintiles. In accordance with WHO regions, the age-standardized QCI score was highest in the region of America and lowest in African regions in 1990 and 2019. WHO regions' QCI gap decreased by 2019 compared to 1990, similar to SDI quintiles. Nationally, Canada had the highest QCI score, followed by the USA and Italy, while the Central African Republic was the worst. The evaluation of the global trend of gender inequity reveals that men received slightly better care. In regions with a low SDI, the ratio of quality of care disparities between men and women surprisingly favored women.

Interpretation within the context of the wider literature

Globally, increasing incidence, death, and DALYs rates for KC indicate the importance of this disease. This increase in incidence may be attributable to global aging [25], an increase in global life expectancy [26], and more accurate diagnostic methods [27, 28]. Smoking, hypertension, and low physical activities are possible risk factors for KC [29]. As an example, globally, hypertension prevalence is on the rise [30], which could be associated with increased age-standardized incidence and death rates of KC. As demonstrated in the results, KC incidence and mortality rates were higher in nations with a high SDI in 2019. This finding may result from a more efficient KC diagnosis due to novel diagnostic methods recently implemented in high-income countries, such as AI-based methods [28], screening, increased number of healthcare facilities, and their improved accessibility.

Despite the increased prevalence of KC in regions with a high SDI, the age-standardized QCI score is higher in these countries. In Canada, which has the highest age-standardized QCI score (99.6), the Canadian KC information system (CKCis) provides demographical, pathological, clinical, and epidemiological information on KC [31], thereby empowering policymakers and healthcare providers to prepare higher-quality care for KC patients. There is also a genetic screening guideline for hereditary renal cell cancers in Canada, which leads to earlier detection of tumors and better outcomes due to earlier diagnosis [28, 32]. Canada is ranked first in the QCI, with the USA following closely in second place. The National Comprehensive Cancer Network plays a crucial role in advancing the quality of cancer care in the USA by developing guidelines, conducting oncology research, and educating healthcare professionals. The treatment recommendations for kidney cancer, as outlined in the NCCN Guidelines, are organized based on histology. This classification system offers valuable advice in the process of selecting appropriate treatments, taking into account many aspects such as effectiveness, safety, available evidence, and other relevant considerations that influence treatment decisions [27, 33].

On the other hand, possible factors for the lower quality of care in African regions include a lack of social awareness, inadequate health care supply, a lack of resources, and the absence of preventative actions [34]. Additionally, poverty drives the majority of patients to abandon their treatment plans. Inaccurate identification of the cause of death in African

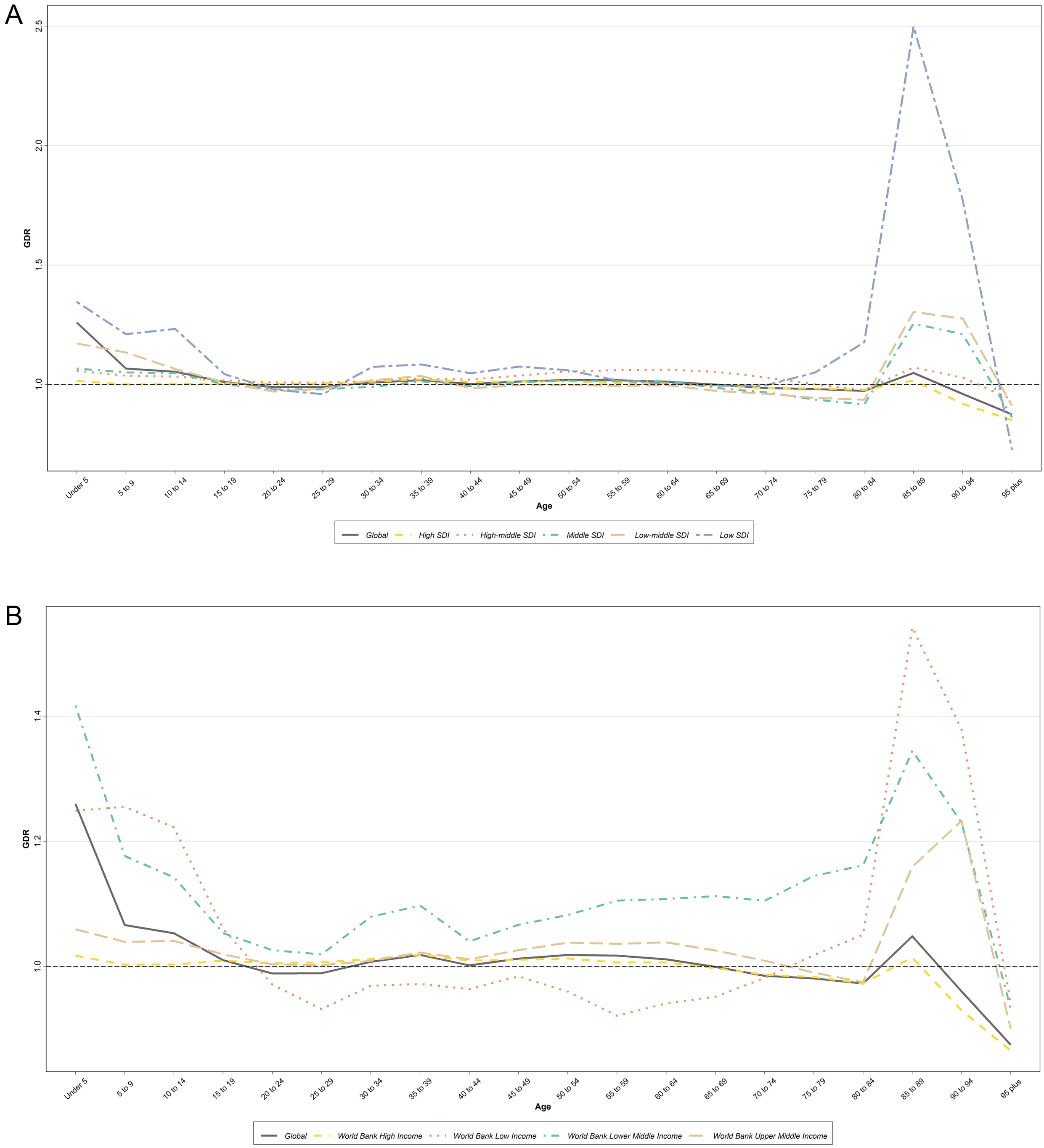

Figure 3 Age pattern of GDR for KC in 2019; 3A in SDI quintile regions and 3B in WBIL regions.

regions results in bias in death registration [35]. Due to a lack of access to treatment, a large number of patients with KC likely die without ever receiving a formal diagnosis [36]. According to the WHO, the African area experiences substandard quality of care due to various health systemic factors, including deficiencies in the oncology workforces, inadequate systems, and a fragile oncology infrastructure. The aforementioned challenges are exacerbated by socio-cultural obstacles, including fatalism and stigma, as well as a prevailing lack of knowledge among both healthcare providers and the general population regarding the indications and symptoms of cancer. Additionally, the utilization of alternative medicines may contribute to delays in seeking appropriate medical care [37].

In this study, the quality of treatment provided to men was marginally superior. In contrast to similar research on thyroid, liver, and pancreatic cancers, the QCI for KC favors women in low SDI quintiles and men in high SDI quintiles. Men have twice the risk of developing KC compared to women [38]. A better outcome for KC in women could be one of the causes of a higher QCI in low SDI countries [39]. Cultural concerns can influence referring to medical centers, receiving medical care, and continuing therapy, all of which contribute to gender inequity.

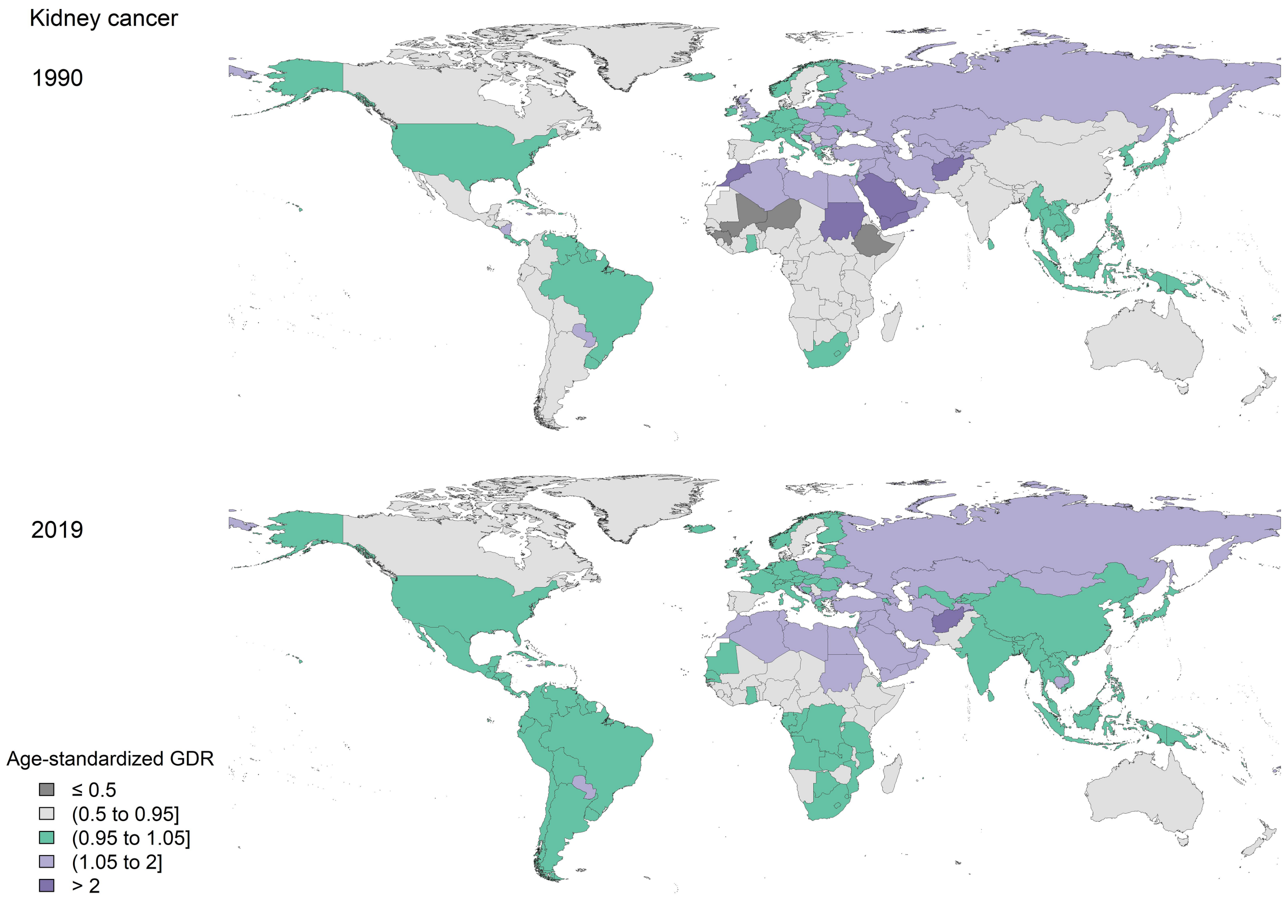

Figure 4 The age-standardized GDR pattern for KC by countries, 1990 and 2019.

According to WHO priorities, infectious diseases such as COVID-19, Crimean-Congo hemorrhagic fever, Ebola virus disease, and Marburg virus disease are the priorities of worldwide healthcare resource allocation [40]. We can realize priorities in any region by looking at mortality. In high-income regions, such as Europe and North America, the death rate due to non-communicable diseases is higher than that of infectious diseases. It is more for infectious diseases in low-income regions, such as Africa [41]. Although KC is not among the most prevalent diseases worldwide, knowing its burden and epidemiological statistics is valuable. Considering the recent improvements in the management of communicable diseases as well as prevalent non-communicable diseases like diabetes and breast cancer, we believe that it is the proper time to address other diseases like KC, which we evaluated in this article.

KC incidence rates climb progressively with age, reaching a peak at ∼75 years of age [29]. Global QCI score for KC decreases with age generally. But as we can see in Fig. 2, two age extremities (<5 years and >85 years) have the lowest global QCI score. The various histopathological characteristics of KCs may be a contributing factor. For example, Wilms tumor is most prevalent in children aged 0–4 years [42], and RCC, is more prevalent in the elderly [29]. Young age is an independent prognostic factor for KC; hence, the prognosis and QCI score of KC decrease with age [43].

Strengths and limitations

This study assesses KC care quality and provides epidemiological indicators and burdens at global, regional, and national levels, stratified by age and gender. QCI is a valid statistic that could be utilized as a single proxy metric to assist policymakers in understanding KC medical care inequalities between countries and regions. This is the first study to use the GBD study 2019 results to assess the quality of care and probable healthcare disparities for KC patients of different ages and sexes in different countries. The GBD study is one of the most thorough and up-to-date disease burden studies, although most of its limitations were due to GBD data collection and reporting methods, which we could not modify. First, GBD grouped all types of kidney cancer with different age trend and prognosis into KC. Second, data scarcity in low- and middle-income nations requires artificial intelligence-based out-of-sample data validation, which may yield less accurate results. Ultimately, we could not include the costs of care in our index development because we did not have access to the data.

Implications for policy, practice, and research

QCI enables policymakers and healthcare organizers to gain remarkable insight into the functioning of health systems and the extent of socioeconomic disparities. Given the demographic shift towards an aging population, it is imperative to implement suitable policies and resource allocation strategies to mitigate the impact of KC on the healthcare system. This will enhance the quality and equity of healthcare and alleviate the burden on the system in the long run.

Conclusions

In this study, QCI was investigated for KC as a practical method for assessing and comparing the quality of cancer care on varying scales. Although the quality of care for the disease has improved from 1990 to 2019, there is a significant gap between nations and territories. Given the disparities, promoting equality and narrowing the gap is essential. Considering the epidemiologic characteristics and disparities of KC care, there is a need for more efficient public healthcare planning.

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Author contributions

Conceptualization: Farshad Farzadfar, Erfan Ghasemi, Sahar Saeedi Moghaddam; Mohamad Mehdi Khadembashiri.

Data collection, analysis, and visualization: Erfan Ghasemi, Sahar Saeedi Moghaddam., Zahra Esfahani, Naser Ahmadi.; Writing – Original Draft: Mohamad Mehdi Khadembashiri, Mohammad Amin Khadembashiri, Mohamad Eslami[1].; Writing–Review & Editing: Sina Azadnajafabad, Mohammad-Mahdi Rashidi[1]., Sahar Saeedi Moghaddam, Mohamad Mehdi Khadembashiri, Mohammad Amin Khadembashiri Mohamad Eslami, Mohammadreza Naderian., Sahar Mohammadi Fateh[1].; Resources: Farshad Farzadfar., Bagher Larijani[6].; Supervision: Farshad Farzadfar., Bagher Larijani[6]., Nazila Rezaei[1]., Farzad Kompani[5]. All authors have read and approved the manuscript prior to submission.

Supplementary data

Supplementary data is available at *IJQHC* online.

Conflict of interest

The authors have no conflict of interest to disclose.

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Data Availability

The dataset used as an input in this paper is available in the GBD repository, [http://ghdx.healthdata.org/gbd-results-tool].

Ethical Approval and Consent to participate

No individual data were used in this paper and the information is based on aggregated pre-existing online secondary data. Data reported in this study was aggregated epidemiologic data and no individual data was reported.

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