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High Fasting Plasma Glucose-Attributable Colorectal Cancer Burden in Western Pacific's Elderly (1990-2021): Temporal Trends, Socioeconomic Determinants, and Health Workforce Correlations

Dehui Zhong[1#], Hai Huang[2#], Lingling Pu[3*]

1 Department of Gastroenterology, Dazhu County People's Hospital, Dazhou, Sichuan, 635100, China.

2 Department of Pathology, Dazhu County People's Hospital, Dazhou, Sichuan, 635100, China.

3 Demonstration Center for Experimental Teaching in Biomedicine, Chengdu Medical College, Chengdu, 610500, China.

* Authors to whom correspondence should be addressed.

# These authors contributed equally to this work.

E-mail addresses: 15984796588@163.com (Dehui Zhong), 18282224173@163.com (Hai Huang), pulingling426@cmc.edu.cn (Lingling Pu).

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Abstract

Background: Colorectal cancer (CRC) is a major global health problem. In the Western Pacific Region, its incidence is rising, especially among the elderly. Metabolic risk factors like high fasting plasma glucose (FPG) contribute to CRC burden, yet no study has explored this in the western pacific region's elderly. Also, the relationship between CRC and human resources for health (HRH) in this region is unknown.

Methods: Analyzed CRC burden due to high FPG in 31 western pacific region countries by Global Burden of Disease Study 2021, including trends, age-specific trends, SDI correlations, decomposition analysis, and HRH-burden relationship.

Results: In 2021, China had the highest CRC burden related to high FPG, Tokelau the lowest. From 1990-2021, the burden increased significantly in most countries. In most countries, the burden of disease is highest in people aged 60-69 years, with the most rapid increase in those aged 95 years and older. The correlation with SDI weakened over time. Population growth was the main driver of burden increase. Overall HRH density showed a positive correlation with CRC burden, with the greatest associations found in "Aides & Emergency Medical Workers" and "Nursing & Midwifery Professionals."

Conclusions: The CRC burden due to high FPG in the western pacific region's elderly has increased. Factors like population growth, epidemiological changes, and aging play roles. The complex relationships with SDI and HRH offer insights for public health policies. These findings underscore the urgent need for integrated public health strategies targeting metabolic risk factor control in the elderly, alongside critical evaluation and optimization of health workforce deployment and roles to effectively address the rising CRC burden in the region.

Keywords: Colorectal cancer, high fasting plasma glucose, aging, Western Pacific Region, public health, DALYs.

Introduction

Colorectal cancer (CRC) is the third leading cause of cancer-related mortality and the second leading cause of cancer-related disability-adjusted life years (DALYs) worldwide[1]. In 2019, CRC was responsible for approximately 1.09 million deaths and 24.3 million DALYs globally[2], reflecting its substantial impact on population health and healthcare systems. The Western Pacific Region, one of the six WHO-defined regions, represents about a quarter of the world's population. Research has documented a continuous rise in CRC incidence within the western pacific region, positioning it as a major public health issue[3]. The incidence of CRC increases with age, particularly accelerating in older populations[4]. Furthermore, the western pacific region is home to the largest and fastest-growing elderly population globally, with over 245 million individuals aged 65 and older[5]. However, to date, no studies have specifically addressed the burden of CRC in the elderly population of the Western Pacific region.

The contribution of metabolic risk factors to the global burden of common cancers has gained significant attention in recent years, with CRC being the most prevalent cancer associated with such risks. The DALYs attributable to CRC from metabolic risk factors have increased from 1.41 million in 1990 to 3.75 million in 2019[6], highlighting an escalating problem. Among metabolic risk factors, elevated body mass index (BMI) and high fasting plasma glucose (FPG) are the primary contributors to CRC[7]. It has been documented a dose-response relationship, where increasing levels of FPG are associated with a correspondingly elevated risk of CRC[8]. Globally, the age-standardized DALYs rate (ASDR) for CRC due to high FPG reached 23.33 per 100,000 in 2019[7]. However, the specific burden of CRC attributable to high FPG within the rapidly aging Western Pacific Region population remains entirely unquantified.

Human Resources for Health (HRH) encompass the variety of professional occupations dedicated to improving and promoting health. HRH plays a pivotal role in accelerating the achievement of universal health coverage and specific sustainable development goals[9]. Research has shown that HRH is closely associated with life expectancy, as well as maternal, neonatal, infant, and under-five mortality rates[10]. Previous studies have examined the relationship between the burden of cardiovascular diseases (CVD) and HRH availability in the western pacific region, revealing a negative correlation between CVD burden and healthcare workforce density[11]. Strikingly, the potential relationship between CRC burden, a major and growing threat in the aging Western Pacific Region, and the critical resource of HRH has never been investigated. Understanding this potential link is essential for evidence-based health workforce planning and resource allocation.

This study aims to fill this gap by providing a detailed analysis of the burden of CRC attributable to high FPG in individuals aged 60 and above in the Western

Pacific Region. Furthermore, it will explore the potential implications for HRH. By analyzing data from 1990 to 2021, this research seeks to provide scientific evidence that can inform the development of effective public health policies and resource allocation strategies, ultimately addressing the growing burden of CRC due to high FPG and optimizing the distribution of healthcare workforce resources.

Materials and Methods

Data Sources

This study utilized data from the Global Burden of Disease Study 2021 (GBD 2021) database (https://ghdx.healthdata.org/gbd-2021). We extracted data for 31 countries and territories in the Western Pacific region from 1990 to 2021. The selected parameters included high FPG as the risk factor and colorectal cancer as the cause. We analyzed both DALYs and deaths, examining both absolute numbers and rates per 100,000 population for adults aged 60 years and above[11-13].

HRH data were obtained from the GBD 2019 Health Workforce Collaborators, covering the period from 1990 to 2019. The dataset encompassed a wide range of health worker categories, including physicians, dentistry personnel, pharmaceutical personnel, nursing and midwifery professionals, and various allied health professionals. Specifically, it included data on physicians, clinical officers, community health workers, dentists, pharmacists, emergency medical workers, audiologists, counsellors, dieticians, nutritionists, environmental health officers, medical lab technicians, optometrists, personal care workers, psychologists, radiographers, physical therapists, and traditional or complementary practitioners. The density values for each category represent workers per 10,000 population[14].

Disease and Risk Factor Definitions

Colorectal cancer is classified under the first level of non-communicable diseases (NCDs), the second level of neoplasms, and the third level of specific cancers in the GBD 2021 framework. It corresponds to ICD-10 codes C18-C19.0, C20, C21-C21.8. High FPG is defined as the mean FPG in a population, measured in mmol/L. We consider any level above the theoretical minimum-risk exposure level (TMREL) of 4.9–5.3 mmol/L as high FPG[12, 13].

Statistical Analysis

We constructed Estimated Annual Percentage Change (EAPC) models to depict long-term trends in the age-standardized rates of disease burden. The EAPC was calculated by fitting a simple linear regression of the natural logarithm of age-standardized rates against year. The slope of the regression equation represents the EAPC value, indicating the annual percentage change. To investigate factors contributing to global disparities in disease burden, we employed the Das Gupta decomposition method. This analysis disaggregated

changes in disease burden into contributions from population growth, population aging, and epidemiological changes. We analyzed the relationship between the Socio-demographic Index (SDI) and disease burden indicators using LOESS (locally estimated scatterplot smoothing) regression and Spearman's rank correlation tests. A similar approach was used to examine the relationship between HRH density and disease burden indicators for each health worker category. All data processing, statistical analyses, and visualizations were performed using R version 4.4.1, employing various packages for data manipulation, visualization, geospatial analysis, and statistical testing. Uncertainty intervals were calculated using the bootstrap method with 1000 iterations. All statistical tests were two-sided, with p-values less than 0.05 considered statistically significant.

Result

Trends in Disease burden of Colorectal Cancer Attributable to High Fasting Plasma Glucose

An analysis was conducted on the disease burden of colorectal cancer attributable to high FPG in 31 countries of the Western Pacific Regions. The results showed that in 2021, China had the highest number of DALYs and deaths in this region. The DALYs were 288,946.93 (95% UI: 140,494.94-453,956.73), and the number of deaths was 14,982.68 (95% UI: 7,322.68-23,546.95). Tokelau had the lowest burden, with DALYs of 0.37 (95% UI: 0.18-0.60) and deaths of 0.02 (95% UI: 0.01-0.03). The country with the highest ASDR and age-standardized mortality rate (ASMR) was the Marshall Islands, with values of 282.05 (95% UI: 134.40-467.17) and 15.32 (95% UI: 7.31-25.27) respectively. Papua New Guinea had the lowest, with ASDR of 38.20 (95% UI: 17.04-66.13) and ASMR of 2.04 (95% UI: 0.91-3.55) (Figure 1; Table S1-2).

During the period from 1990 to 2021, the number of DALYs for colorectal cancer attributable to high FPG in the Western Pacific region increased significantly. In 11 countries, the increase was more than 200%. Except for Tokelau, where the change in the number of deaths was zero, the number of deaths in other countries also increased substantially. In 12 countries, the increase exceeded 200%. Cambodia had the most significant increase in the number of DALYs and deaths, reaching 527.72% and 535.41% respectively. Regarding the changes in ASR, 24 countries showed an upward trend. Viet Nam had the most rapid increase in ASDR and ASMR, with growth rates of 129.02% and 122.13% respectively, and the EAPC values were 2.83 (95% CI: 2.61-3.06) and 2.69 (95% CI: 2.45-2.94) respectively. Among the countries with a downward trend, aged countries accounted for more than 70%. Singapore had the largest decrease in ASDR and ASMR, with decreases of-41.19% and-38.1% respectively, and the EAPC values were-2 (95% CI:-2.2-- 1.79) and-1.87 (95% CI:-2.07-- 1.67) respectively (Figure 2; Table S1-2).

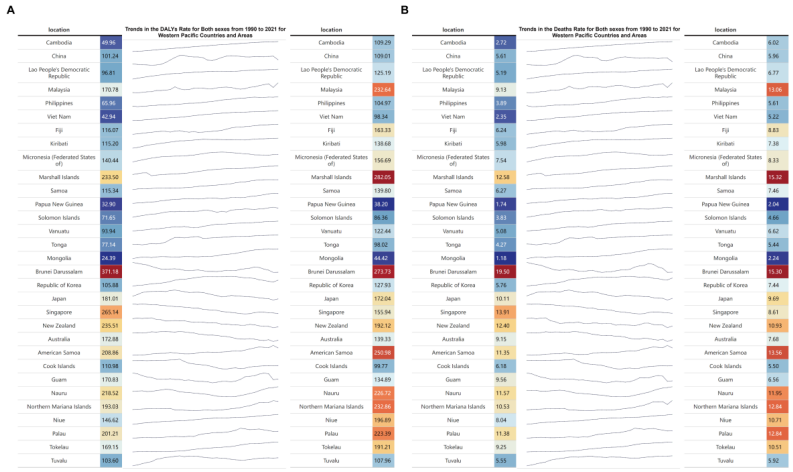

Figure 1. ASDR and ASMR due to colorectal cancer attributable to high fasting plasma glucose in the Western Pacific region, 1990-2021, for both sexes combined (males and females) aged 60 years and above.

A) Trends in ASDR, 1990-2021; B) Trends in ASMR, 1990-2021

B)

Age Group-Specific Trends in Burden of Colorectal Cancer Attributable to High Fasting Plasma Glucose

To explore the age-specific distribution of the disease burden of colorectal cancer attributable to high FPG in countries of the Western Pacific region, the population aged 60 and above was grouped at 5-year intervals. The research findings indicate that in 2021, the maximum number of DALYs in most countries was concentrated in age groups below 80 years. Specifically, the peak of DALY numbers in 18 countries occurred in the 60-64 years old age group, and in 8 countries, it was in the 65-69 years old age group. However, the distribution of the peak number of deaths was more dispersed. Except for the age group above 90 years, the peak number of deaths occurred in various age groups. The 65-69 years old age group had the largest number of countries with the peak number of deaths, reaching 10, followed by the 60-64 years old age group with 8 countries. It is noteworthy that the peak number of deaths in Japan occurred in the 85-89 years old age group (Table S3-4). During the period from 1990 to 2021, in the Western Pacific region, the maximum increase in the number of DALYs and deaths in most countries occurred in the age group above 95 years, with 21 and 20 countries respectively. Meanwhile, in some regions such as Niue, Viet Nam, and Brunei Darussalam, the maximum increase was observed in the younger age groups. Additionally, in a few countries like Japan and Tokelau, the number of DALYs or deaths in the younger age groups decreased. The disease burden in Micronesia

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(Federated States of) showed a V-shaped change, with a significant increase in both the younger and older age groups, but a decrease of approximately 12% in the disease burden in the 75-79 years old age group. Notably, in Niue, the maximum increase occurred in the 60-64 years old age group, while a downward trend was observed in the 80-94 years old age group, with the largest decrease in the 90-94 years old age group (Figure 3; Table S3-4).

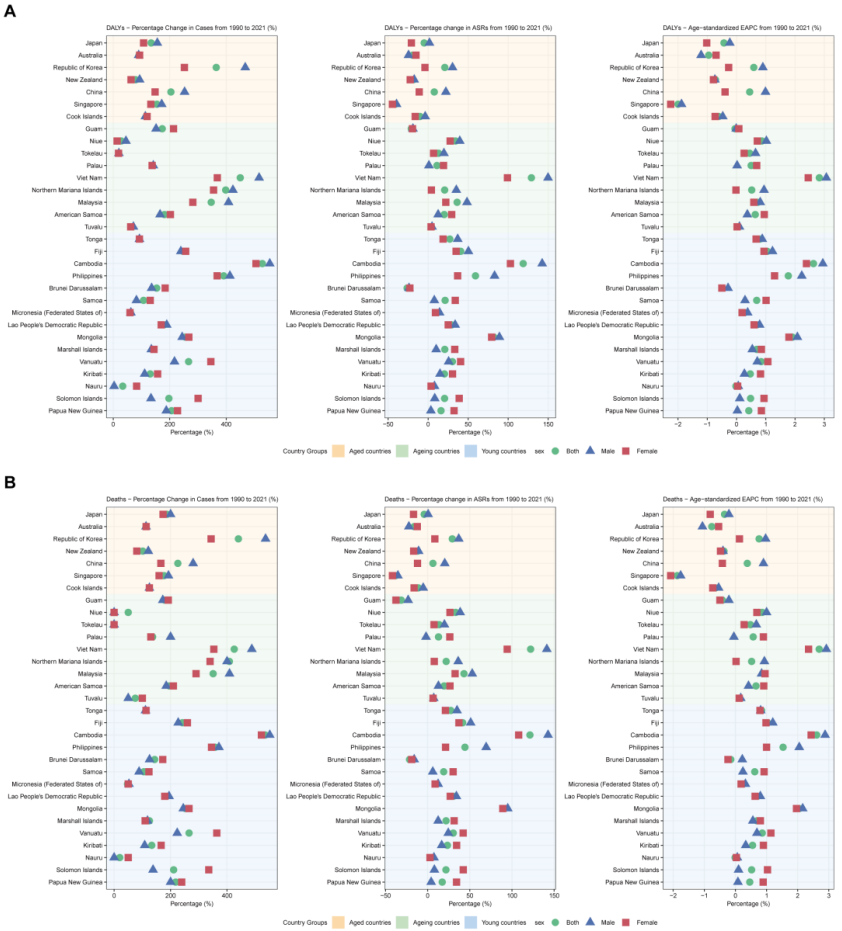

Figure 2. Percentage change in numbers and ASRs of DALYs and deaths, and EAPC in ASRs due to colorectal cancer attributable to high fasting plasma glucose in the Western Pacific region, 1990-2021, for both sexes combined, males, and females aged 60 years and above.

A) DALYs: Percentage change in numbers and ASRs, and EAPC in ASRs; B) Deaths: Percentage change in numbers and ASRs, and EAPC in ASRs.

From the perspective of ASRs, the peak distribution of the ASDR was relatively scattered. The peaks of ASDR in 14 countries were in the age group above 95 years, and in 9 countries, they were in the 85-89 years old age group. The peak distribution of the ASMR was mainly concentrated in the higher age groups. The peaks of ASMR in 21 countries were in the age group above 95 years, in 5 countries in the 90-94 years old age group, in 4 countries in the 85-89 years old age group, and in 1 country in the 80-84 years old age group (Table S3-4). The maximum increase in ASDR and ASMR in most countries occurred in the age group above 95 years, involving 22 and 23 countries respectively. In a few countries, ASDR and ASMR in the younger age groups decreased, and in most of these countries, the maximum decrease occurred in the 60-64 years old age group. The Philippines and Guam were rather special, with an increase in ASDR and ASMR in the younger age groups and a decrease in the older age groups, with the largest decrease in the 90-94 years old age group. In addition, although a decrease was observed in the younger age groups in China, a downward trend also occurred in the age group above 90 years, with the largest decrease in the 90-94 years old age group (Figure 3; Table S3-4).

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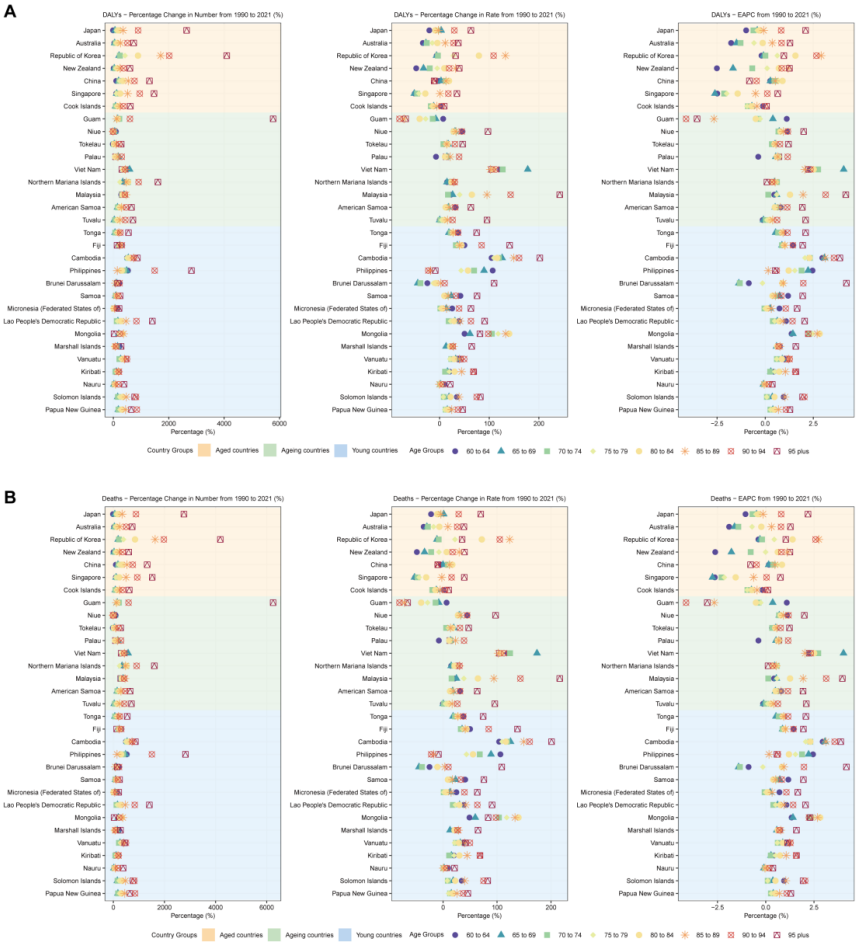

Figure 3. Percentage change in numbers and ASRs of DALYs and deaths, and EAPC in ASRs due to colorectal cancer attributable to high fasting plasma glucose in the Western Pacific region, 1990-2021, for both sexes combined (males and females), stratified by 5-year age groups from 60 years and above.

A) DALYs: Percentage change in numbers and ASRs, and EAPC in ASRs by age group; B) Deaths: Percentage change in numbers and ASRs, and EAPC in ASRs by age group.

Correlation Between Burden of Colorectal Cancer Due to High Fasting Plasma Glucose in the Aging Western Pacific Population and SDI

During the period from 1990 to 2021, a positive correlation was observed between the disease burden of colorectal cancer due to high FPG in the aging population of the Western Pacific region and the SDI. However, this correlation

exhibited subtle differences across different time periods. In 1990, there was a significant correlation between the ASMR, ASDR, and SDI (Spearman's R = 0.7, P < 0.01). Specifically, when SDI was less than 0.3, both ASDR and ASMR decreased with the increase of SDI. When SDI ranged from 0.3 to 0.4, ASDR and ASMR increased. When SDI was in the range of 0.4-0.5, they decreased again. After SDI exceeded 0.5, ASDR and ASMR rose rapidly until SDI reached approximately 0.66, at which point they decreased again. By 2019, the correlation between ASDR, ASMR, and SDI weakened (Spearman's R = 0.48, P < 0.01). During this period, when SDI was less than approximately 0.58, ASDR and ASMR increased continuously. After SDI exceeded 0.58, they began to decline until SDI was approximately 0.63. In the range of 0.63-0.7, they increased again. In the range of 0.7-0.77, the change became more gentle. After SDI exceeded 0.77, they decreased again. Data from 2021 indicated that the correlation between ASDR and ASMR further declined, and the significance also decreased (Spearman's R = 0.42, P < 0.05). The curves of ASDR and ASMR changing with SDI were similar to those in 1990, but with a difference: when SDI exceeded 0.7, ASDR and ASMR no longer entered a stable phase but decreased rapidly again (Figure 4).

Decomposition Analysis of Changes in Burden of Colorectal Cancer Due to High Fasting Plasma Glucose from 1990 to 2021

A decomposition analysis of the changes in the disease burden of colorectal cancer attributable to high FPG in the Western Pacific region over the past 32 years (from 1990 to 2021) was conducted by considering factors such as aging, population growth, and epidemiological changes. The results of the analysis indicate that population growth had a positive contribution to the increase in both the number of DALYs and deaths in all countries of the region. Moreover, for the majority of countries, population growth was the primary driving factor for the rise in the disease burden. In Singapore, for instance, the contribution of population growth to the increase in the disease burden exceeded 150%. The contribution of epidemiological changes ranked second. In Niue, epidemiological changes had the most significant impact on the number of DALYs and deaths, with contribution rates reaching 116.53% and 180.76% respectively. However, in seven countries, the contribution of epidemiological changes was negative. Singapore was the most affected by this negative contribution, with rates of -74.44% and -62.37% for DALYs and deaths respectively. Regarding aging, it had the greatest contribution to the number of DALYs and deaths in Tokelau, with contribution rates of 29.51% and 49.34% respectively. Overall, however, the contribution of aging to the disease burden in most countries was relatively small, and it was negative in 13 countries (Figure 5; Table S5).

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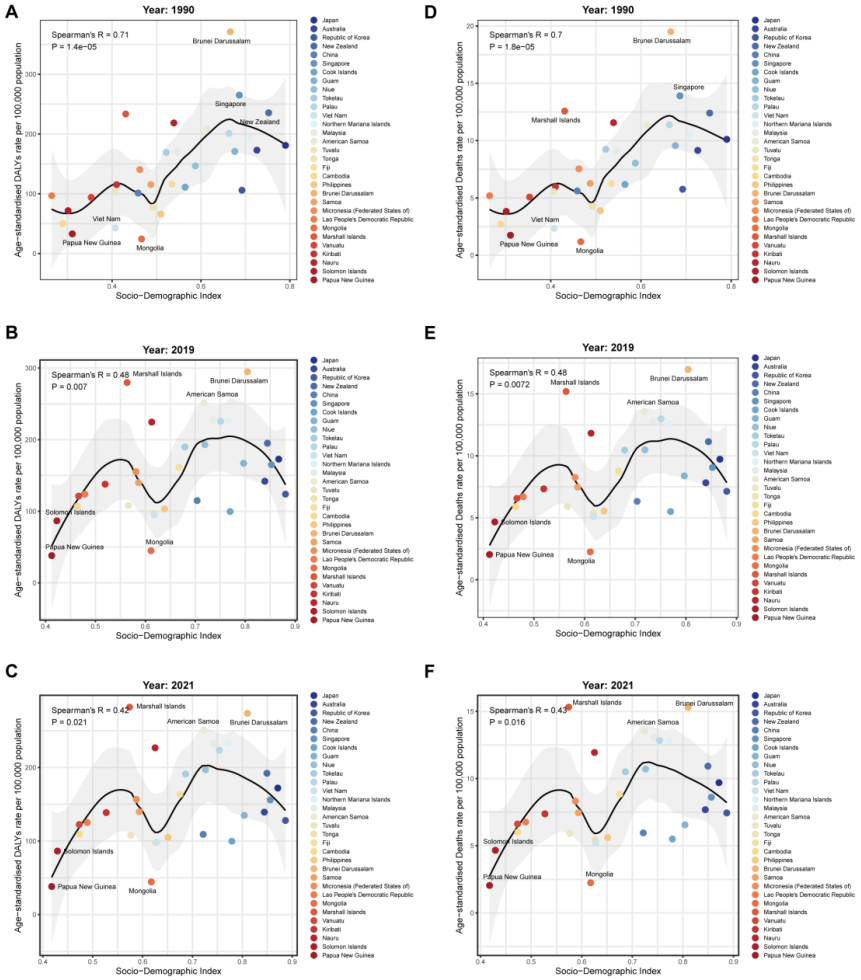

Figure 4. Correlation between ASDR and ASDR due to colorectal cancer attributable to attributable to high fasting plasma glucose and Socio-demographic Index (SDI) in the Western Pacific region for both sexes combined (males and females) aged 60 years and above.

A) Age-standardized DALY rates vs. SDI in 1990; B) Age-standardized DALY rates vs. SDI in 2019; C) Age-standardized DALY rates vs. SDI in 2021; D) Age-standardized death rates vs. SDI in 1990; E) Age-standardized death rates vs. SDI in 2019; F) Age-standardized death rates vs. SDI in 2021

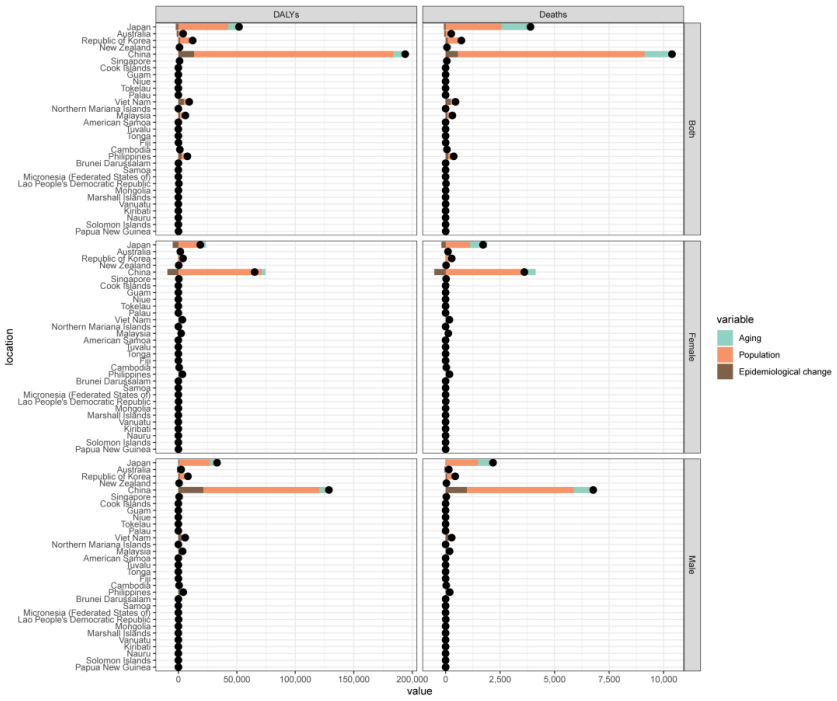

Figure 5. Decomposition analysis of ASDR and ASMR due to colorectal cancer attributable to high fasting plasma glucose in the Western Pacific region, 1990-2021, for both sexes combined (males and females) aged 60 years and above.

Relationship Between Human Resources for Health and Burden of Colorectal Cancer Due to High Fasting Plasma Glucose

We evaluated the correlation between the density of human resources for health (HRH) and the disease burden of colorectal cancer attributable to high FPG in the Western Pacific region. The results indicated a positive correlation between the overall HRH density and the ASMR, as well as the ASDR. The Spearman rank correlation coefficients were 0.48 and 0.47 respectively, which was approximately 0.2 lower than that in 1990 (Figure 6A-B). Upon further analysis of the correlation of the densities of 21 job categories, it was found that "Aides & Emergency Medical Workers" and "Nursing & Midwifery Professionals" had the most significant correlations with the disease burden. Taking the data of 2019 as an example, the Spearman's R between the density of Nursing & Midwifery Professionals and ASDR, ASMR were 0.58 and 0.57 respectively ($P < 0.01$). When the number of Nursing & Midwifery Professionals per 10,000 population was less than 80, both ASDR and ASMR showed a fluctuating upward trend. However, when this number exceeded 80, ASDR and ASMR changed slightly,

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with only a small decline. For Aides & Emergency Medical Workers, the Spearman rank-correlation coefficients between their density and ASDR, ASMR were both 0.4 ($P < 0.05$). When the number of Aides & Emergency Medical Workers per 10,000 population was less than 50, ASDR and ASMR fluctuated. Once this number exceeded 50, ASDR and ASMR gradually decreased (Figure 6C-D).

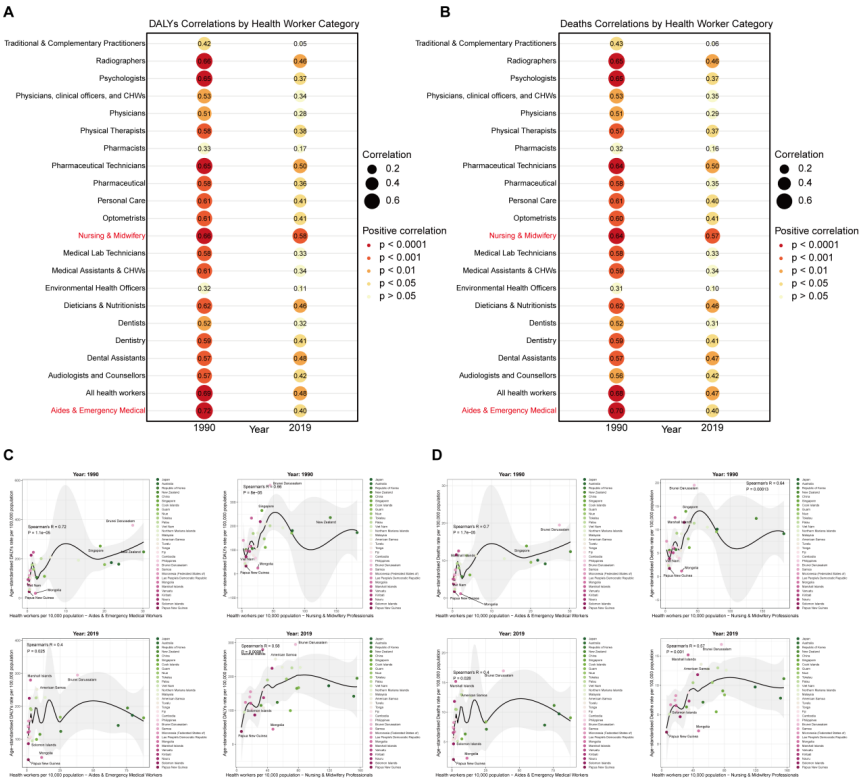

Figure 6. Correlation between ASDR and ASMR due to colorectal cancer attributable to attributable to high fasting plasma glucose and 22 common Human Resources for Health (HRH) indicators in the Western Pacific region for both sexes combined (males and females) aged 60 years and above.

A) Bubble chart for ASDR and HRH indicators in 1990 and 2019; B) Bubble chart for ASMR and HRH indicators in 1990 and 2019; C) Scatter plots for ASDR with the two strongest correlating HRH indicators (Aides & Emergency Medical Workers and Nursing & Midwifery Professionals) in 1990 and 2019, highlighting the top three countries with highest and lowest burden; D) Scatter plots for ASMR with the two strongest correlating HRH indicators (Aides & Emergency Medical Workers and Nursing & Midwifery Professionals) in 1990 and 2019, highlighting the top three countries with highest and lowest burden

Density Distribution of Human Resources for Health in the Western Pacific Region

There are significant differences in the distribution density of two types of HRH, namely Aides & Emergency Medical Workers and Nursing & Midwifery Professionals, across the Western Pacific regions (Figure 7). In 2019, Singapore had the highest density of Aides & Emergency Medical Workers, reaching 87.84 (95% CI: 60.79-125.14) per 10,000 population, while Tonga had the lowest, with only 0.91 (95% CI: 0.59-1.33) per 10,000 population. For Nursing & Midwifery Professionals, New Zealand had the highest level, at 155.86 (95% CI: 116.03-200.76) per 10,000 population, and Papua New Guinea had the lowest, with 6.18 (95% CI: 4.18-8.93) per 10,000 population. From 1990 to 2019, the number of Aides & Emergency Medical Workers increased across the entire Western Pacific region. China had the largest increase, with a growth rate of 1998.94%, while the Northern Mariana Islands had the smallest increase, at 3.84%. Regarding the density of Nursing & Midwifery Professionals, the Federated States of Micronesia had the largest increase, by 787.07%, and Guam had the smallest increase, at 1.34%. However, the density of Nursing & Midwifery Professionals decreased in Australia, the Philippines, and Papua New Guinea, with reduction rates of-17.19%,-7.19%, and-2.52% respectively (Table S6-7).

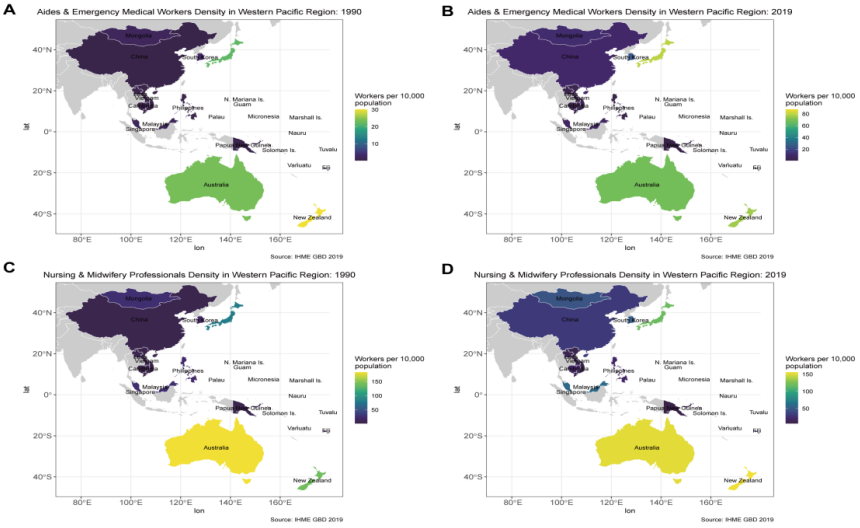

Figure 7. Density distribution maps of selected Human Resources for Health indicators in the Western Pacific region.

A) Density of Aides & Emergency Medical Workers in 1990; B) Density of Aides & Emergency Medical Workers in 2019; C) Density of Nursing & Midwifery Professionals in 1990; D) Density of Nursing & Midwifery Professionals in 2019.

Discussion

The Western Pacific Region is the area with the most rapid economic growth among countries worldwide. The rapid aging process, along with changes in diet and lifestyle, has led to a continuous increase in non - communicable diseases such as obesity, diabetes, and cancer in this region[15]. High FPG, by disrupting glucose metabolism and promoting the development of insulin resistance, thereby increasing the risk of cancer, has become an important metabolic risk factor for cancer[16, 17]. Our study systematically analyzed the burden of CRC in the elderly population aged ≥60 in 31 countries of the Western Pacific Region from 1990 to 2021, which was caused by high FPG. The results reveal a substantial and escalating burden, mainly driven by population growth, characterized by significant heterogeneity across countries and complex relationships with socioeconomic development and health workforce metrics. This suggests that the prevention, control, and management of CRC related to high FPG in the elderly population in this region face complex and severe challenges.

Among the countries in the Western Pacific Region, China bears the highest absolute burden. Its number of DALYs and deaths far exceed those of other countries, and it has maintained a high burden from 1990 to 2021. On the one hand, this is related to China's large population size and rapid aging process, which has led to an increase in the total number of elderly people[18]. On the other hand, with economic development, changes in lifestyle and dietary structure have led to a continuous increase in the incidence and mortality of CRC[19, 20]. In terms of ASRs, the Marshall Islands show the highest disease burden. As an affiliated island of the United States, the Marshall Islands have a more Western - style diet, resulting in a high prevalence of diabetes, obesity, and hypertension[21], which indirectly increases the disease burden caused by high FPG. In addition, reports indicate that due to local public policies and issues such as healthcare awareness, the cancer screening rate is low, resulting in a relatively high number of DALYs and mortality related to CRC[22]. This stark contrast highlights how population dynamics, behavioral factors, and healthcare system strengths and weaknesses interact to shape the burden landscape.

While population aging is a well-recognized driver of NCDs[23], our decomposition analysis offers a crucial nuance in the CRC burden caused by high FPG in the Western Pacific Region: population growth and epidemiological changes were the predominant drivers, with the demographic effect of aging itself playing a relatively smaller role. Cambodia exemplifies this pattern, the number of DALYs and deaths has increased sharply over the past 32 years, while the contribution of aging is less than 1%. Population growth and epidemiological changes play a decisive role. Since the 1990s, Cambodia has implemented a series of reforms. Driven by tourism, the textile industry, and the construction industry, its economy has experienced strong growth[24]. It fueled population expansion

and increased life expectancy, and so exacerbating the disease burden of the elderly[25]. In addition, Cambodia is still a low - to - middle - income country, with inadequate health awareness among the people and imperfect national medical resources. There is a recognized deficiency in the early identification and prevention of cancer. More than 70% of cancer patients are in the advanced stage when treated by oncologists[26, 27], which invisibly increases the DALYs and mortality. This finding underscores that mitigating future burden requires not only preparing for an aging society but also urgently addressing modifiable risk factors and strengthening health systems.

In this study, the relationship between the disease burden and the SDI reveals a non - linear pattern that has evolved over time. In the early years (e.g., 1990), there was a significant positive correlation, with a higher disease burden concentrated in countries with a high SDI. The weakening and increasingly non-linear relationship by 2021 suggests diverse epidemiological trajectories. This non - monotonic relationship indicates that countries at different stages of socioeconomic development may face unique challenges and opportunities in managing the risk of CRC. For example, in countries with a middle SDI level, such as Vietnam, Cambodia, and Mongolia, often experience a rapid rise in ASDR/ASMR as economic development facilitates lifestyle changes (increased caloric intake, reduced physical activity) that elevate high FPG and CRC risk before robust preventive and healthcare infrastructures are fully established. In contrast, in countries with a high SDI, such as Singapore, Brunei Darussalam, and Australia, benefit from advanced healthcare systems, effective screening programs, and greater health awareness, enabling them to stabilize or even reduce burden despite high baseline risk factor exposure. This non-monotonic pattern underscores the need for tailored interventions aligned with a country's specific stage in the health transition.

Age-specific analysis further illuminates the impact of hyperglycemia on the heterogeneity of CRC in different elderly population groups. In many countries, the largest number of DALYs is observed in the 60-64 years old or 65-69 years old age groups. However, the peak of the number of deaths varies significantly. In some countries, such as Japan, the peak occurs later (e.g., 85-89 years old). This variability may reflect differences in screening practices, diagnostic capabilities, and treatment accessibility among different age groups and regions.A particularly concerning finding is that in most countries, the absolute and relative increases in the disease burden are most significant in the population aged 95 and above. As the elderly age, the functions of multiple organs decline[28, 29], and they are often accompanied by multiple diseases. Approximately 92% of the elderly suffer from at least one chronic disease, and 77% have two or more[30]. This poses challenges to treatment and care. In the future, with the increase in life expectancy, most countries may need to develop medical care models specifically for the

elderly.

An additional layer of complexity comes from our study of the density of HRH. Specific occupational categories, especially nursing and midwifery professionals, as well as auxiliary and emergency medical workers, play a critical role in CRC outcomes. Nurses account for approximately 59% of the global health workforce (from the "State of the World's Nursing 2020" report), are crucial for achieving Sustainable Development Goals 3.4 and 3.8, which focus on reducing the burden of NCDs (including cancer) and achieving universal health coverage, respectively [31]. Their role in CRC prevention and management is well-documented[32]. In addition, although most countries actively promote CRC screening programs, the emergency rate remains high[33], which leads to a high correlation between its density and the CRC burden. In areas where the density of these professionals exceeds a certain threshold (e.g., more than 80 nursing professionals per 10,000 population), the burden seems to stabilize or even decrease slightly. This indicates that, in addition to the presence of healthcare workers, the quality and functional deployment of these professionals are crucial in early detection, patient education, and the effective management of high FPG and its complications. Significant regional disparities in HRH distribution, particularly shortages of these key cadres in less developed areas[34], hinder CRC control and underscore the urgent need for targeted investments in health workforce capacity, especially amidst aging populations and rising metabolic diseases[35].

These findings have multiple implications for public health policies and practice. Prioritize metabolic health in the elderly through intensified diabetes/pre-diabetes screening and management. Strengthen accessible, high-quality CRC screening, particularly targeting the 60-69 peak incidence age group while overcoming access barriers. Develop specialized care models for the complex needs of the very old (85+) and oldest-old (95+), integrating geriatric oncology and palliative approaches. And significantly increase nurses and allied health professionals in underserved areas; enhance their frontline roles in prevention, screening, and chronic disease management (e.g., diabetes); and focus on workforce quality, continuous development, and integrated teamwork beyond mere density metrics. Given the country-specific SDI levels and epidemiological stages, tailored strategies that take into account the local environment and resource availability are required.

Despite its advantages, our study has some limitations. The accuracy of the data depends on the quality of each country's disease surveillance system, which may vary, potentially leading to under-reporting or misclassification of cases. In addition, changes in diagnostic criteria during the study period and the evolving understanding of metabolic diseases may affect the consistency of trend estimates. Finally, the data on healthcare human resources are limited to 2019, which does

not take into account the impact of the COVID - 19 pandemic on the healthcare system or the possibility of recent changes in workforce availability.

Conclusion

In conclusion, over the past three decades, due to the increasing incidence of metabolic diseases, population growth, and aging, the burden of CRC caused by high FPG in the aging population of the Western Pacific Region has increased significantly. However, this burden is not solely explained by aging. Other factors such as lifestyle, healthcare accessibility, and socioeconomic development also play important roles. To address this increasingly severe challenge, it is crucial to strengthen the healthcare workforce, improve early detection and prevention strategies, and adopt public health policies that target the aging and metabolic risk factors in specific regions. Tailored interventions are essential for reducing the increasing burden of CRC and improving the health status of the aging population in the Western Pacific Region.

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Supplementary materials:

Table S1. Changes in DALYs number and ASDR for colorectal cancer attributable to high fasting plasma glucose among adults aged 60 years and above in the Western Pacific region from 1990 to 2021, by sex (both sexes combined, males, and females)

Table S2. Changes in deaths number and ASMR for colorectal cancer attributable to high fasting plasma glucose among adults aged 60 years and above in the Western Pacific region from 1990 to 2021, by sex (both sexes combined, males, and females)

Table S3. Changes in DALYs number and ASDR for colorectal cancer attributable to high fasting plasma glucose among adults aged 60 years and above in the Western Pacific region from 1990 to 2021, by age group (both sexes combined)

Table S4. Changes in deaths number and age-standardized death rates for colorectal cancer attributable to high fasting plasma glucose among adults aged 60 years and above in the Western Pacific region from 1990 to 2021, by age group (both sexes combined)

Table S5. Decomposition analysis of changes in age-standardized DALY rates and death rates for colorectal cancer attributable to high fasting plasma glucose among adults aged 60 years and above in the Western Pacific region from 1990 to 2021 (both sexes combined, males, and females)

Table S6. Density of Aides & Emergency Medical Workers per 10,000 Population in Western Pacific Countries and Territories, 1990 and 2019

Table S7. Density of Nursing & Midwifery Professionals Workers per 10,000 Population in Western Pacific Countries and Territories, 1990 and 2019