



The global cancer divide: Relationships between national healthcare resources and cancer outcomes in high-income vs. middle- and low-income countries

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Abstract *Background:* Cancer continues to rise as a contributor to premature death in the developing world. Despite this, little is known about whether cancer outcomes are related to a country's income level, and what aspects of national healthcare systems are associated with improved cancer outcomes.

Methods: The most recent estimates of cancer incidence and mortality were used to calculate mortality-to-incidence ratio (MIR) for the 85 countries with reliable data. Countries were categorized according to high-income (Gross Domestic Product (GDP) > \$15,000) or middle/low-income (GDP < \$15,000), and a multivariate linear regression model was used to determine the association between healthcare system indicators and cancer MIR. Indicators study included per capita GDP, overall total healthcare expenditure (THE), THE as a proportion of GDP, total external beam radiotherapy devices (TEBD) per capita, physician density, and the year 2000 WHO healthcare system rankings.

Results: Cancer MIR in high-income countries (0.47) was significantly lower than that of middle/low-income countries (0.64), with a $p < 0.001$. In high-income countries, GDP, health expenditure and TEBD showed significant inverse correlations with overall cancer MIR. A \$3040 increase in GDP ($p = 0.004$), a \$379 increase in

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THE ($p < 0.001$), or an increase of 0.59 TEBD per 100,000 population ($p = 0.027$) were all associated with a 0.01 decrease in cancer MIR. In middle/low-income countries, only WHO scores correlated with decreased cancer MIR ($p = 0.022$); 12 specific cancer types also showed similar significant correlations ($p < 0.05$) as overall cancer MIR.

Conclusions: The analysis of this study suggested that cancer MIR is greater in middle/low-income countries. Furthermore, the WHO healthcare score was associated with improved cancer outcomes in middle/low-income countries while absolute levels of financial resources and infrastructure played a more important role in high-income countries.

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1. Background

Cancer is an increasingly important problem in the developing world. Greater than half of cancer cases worldwide arise in developing countries, and this proportion is expected to rise to 70% by 2020 [1]. As cancer incidence and mortality rates remain high in the developed world and continue to rise in the developing world [2], the United Nations and WHO have placed greater emphasis on cancer treatment and prevention. Despite this emphasis, certain basic facts about cancer worldwide remain unknown. Given the cultural, socioeconomic, and environmental factors that can influence cancer outcomes, it is unclear whether and to what extent national economic and health system characteristics are associated with cancer outcomes, and whether a country's wealth mediates these effects.

Prior studies have suggested a relationship between healthcare spending and improved cancer outcomes in particular subsets of developed countries [3,4], but these analyses were limited either by using only one measure of healthcare infrastructure [3] or by investigating a limited number of wealthy countries without comparing results to the less-developed countries [4]. Furthermore, cancer outcomes may be affected differently in countries of differing income levels due to the specific aspects of healthcare infrastructure toward which spending is geared. Although mortality rates can illustrate health disparities, they can be misleading due to survival rates and incidences that may vary substantially among studied groups.

The mortality-to-incidence ratio (MIR) is a useful tool when comparing diverse groups as it reduces outcome differences influenced by incidence and instead approximates a prognosis. This can be helpful in identifying underlying causes for differences in cancer outcomes such as health system-related attributes [5,6].

One relatively unexplored measure of healthcare infrastructure with a potentially large impact

on a nation's cancer mortality is access to radiation therapy [7]. Radiation therapy is often underutilized in developing countries due to the large upfront cost of capital. In fact, 22 countries in Africa and Asia lack radiation therapy facilities, while many others have a fraction of the machines required by their populations [8]. Furthermore, radiation therapy may be used differently in the developing world than in countries with high income. In high-income countries, radiation therapy has been compared with an "arms race" of ever more expensive and complicated technology of increasing cost [9]. However, in middle- and low-income countries, radiation treatment is likely simpler and may be more focused on palliative treatment [7]. Whether radiation therapy impacts cancer MIR in the context of a nation's income and other health infrastructure is unknown. Additionally, access to radiation therapy is often an indirect marker of the availability of multidisciplinary cancer centers and overall access to cancer care. Thus, measurement of access to radiotherapy perhaps provides one of the most specific measurable indicators of access to cancer treatment worldwide.

The overall organization of a national healthcare system is another factor that may affect cancer MIR. The year 2000 World Health Organization (WHO) overall healthcare system rankings provided a systematically derived, quantifiable measure of healthcare system fairness and effectiveness for 191 countries [10,18]. The ranking was based on healthcare system responsiveness, the distribution of responsiveness, overall level and distribution of health, and the fairness of distribution of the financial burden of a system. No study to date has measured the association between these rankings and cancer MIR. See Appendix A for a more detailed explanation of the WHO scores.

This study foremost investigated the extent to which cancer MIR varies between middle/low-income and high-income countries. Secondly, the

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