Economist Intelligence Unit

The Economist

Breakaway: The global burden of cancer—challenges and opportunities

A report from the Economist Intelligence Unit

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Contents

Preface

Breakaway: The global burden of cancer—challenges and opportunities, is an Economist Intelligence Unit report commissioned by LIVE**STRONG**. It presents the results of research and analysis on the health and economic burden of cancer, global expenditures for cancer control and the funding gap relating to achieving a global expenditure standard for treatment and care. The primary collaborators on the project were Nancy Beaulieu and David E. Bloom of the Harvard School of Public Health, Lakshmi Reddy Bloom of Data For Decisions LLC and Richard M. Stein of the Economist Intelligence Unit. Research assistance was provided by Lillian R. Aronson and Michael O. Harhay of the University of Pennsylvania, and Elizabeth Cafiero and Marija Ozolins of the Harvard School of Public Health. Jacques Ferlay of the International Agency for Research on Cancer (IARC) provided assistance with the GLOBOCAN 2002 database. Leo Abruzzese and Rob Powell of the Economist Intelligence Unit edited the report. Mike Kenny was responsible for layout and design.

This report relies on a number of sources for background material as well as for the data underlying the new estimates of cancer incidence, related costs and the newly conceived global expenditure standard described in this document. The authors acknowledge all of those prior research and data collection efforts.

Because this report includes information that may be useful to a number of different audiences—including the international health policy community, public health officials and portions of the research community, among others—we have elected to move some of the technical discussion as well as other related and (in our opinion) useful information to a series of appendices. We hope that decision assists with ease of navigation of the report.

There are many challenges associated with a project of this scope. For example, there are issues relating to important concepts and definitions such as the burden of disease, which is defined differently by different authors. Perhaps most important are issues relating to data and methodologies employed in the new analysis described in this report. Differences of opinion relating to alternate research strategies are valid. Our choice of methodologies is related to our choice of data sources and the availability of data as well as its limitations. Beyond the results of our analysis and other information presented in this report, we think that a project of this scope is worthwhile for the discussion it may encourage around the need for and availability of good data.

Finally, the Economist Intelligence Unit thanks all those who contributed time and insight toward the completion of this project.

August 2009

Introduction

Cancer. The word is ripe with meaning. The mystery and stigma associated with the disease is so great that in some societies and cultures the word is rarely used and the illness never discussed. There is tragic irony in that. Cancer is widespread. It is the second-leading cause of death and disability in the world, behind only heart disease. Based on the most complete and current data available, cancer accounts for one out of every eight deaths annually (Mathers and Loncar. 2006). More people die from cancer every year around the world than AIDS, tuberculosis and malaria combined. Cancer deaths occur with nearly six times the frequency of traffic fatalities on an annual basis, and 42 times the frequency of deaths from injuries suffered in war. While at one time the disease was widely thought to afflict only the elderly in affluent countries—where it was seen as a death sentence—cancer has now moved beyond high income countries of the developed world. In the low and middle income countries of the developing world the consequences of the growing burden of new cancer cases and deaths is expected to continue to worsen (Boyle and Levin [eds.] 2008). In the US one out of every two men and one out of every three women will experience some type of cancer in the course of their lives (National Cancer Institute, SEER Cancer Review). One recent estimate is that the overall lifetime risk of developing cancer (both sexes) is expected to rise from more than one in three to one in two by 2015 (Peedell, 2005). Cancer is a global challenge.

More new cases of cancer arise and more deaths from the disease occur today in the lower-income and middle-income countries that make up the developing world, than in high income countries. In the places where cancer is growing fastest, the silence that accompanies the disease is often the result of a complete lack of meaningful information for those affected by cancer—the disease may go undetected and untreated until it leads to death. Even then, the cause of death may remain undiagnosed. Frequently, the lack of treatment extends even to an absence of pain management for those affected by cancer over the entire course of their illness—for example, in at least a few countries restrictions on the availability of narcotics mean they cannot be dispensed by health professionals. The silence in those parts of the world where cancer goes undetected, undiagnosed and untreated adds another dimension to the threat—these are manifestations of a growing but hidden epidemic.

Indeed, even when cancer is discussed in these developing countries, misinformation and superstition often fill the air—while the stigma associated with being a cancer patient still remains in many countries and in all income groups.

Even while the world is awakening slowly to the growing burden of cancer—which is like a wave that is still building—far too little is being spent globally to manage the growing crisis. In the developed world, much spending on cancer research and cancer control is fragmented and unco-ordinated. The expenditures associated with cancer management and control may represent a share of total health spending that is below the proportion of the total health burden represented by cancer. In the developing world, the crisis is worsening. Aid donors and recipients have ramped up spending to address the immediate needs created by the most challenging infectious diseases, but non-communicable disease

Causes of death worldwide, 2002

	Deaths (000)	%
Communicable, maternal, perinatal and nutritional conditions	**18,378**	**32.2**
Infectious and parasitic diseases	10,908	19.1
Diarrhoeal diseases	1,868	3.3
Tuberculosis	1,565	2.7
HIV/AIDS	2,853	5.0
Malaria	911	1.6
HIV/AIDS + Tuberculosis + Malaria	5,329	9.3
Noncommunicable diseases	**33,473**	**58.7**
Heart diseases	11,203	19.7
Malignant neoplasms (cancers)	7,109	12.5
Injuries	**5,159**	**9.0**
Road traffic accidents	1,189	2.1
Violence	558	1.0
War	171	0.3
All causes	**57,011**	**100**

Based on International Classification of Disease codes (ICD).
Source: Mathers CD, Loncar D (2006). Projections of global mortality and burden of disease from 2002 to 2030. PLoS Medicine. 2006; 3(11): 2011-2030. Dataset S1.

spending—including that for cancer control—has not kept pace(Stuckler, et al. 2008; Ravishankar, et al. 2009). Cancer and other non-communicable diseases are often hidden by the diminutive "other" in tallies of healthcare expenditures. Classifying the disease this way keeps it out of sight—and out of the line of targeted action. As a result, the wave continues to grow.

Time to act

It has been nearly two generations since the US government proclaimed a "War on Cancer" with the 1971 passage of the National Cancer Act. The fight has not been without victories, especially as other countries joined the effort and created an international campaign. In the US, for example, the incidence rate for new cancer cases and the overall death rates for men and women from cancer are declining (ACS. Cancer Statistics 2009 Presentation. Available at: http://www.cancer.org/docroot/PRO/content/PRO_1_1_Cancer_Statistics_2009_Presentation.asp). The intervening years have produced many voices and agencies to counter the silence surrounding cancer. Nonetheless, the disease remains the second-largest cause of death around the world. According to the most recent edition of the World Cancer Report (Boyle and Levin [eds.] 2008) in the past 30 years the burden of cancer doubled, based on incidence of new cases and deaths. The burden of cancer is predicted to continue growing at an alarming rate into the future with the growth coming in large part from lower- and middle-income countries (Boyle and Levin [eds.] 2008), where healthcare budgets are already stressed and the focus has been on infectious disease. These countries are experiencing an unprecedented surge in the incidence of new cancer cases, especially owing to tobacco use and the adoption of Western diets and lifestyles. Even in many high income countries of the

developed world, including the US—and despite the decline in cancer mortality rates over several decades (Kort. 2009)—the disease still accounts for more than 20% of all deaths annually. The irony and the tragedy is that around the world the policy community in conjunction with medical providers already can do much to control this devastating disease. Many cancers and cancer cases can be prevented. Treatment can be extended to cancer patients and survivors, whether that means cure, management of the disease or palliative care.

There are many reasons for suggesting that the time is right to focus on cancer control around the world. Many technological and policy breakthroughs have been achieved in the past 20 years across the spectrum of cancer control. More broadly, leaders in many countries are making healthcare a national and global priority. For example, China, Ecuador, India and Singapore all have recent initiatives to improve health outcomes and access to healthcare for large numbers of citizens. Already this year, in the US, President Barack Obama called for a new, integrated global health strategy and for "...a new effort to conquer a disease that has touched the life of nearly every American, including me, by seeking a cure for cancer in our time" (Dunham, Will. "Obama cancer cure vow requires more funds: experts." Reuters. Feb. 25, 2009. Available at: http://www.reuters.com/article/healthNews/idUSTRE5107JC20090225). In the UK, the office of the prime minister, Gordon Brown, issued a report that links improved global health strategy to economic prosperity, national and international security and stability. The link between improved health outcomes, including lengthened life expectancy, and economic development is the subject of much academic investigation (Bloom, et al. 2003; Bloom, et al. 2004; Bloom, et al. 2009; Sachs [chair] 2001). While these are all reasons for optimism—in reality, any might be identified as the right reason for acting today—the truth is that inaction or the status quo is a costly and avoidable choice.

What this report does

This report examines the global burden of cancer in detail based on estimates of new cases of cancer and associated costs. It presents estimates of more than two dozen cancers by site, sex and geography in 2009 and projected to 2020. Epidemiologic measures such as incidence (the number of new cases during a specific period of time) and case fatality rates (an approximation of how many new cancer cases will result in deaths) are employed to provide detail by country-income group and geographic region, as well as for the world. Next, the report estimates the global economic burden of new cancer cases in 2009. The analysis considers medical and non-medical costs as well as lost productivity. The cost of cancer research is also considered. Subsequent to this "monetisation" of the global burden of cancer, the report examines costs associated with cancer control, including expansion of measures to achieve a global treatment expenditure standard. Achieving that standard would set spending across countries to levels based on estimated costs of treatment in the country with the lowest case fatality rate for each site-specific cancer. Aggregate costs associated with the global treatment expenditure standard represent the "gap" between present-day spending and what is required to treat all cancers at the same level as the global standard. Descriptions of the methodologies employed for all analyses are included. This report concludes with a discussion of the challenges and the many opportunities relating to global cancer control. If implemented, many cancer prevention and control efforts will have positive effects on other chronic

Distribution of new cancer cases by income group and geographic region, 2009

Income group	Total population ('000s)	% of world population	Estimated new cancer cases (all sites)	% of new cases	Estimated cost of new cancer cases (all sites, $m)	% of costs
Low Income	1,009,525	14.8	899,275	7.1	647	0.2
Lower Middle Income	3,791,610	55.7	4,953,671	39.0	8,209	2.9
Upper Middle Income	964,861	14.2	1,938,748	15.2	8,945	3.1
High Income	1,042,971	15.3	4,922,418	38.7	268,002	93.8
Total	**6,808,967**	**100.0**	**12,714,112**	**100.0**	**285,804**	**100.0**

Geographic group	Total population ('000s)	% of world population	Estimated new cancer cases (all sites)	% of new cases	Estimated cost of new cancer cases (all sites, $m)	% of costs
Africa	1,007,766	14.8	816,747	6.4	849	0.3
Americas	889,640	13.1	2,772,681	21.8	153,941	53.9
Asia	4,107,263	60.3	5,851,340	46.0	43,951	15.4
Europe	730,365	10.7	3,062,704	24.1	82,684	28.9
Oceania	73,933	1.1	210,640	1.7	4,379	1.5
Total	**6,808,967**	**100.0**	**12,714,112**	**100.0**	**285,804**	**100.0**

Distribution of new cancer cases by income group and geographic region, 2020

Income group	Total population ('000s)	% of world population	Estimated new cancer cases (all sites)	% of new cases
Low Income	1,261,911	16.5	1,228,134	7.6
Lower Middle Income	4,250,681	55.6	6,615,124	40.9
Upper Middle Income	1,036,459	13.6	2,409,521	14.9
High Income	1,095,344	14.3	5,938,265	36.7
Total	**7,644,395**	**100.0**	**16,191,044**	**100.0**

Geographic group	Total population ('000s)	% of world population	Estimated new cancer cases (all sites)	% of new cases
Africa	1,268,582	16.6	1,093,608	6.8
Americas	992,762	13.0	3,616,023	22.3
Asia	4,579,687	59.9	7,784,320	48.1
Europe	721,566	9.4	3,424,466	21.2
Oceania	81,799	1.1	272,628	1.7
Total	**7,644,395**	**100.0**	**16,191,044**	**100.0**

For 2009, the sum of group estimates (income groups and geographic groups)—"Total"—is approximately 1.4% lower than the estimated number of new cancer cases for the "World" (as reported in subsequent tables). For 2020, the sum of group estimates is approximately 3.4% lower than the "World" estimate. This is because the "World" estimates include countries for which GLOBOCAN does not report separate country data. Estimates for those countries are not included in this table, nor are they used in subsequent analysis of cancer sites and costs.

diseases that are also growing around the world.

As the statement by the US president and the report from the UK prime minister point out, a focus on improved global health outcomes will have positive spillover effects on economic development, prosperity, international security and stability. Such claims are worth exploring and acting upon if true. At least one such premise—that "healthier means wealthier"—that population health is a key driver of economic growth—is already the focus of much academic research (see, for example, Bloom, et al. 2009).

A tool for policymakers

The point of addressing several areas in a single report is to provide background for advancing the policy discussion. Indeed, much in this document should be useful to policymakers. There is still need for more data, research and analysis to continue the fight against cancer on all fronts—from biomedical research to cancer surveillance and control to efforts on behalf of cancer survivors. Appropriating the funds to carry out those efforts is in the purview of policymakers.

A series of firsts

Addressing the issues at the heart of this report required the assembly of a substantial body of information from a variety of sources. It also required significant data analysis and modeling. Besides informing the report, the analysis was important because—to the best of our knowledge—it represents at least two firsts: the first time that the global burden of cancer has been converted to economic terms; and the first time that a global treatment expenditure standard has been considered and the spending gap to achieve that has been quantified. These firsts are possible because of the important work and valuable data sources completed by researchers preceding this effort.

En route, this report also touches other areas of importance relating to cancer incidence and cancer control around the world. It describes the spectrum of cancer control—that is, what is possible today, and what is and is not being done in many parts of the world. Much of the discussion in this report divides around two groups in global economic geography—high income countries of the developed world, on the one hand, and low- and middle-income countries of the developing world on the other. While the health and economic burden of cancer is already great in the developed world, as shown by much of the data in this report, a silent epidemic is growing in less well-off, resource scarce regions. Cancer is among the most severe of several non-communicable diseases affecting the developing world as people there live longer and adopt Western diets and lifestyles.

Key facts and findings:

Cancer remains a vexing health and economic challenge around the world:

- We estimate there will be 12.9m new cancer cases globally in 2009.
- By 2020, we expect the number of new cancer cases worldwide to rise to 16.8m.
- By 2030, the number of new cancer cases is expected to rise to 27m, with 17m cancer deaths (Boyle and Levin [eds.] 2008).
- Based on a widely accepted set of estimates of global mortality from all causes, more people die every

year from cancer than from HIV/AIDS, malaria and tuberculosis combined (Mathers and Loncar. 2006)

- In the past 30 years, the global burden of cancer doubled, based on the incidence of new cancer cases and deaths (Boyle and Levin [eds.] 2008).
- We estimate the costs associated with new cancer cases in 2009 to be at least US$286bn. Medical costs make up more than half of that economic burden, while productivity losses account for nearly one-quarter of the total. These sums are before adding in at least US$19bn spent on cancer research worldwide.

Cancer is a rapidly growing challenge in the developing world:

- Today, more than 50% of new cancer cases and nearly two-thirds of cancer deaths occur in the low income, lower middle income and upper middle income countries of the developing world. By comparison, in 1970, the developing world accounted for 15% of newly reported cancers (Boyle and Levin [eds.] 2008).
- By 2030, the developing world is expected to bear 70% of the global cancer burden (Boyle and Levin [eds.] 2008).

The dramatic shift corresponds to an increase in a number of risk factors in the developing world:

- Since cancer remains predominantly an illness for which the risk increases with age, as populations age cancer incidence and deaths also rise.
- Cancer death rates are typically higher in the developing world because many cancers are detected there after they have progressed to more advanced stages—when interventions may be less successful or more costly (which is problematic in resource-scarce countries).
- Many factors associated with the adoption of Western lifestyles and behaviours are contributing to the rising burden of cancer in the developing world, including increased tobacco consumption, higher-fat and lower-fiber diets, and reduced physical activity.

The increase in smoking in the developing world since the mid-1980s is the single biggest cause of the predicted increase in new cancer cases and deaths in the developing world:

- Lung cancer is the leading cause of death among all cancers in the developed and developing world (Boyle and Levin [eds.] 2008).
- It takes about 40 years for the increase in smoking rates to be fully reflected in cancer epidemiology statistics (Boyle and Levin [eds.] 2008). As a result, the number of deaths in the developing world will continue to rise based on past activities as well as the projected increase in new lung cancer cases.
- By our estimates, the number of new cases of lung cancer in the developing world will be 978 thousand in 2009 and 1.4m in 2020. In 2020, new lung cancer cases in the developing world will account for 63% of new lung cancer cases worldwide.

New cancer risks in the developing world are growing, while previously existing cancer risks remain prominent:

- The incidence and death rates from cancers caused by chronic infections remain significantly higher in

the developing world. Such cancers include liver cancer (related to hepatitis B and C), stomach cancer (related to H. pylori) and cervical cancer (related to human papilloma virus, HPV).

- These patterns are both frustrating and discouraging in the wake of evidence from the developed world that vaccines for hepatitis B and HPV make these cancers largely preventable.
- We estimate that 89% of new cervical cancer cases worldwide in 2009 will occur in the developing world.
- The incidence of Kaposi sarcoma related to HIV/AIDS infection is of serious concern for Africa, where it is the second and third most common cancer among men and women, respectively (Boyle and Levin [eds.] 2008).

Poverty continues to be linked to cancer, especially in the developing world:

- Cancer control is much less established in the developing world, including prevention and detection. Evidence shows that only 5% of global resources for cancer are spent in the developing world (WHO. 2002), with adverse consequences for surveillance and the full spectrum of cancer-control measures.
- Because cancers are not detected in the early stages, when many are more easily treatable, treatment is less effective. Cancers have already progressed to where they are incurable in fully 80% of patients in developing countries (Kanavos. 2006).
- In many cases, either because cancers are not diagnosed or for other reasons, no treatment may be available.
- Palliative care, pain relief and support are also less frequently available in the developing world (Boyle and Levin [eds.] 2008).

The specific challenges relating to cancer control in the developing world are exacerbated by other, related phenomena. These include inadequate health systems infrastructure, scarcity of necessary specialised skills (and specialists), high diagnostic and treatment costs, and the resulting inability to provide lengthy, complex personalised treatment regimens and follow-up care, as necessary (Axios. 2009).

Some of these challenges are caused at least in part by inadequate funding. There is evidence of disparities in healthcare expenditure in the developed world compared with the burden of the disease. Chronic diseases—cancer among them—account for a much larger share of the total disease burden than does related spending as a share of all healthcare outlays. Governments, donors and other funders heavily skew funding toward infectious diseases (Stuckler, et al. 2008; Ravishankar, et al. 2009). It is, to some extent, as a result of the victories scored there—which have reduced child mortality and lengthened life expectancy—that chronic disease has been able to proliferate so dramatically.

The rise in the disease burden from lung cancer and other cancers (and diseases) related to tobacco consumption and adoption of Western lifestyles is, often about a lack of adequate and effective cancer control programmes. Studies have since shown that many such cancers were avoidable in the developed world—as illustrated by declining incidence and death rates in the wake of the introduction of effective cancer controls. The same mistakes—at great expense in terms of human life and productivity—do not

have to be repeated in the developing world. Nonetheless, that is the way the world is headed. Policy needs to be steered toward the creation of adequate and effective cancer control programmes. The job is not finished in the developed world, and is only just beginning in emerging economies.

Next steps

Where to start—greater global visibility for cancer initiatives

Cancer and other chronic diseases are not effectively recognized or targeted in systematic fashion—through cancer control programmes integrated into the health system—by many governments or donors. Evidence of this appears in the literature examining donor assistance for health and through the examination of healthcare budgets and articles that analyse cancer control in many resource scarce areas such as India and Sub-Saharan Africa. Evident disparities between funding allocations and cancer's share of overall burden of disease have been noted. As populations live longer in many parts of the world and with the increase in risk factors such as adoption of Western lifestyle behaviors, the burden of cancer will continue to rise. Many international health voices have already called for heightened priority for cancer surveillance and control.

Cancer surveillance—effective cancer control strategies require monitoring

Epidemiologists, cancer control researchers and policymakers have made great use of the limited data in existence. The best way to plan effective cancer control strategies is to base them on accurate measures of trends and patterns, and on detailed and rigorous understandings of the determinants and consequences of different cancers. The need for greater resources for cancer surveillance is widely accepted, to increase the share of the world's population that is covered by such measures.

Successful cancer control programmes are built upon effective strategies and evidence

Integrated healthcare systems create opportunities to effectively manage and leverage scarce resources. Cancer surveillance and control has an important role to play in defining healthcare policies. There are opportunities to contain the spread of cancer and manage the disease across for regions with all levels of resource availability. Implementing effective cancer control programmes is likely to pay dividends in other areas of healthcare, and may also help advance economic development.

Cancer is a costly disease, but effective resource allocation yields positive outcomes

Cancer surveillance and control programmes should consider target outcomes and priorities according to the level of resources available. In this way, the effectiveness of programmes can be improved. Not every programme will yield similar outcomes wherever implemented for a variety of reasons. Proper planning and priority setting is essential.

The developed world offers many lessons relating to the burden of cancer and cancer control strategies

Cancer prevention is an important and effective strategy for attacking the growing burden of diseases in

the developing world. Programmes should be implemented today to lessen the adverse impacts of cancer for generations into the future. In the developed world, effective cancer control programs have shown great success—however only after cancer incidence rates and death rates grew without being challenged for many decades. There is no reason to replicate such mistakes today.

Survivorship and palliative care—the quality of life can be improved for those affected by cancer throughout their lives

There is worldwide demand for and evidence of how to improve the quality of life in settings with all levels of resource availability. Raising the priority accorded to survivorship interventions and palliative care is an important worldwide goal. As often happens, related interventions should not be ignored just because resources are scarce.

What is cancer?

Cancer is a generic term that refers to a group of chronic diseases characterised by the uncontrolled growth of abnormal cells within the body. Normally, cells divide and replicate to replace worn-out cells or to repair some form of injury to tissues of the body. After a predictable period, normal cells wear out and die. Cancer cells do not grow, divide and die in the same predictable fashion as normal cells. Rather, they grow, divide and create more abnormal cells, which outlive normal cells. The abnormal cells often spread to other body parts, invading other organs or systems (for example, spreading from the liver to the lymph nodes or from the lungs to the brain). When they do, that is called metastasis. Cancer that has metastasised to other parts of the body is still classified as the first cancer that affected the victim—for example, metastatic breast cancer that has spread to the kidneys is still called breast cancer, not kidney cancer.

Not all cancers spread, however, nor does every new case of cancer result in death. Some cancers grow very slowly and do not spread during the normal span of life. The vast majority of cancers do metastasise, however, and it is the invasion of and damage to other tissues and the crowding out of normal bodily functions that leads to death.

There are more than 100 types of cancers. They are classified according to the types of cells in which they develop. Most cancers, but not all, affect solid tissue and organs in the body. In these cases, cancer cells damage normal tissue by clumping together to form tumours. Other cancers involve the widespread distribution of cancer cells throughout the circulatory or lymphatic system or in the bone marrow, such as leukemia, lymphomas and multiple myeloma, respectively. At least in the first instance, these cancers may not be tumour forming. Tumours may or may not metastasise. Benign tumours do not metastasise, are not life threatening and are not classified as cancer. Malignant tumours are cancers.

The mechanism of disease for cancers is quite complex and not fully understood. Most cancers arise from damage to genes or genetic mutations, either of which may be caused by internal or environmental factors. During the 1970s, scientists discovered two families of genes that play major roles in the genesis and spread of cancer (ACS):

- *Oncogenes* are mutated forms of genes that cause normal cells to proliferate out of control and convert to cancer cells.
- *Tumour suppressor* genes are normal genes that regulate cell division, repair mistakes in DNA and control the preprogrammed death of cells (known as apoptosis). When tumour suppressor genes malfunction, cells can grow out of control, leading to cancer.

The external or environmental factors that affect carcinogenesis—the formation of cancer—include radiation, chemicals, tobacco, dietary factors and infectious disease. As of January 2009, the World Health Organization's (WHO) International Agency for Research on Cancer (IARC) had identified 108 chemical,

physical and biological carcinogens. Because of the complexity of the disease mechanism, not every exposure leads to cancer. Internal factors that may lead to cancer include hormones, immune conditions, metabolic disorders and inherited genetic anomalies. The interaction of an individual's behaviour with the environment and genetic makeup is not fully understood. The relatively lengthy latency period between exposure to carcinogens or other risk factors (such as behaviour) and the onset of the disease adds to the difficulty in tracing causality.

Cancer is often mistakenly regarded exclusively as a disease of old age—perhaps because much of the damage to DNA that leads to the disease occurs near the time that cells are programmed to die. While cancer is primarily a disease affecting older people, it can strike at any age, depending on the type of cancer and the exposure to, or the presence of, risk factors. In the US, cancer is the second-leading cause of death for children between the ages of one and 14 (CDC. Data & Statistics. Feature: Cancer in Children.). Indeed, some cancers affect only newborns, adolescents or young adults. Neuroblastomas are a form of cancer rarely found in children over the age of ten (ACS), while lymphomas and germ cell tumours such as testicular cancer are more common in 15-19 year olds. By contrast, so-called lifestyle cancers that are related to environmental factors which may or may not be the result of choice (compare exposure to environmental radiation or industrial carcinogens with obesity, alcohol and tobacco consumption, promiscuous sexual activity or needle-sharing for injection of illegal drugs) often show up in the population cohort spanning young adults through middle age. The reality is that some form of cancer can strike almost anyone at any time.

For a variety of reasons—among them, increasing life expectancy among much of the world's population, adoption of Western diet and lifestyles in much of the developing world, and widespread exposure to carcinogens—the burden of cancer is increasing, especially in the low- and middle-income countries that make up the developing world. Cancer is not a new disease, however. The first written description is on a papyrus document dating back to approximately 1600 BC. It mentions eight cases of tumours of the breast and describes treatment by cauterisation (ACS). Physical evidence of cancer, including bone, head and neck cancers, has been found among fossilised bone tumours and human mummies from ancient Egypt (Boyle and Levin [eds.] 2008). It was the Greek physician Hippocrates, considered the Father of Medicine, who first referred to non-ulcer forming and ulcer-forming tumours as *carcinos* and *carcinoma*, which mean "crab" in Greek—perhaps because the projections in the body from a cancer resembled a crab in appearance (ACS). Later, the Roman physician Celsus (28-50 BC) used the Latin term for crab, *cancer* (ACS). Another Roman physician, Galen, (130-200 AD) used the Greek word for swelling, oncos, to describe tumours (ACS). That is the root of the modern English words, *oncology* and *oncologist*. Today, cancers are also referred to as *malignant neoplasms*.

The health and economic burden of cancer

Overview

A key objective of this report is an exploration of the global burden of cancer in demographic and economic terms, including the distribution of new cancer cases by site, gender and geography for 2009 and 2020 and costs associated with the current year estimates. In addition, our analysis considers a global treatment expenditure standard based on current practice, and identifies the global funding gap necessary to achieve that spending standard for more than two dozen cancers worldwide. A complete description of the methodologies employed for all of the analysis is provided in Appendix E. Briefly, this exploration begins by determining the number of new cases of cancer in 2009, disaggregated by country and cancer site. These 2009 estimates are based on IARC (International Agency for Research on Cancer) estimates of new cases in 2002 for 26 unique site-specific cancers, as well as an imputation for cancer cases at all other sites. Also taken into consideration for this analysis were age at time of diagnosis and sex.

The economic burden of new cancer cases includes treatment and care costs, research and development costs associated with cancer control, and foregone income as a result of time away from work. For this analysis, country-specific estimates of per-case costs of treatment and care for different cancers and of lost income due to cancer morbidity were constructed. Those per-case costs were then multiplied by the number of new cancer cases in 2009 to obtain treatment/care costs and foregone income associated with all new cancer cases in 2009—again, by country and cancer site.

Our estimate of the global burden of new cancer cases in economic terms for 2009 was made by aggregating the country and site-specific data and adding in estimates of research and development costs (which are not available by country and cancer site). The totals thus derived are conservative, insofar as they do not include the pecuniary value of pain and suffering, the cost of cancer screening (for example, mammography and Pap smears), the cost of cancer prevention (such as HPV vaccination and anti-cancer public health messaging—for example, tobacco cessation programmes), or lost income due to cancer mortality in 2009. The estimates here also do not capture the future costs of treatment/care, morbidity and mortality associated with cancer cases that first surfaced in 2009, nor do they include treatment costs or productivity losses associated with cancer survivors who were diagnosed prior to 2009.

Cancer incidence, 2009–20

Today–2009

In 2009 we estimate that there will be 12.9m new cases of cancer worldwide. That is nearly five times the number of new HIV infections (estimated by UNAIDS to be 2.7m in 2007). Relative to population, new cancer cases are disproportionately concentrated among high income countries and in Europe and the Americas. These countries tend to have more complete reporting of cancer cases, and their populations are also older, which is a risk factor for the development of many cancers. In absolute terms, we estimate that high income countries account for 39% of new cancer cases in 2009. The developing countries (upper and lower-middle income and low-income countries) account for 61% of new cancer cases.

Distribution of new cases of cancer by income group and geographic region, 2009

Income group	Total population ('000s)	% of world population	Estimated new cancer cases (all sites)	% of new cases
Low Income	1,009,525	14.8	899,275	7.1
Lower Middle Income	3,791,610	55.7	4,953,671	39.0
Upper Middle Income	964,861	14.2	1,938,748	15.2
High Income	1,042,971	15.3	4,922,418	38.7
Total	**6,808,967**	**100.0**	**12,714,112**	**100.0**

Geographic group	Total population ('000s)	% of world population	Estimated new cancer cases (all sites)	% of new cases
Africa	1,007,766	14.8	816,747	6.4
Americas	889,640	13.1	2,772,681	21.8
Asia	4,107,263	60.3	5,851,340	46.0
Europe	730,365	10.7	3,062,704	24.1
Oceania	73,933	1.1	210,640	1.7
TOTAL:	**6,808,967**	**100.0**	**12,714,112**	**100.0**

The Total estimated number of new cancer cases is approximately 1.4% lower than the estimated number of new cancer cases for the "World" (as reported in subsequent tables). This is because the "World" estimates include countries for which GLOBOCAN does not report separate country data and as such, they could not be included in this table or used in the analysis of cancer sites and costs.

On a global basis, among the more than two dozen distinct cancers examined, by incidence, lung cancer is the most common diagnosis (12.6%), followed by breast cancer (10.5%), colorectal cancer (9.4%), stomach cancer (8.7%), and prostate cancer (6.4%). However, the pattern varies somewhat across country income groups. For example, cervical cancer and liver cancer are the top two cancers among low-income countries, whereas colorectal, lung, breast, and prostate cancer are the top cancers in the high income countries, where they account for slightly more than half of all new cancer cases.

Number of new cancer cases by site and country income group, 2009

	World[1]		Low income countries		Lower middle income countries		Upper middle income contries		High income countries	
Cancer site	Number	%	Number	%	Number	%	Number	%	Number	%
All sites	**12,888,069**	**100.0**	**899,275**	**100.0**	**4,953,671**	**100.0**	**1,938,748**	**100.0**	**4,922,418**	**100.0**
Bladder	427,397	3.3	16,364	1.8	107,849	2.2	64,070	3.3	227,205	4.6
Brain Cancers	219,404	1.7	9,775	1.1	97,126	2.0	38,783	2.0	68,674	1.4
Breast	1,355,502	10.5	69,249	7.7	414,637	8.4	223,578	11.5	615,497	12.5
Cervix	577,965	4.5	106,551	11.8	300,752	6.1	117,195	6.0	63,450	1.3
Colorectal	1,217,559	9.4	33,907	3.8	312,946	6.3	173,792	9.0	661,493	13.4
Corpus	236,643	1.8	8,480	0.9	51,535	1.0	44,846	2.3	123,157	2.5
Hodgkin's Lymphoma	69,538	0.5	8,366	0.9	23,351	0.5	14,363	0.7	23,189	0.5
Kaposi Sarcoma[2]	71,855	0.6	57,846	6.4	9,035	0.2	4,944	0.3	30	0.0
Kidney	247,673	1.9	9,246	1.0	51,567	1.0	50,004	2.6	127,900	2.6
Larynx	193,207	1.5	21,803	2.4	72,112	1.5	39,648	2.0	56,913	1.2
Leukaemia	344,333	2.7	20,822	2.3	141,597	2.9	53,903	2.8	118,090	2.4
Liver	743,259	5.8	76,161	8.5	505,198	10.2	37,646	1.9	130,483	2.7
Lung	1,623,698	12.6	58,837	6.5	659,723	13.3	229,738	11.8	645,415	13.1
Melanoma	186,865	1.4	6,639	0.7	15,420	0.3	26,014	1.3	131,723	2.7
Myeloma	101,676	0.8	3,680	0.4	23,738	0.5	14,479	0.7	58,044	1.2
Nasopharynx	93,905	0.7	11,735	1.3	68,709	1.4	6,861	0.4	7,950	0.2
non-Hodgkin Lymphoma	351,904	2.7	33,995	3.8	106,431	2.1	43,905	2.3	162,756	3.3
Oesophagus	554,619	4.3	41,794	4.6	403,917	8.2	39,478	2.0	73,467	1.5
Oral Cavity	327,325	2.5	41,090	4.6	161,853	3.3	39,153	2.0	84,895	1.7
Other Pharynx	156,226	1.2	17,712	2.0	73,362	1.5	19,074	1.0	45,069	0.9
Other Sites	1,184,035	9.2	118,699	13.2	441,467	8.9	219,814	11.3	341,052	6.9
Ovary	240,476	1.9	17,663	2.0	88,085	1.8	45,178	2.3	84,641	1.7
Pancreas	277,290	2.2	10,114	1.1	82,723	1.7	49,394	2.5	127,914	2.6
Prostate	821,892	6.4	21,150	2.4	78,446	1.6	133,133	6.9	573,008	11.6
Stomach	1,117,116	8.7	61,329	6.8	587,646	11.9	170,522	8.8	287,865	5.8
Testis	54,324	0.4	3,236	0.4	12,561	0.3	10,935	0.6	25,195	0.5
Thyroid	164,236	1.3	13,045	1.5	61,882	1.2	28,297	1.5	57,345	1.2

* Income Group Classifications: Based on World Bank's List of Economies (July 2009)

(1) The estimated number of new cases for the "World" exceeds the total cases estimated for the countries included in the Income Groups above; this is because the World estimates include countries for which GLOBOCAN does not report separate country data.

(2) IARC estimated Incidence rates for Kaposi Sarcoma only for African countries

Source: Estimated new cases of cancer in 2009 are derived from the authors' calculations based on 2009 population estimates from the United Nations and 2002 cancer incidence rates from the International Agency for Research on Cancer. See Appendix E—Methodology for details.

The distribution of cancers also varies across geographic regions. Among new cancer cases in 2009, the most common in Africa are cervical cancer and breast cancer; in the Americas the most common are prostate cancer and breast cancer; in Asia lung cancer and stomach cancer are most prevalent; in Europe the most common are lung and colorectal; and in Oceania prostate and colorectal are most frequently detected.

Number of new cancer cases by site and geographic region, 2009

	World[1]		Africa		Americas		Asia		Europe		Oceania	
Cancer site	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
All sites	**12,888,069**	**100.0**	**816,747**	**100.0**	**2,772,681**	**100.0**	**5,851,340**	**100.0**	**3,062,704**	**100.0**	**210,640**	**100.0**
Bladder	427,397	3.3	32,235	3.9	106,333	3.8	116,777	2.0	153,835	5.0	6,308	3.0
Brain Cancers	219,404	1.7	10,106	1.2	45,094	1.6	104,285	1.8	51,644	1.7	3,229	1.5
Breast	1,355,502	10.5	83,079	10.2	374,549	13.5	454,427	7.8	387,101	12.6	23,805	11.3
Cervix	577,965	4.5	99,360	12.2	96,693	3.5	319,814	5.5	62,487	2.0	9,595	4.6
Colorectal	1,217,559	9.4	30,160	3.7	278,977	10.1	441,686	7.5	406,292	13.3	25,022	11.9
Corpus	236,643	1.8	8,738	1.1	76,505	2.8	55,449	0.9	83,021	2.7	4,305	2.0
Hodgkin's Lymphoma	69,538	0.5	8,016	1.0	16,496	0.6	25,953	0.4	17,604	0.6	1,199	0.6
Kaposi Sarcoma[2]	71,855	0.6	71,855	8.8	0	0.0	0	0.0	0	0.0	0	0.0
Kidney	247,673	1.9	9,850	1.2	66,637	2.4	64,919	1.1	92,824	3.0	4,487	2.1
Larynx	193,207	1.5	10,816	1.3	34,668	1.3	92,384	1.6	50,005	1.6	2,603	1.2
Leukaemia	344,333	2.7	20,864	2.6	72,448	2.6	155,860	2.7	79,943	2.6	5,296	2.5
Liver	743,259	5.8	65,450	8.0	37,379	1.3	583,384	10.0	58,672	1.9	4,602	2.2
Lung	1,623,698	12.6	24,914	3.1	331,580	12.0	807,311	13.8	409,981	13.4	19,926	9.5
Melanoma	186,865	1.4	9,261	1.1	76,084	2.7	15,399	0.3	66,447	2.2	12,604	6.0
Myeloma	101,676	0.8	5,365	0.7	28,275	1.0	28,897	0.5	35,069	1.1	2,335	1.1
Nasopharynx	93,905	0.7	10,162	1.2	3,148	0.1	76,434	1.3	5,153	0.2	358	0.2
non-Hodgkin Lymphoma	351,904	2.7	37,358	4.6	97,823	3.5	125,179	2.1	79,833	2.6	6,894	3.3
Oesophagus	554,619	4.3	30,653	3.8	36,647	1.3	440,833	7.5	46,893	1.5	3,630	1.7
Oral Cavity	327,325	2.5	21,541	2.6	44,931	1.6	190,763	3.3	64,017	2.1	5,739	2.7
Other Pharynx	156,226	1.2	4,740	0.6	21,127	0.8	89,611	1.5	37,690	1.2	2,048	1.0
Other Sites	1,184,035	9.2	115,159	14.1	243,805	8.8	507,799	8.7	234,157	7.6	20,113	9.5
Ovary	240,476	1.9	15,810	1.9	49,566	1.8	99,491	1.7	67,734	2.2	2,966	1.4
Pancreas	277,290	2.2	8,912	1.1	62,865	2.3	109,505	1.9	84,680	2.8	4,182	2.0
Prostate	821,892	6.4	37,322	4.6	400,680	14.5	86,162	1.5	253,299	8.3	28,274	13.4
Stomach	1,117,116	8.7	32,435	4.0	112,754	4.1	767,525	13.1	186,979	6.1	7,668	3.6
Testis	54,324	0.4	2,277	0.3	16,800	0.6	14,569	0.2	17,348	0.6	934	0.4
Thyroid	164,236	1.3	10,307	1.3	40,817	1.5	76,924	1.3	29,996	1.0	2,525	1.2

(1) The estimated number of new cases for the "World" exceeds the total cases estimated for the countries included in the Continent groupings above; this is because the World estimates include countries for which GLOBOCAN does not report separate country data.

(2) IARC estimated Incidence rates for Kaposi Sarcoma only for African countries

Source: Estimated new cases of cancer in 2009 are derived from the authors' calculations based on 2009 population estimates from the United Nations and 2002 cancer incidence rates from the International Agency for Research on Cancer. See Appendix E—Methodology for details.

Tomorrow–2020

Assuming that every country's age pattern of new cancer cases remains stable, the new analysis undertaken for this report estimates that there will be 30% (3.9m) more new cancer cases in 2020 than in 2009. The increase is driven by population growth and population aging over the next decade.

Number of new cancer cases by site and country income group, 2020

	World[1]		Low income countries		Lower middle income countries		Upper middle income contries		High income countries	
Cancer site	Number	%	Number	%	Number	%	Number	%	Number	%
All sites	**16,793,683**	**100.0**	**1,228,134**	**100.0**	**6,615,124**	**100.0**	**2,409,521**	**100.0**	**5,938,265**	**100.0**
Bladder	576,186	3.4	22,343	1.8	148,300	2.2	81,771	3.4	282,192	4.8
Brain Cancers	269,151	1.6	12,631	1.0	119,481	1.8	45,440	1.9	78,678	1.3
Breast	1,714,641	10.2	94,362	7.7	528,520	8.0	267,322	11.1	703,787	11.9
Cervix	713,346	4.2	144,772	11.8	392,306	5.9	143,515	6.0	69,897	1.2
Colorectal	1,625,035	9.7	46,187	3.8	421,645	6.4	214,239	8.9	805,290	13.6
Corpus	308,779	1.8	11,805	1.0	67,511	1.0	53,964	2.2	144,309	2.4
Hodgkin's Lymphoma	81,208	0.5	11,070	0.9	28,489	0.4	15,542	0.6	25,020	0.4
Kaposi Sarcoma[2]	96,537	0.6	79,199	6.4	11,894	0.2	5,404	0.2	40	0.0
Kidney	324,560	1.9	12,158	1.0	67,208	1.0	59,600	2.5	153,509	2.6
Larynx	255,087	1.5	31,041	2.5	99,127	1.5	49,819	2.1	68,611	1.2
Leukaemia	422,743	2.5	26,572	2.2	166,017	2.5	62,246	2.6	140,025	2.4
Liver	962,437	5.7	103,922	8.5	673,427	10.2	48,507	2.0	158,793	2.7
Lung	2,173,842	12.9	82,527	6.7	913,273	13.8	283,562	11.8	801,508	13.5
Melanoma	237,912	1.4	9,039	0.7	19,870	0.3	30,515	1.3	152,035	2.6
Myeloma	136,129	0.8	4,955	0.4	32,309	0.5	18,607	0.8	71,331	1.2
Nasopharynx	116,072	0.7	15,927	1.3	88,312	1.3	8,565	0.4	9,358	0.2
non-Hodgkin Lymphoma	447,504	2.7	45,052	3.7	137,278	2.1	54,486	2.3	195,467	3.3
Oesophagus	736,153	4.4	59,143	4.8	564,143	8.5	50,299	2.1	89,126	1.5
Oral Cavity	424,328	2.5	57,711	4.7	218,669	3.3	47,978	2.0	100,455	1.7
Other Pharynx	203,126	1.2	25,122	2.0	99,303	1.5	23,403	1.0	52,248	0.9
Other Sites	1,515,901	9.0	160,804	13.1	585,189	8.8	281,457	11.7	411,185	6.9
Ovary	303,496	1.8	23,819	1.9	112,854	1.7	53,756	2.2	97,265	1.6
Pancreas	371,350	2.2	13,823	1.1	113,011	1.7	62,160	2.6	156,465	2.6
Prostate	1,133,141	6.7	29,204	2.4	110,583	1.7	187,089	7.8	736,220	12.4
Stomach	1,480,785	8.8	83,339	6.8	805,308	12.2	215,060	8.9	346,673	5.8
Testis	61,207	0.4	4,157	0.3	14,627	0.2	11,546	0.5	25,310	0.4
Thyroid	199,565	1.2	17,461	1.4	76,469	1.2	33,666	1.4	63,468	1.1

* Income Group Classifications: Based on World Bank's List of Economies (July 2009)

(1) The estimated number of new cases for the "World" exceeds the total cases estimated for the countries included in the Income Groups above; this is because the World estimates include countries for which GLOBOCAN does not report separate country data.

(2) IARC estimated Incidence rates for Kaposi Sarcoma only for African countries

SOURCE: Estimated new cases of cancer in 2020 are derived from the authors' calculations based on 2020 population estimates from the United Nations and 2002 cancer incidence rates from the International Agency for Research on Cancer. See Appendix E—Methodology for details.

Number of new cancer cases by site and geographic region, 2020

	World[1]		Africa		Americas		Asia		Europe		Oceania	
Cancer site	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
All sites	**16,793,683**	**100.0**	**1,093,608**	**100.0**	**3,616,023**	**100.0**	**7,784,320**	**100.0**	**3,424,466**	**100.0**	**272,628**	**100.0**
Bladder	576,186	3.4	43,743	4.0	143,363	4.0	161,073	2.1	177,988	5.2	8,439	3.1
Brain Cancers	269,151	1.6	13,055	1.2	55,220	1.5	128,569	1.7	55,477	1.6	3,908	1.4
Breast	1,714,641	10.2	109,961	10.1	460,521	12.7	577,830	7.4	416,517	12.2	29,162	10.7
Cervix	713,346	4.2	132,128	12.1	124,492	3.4	418,010	5.4	63,747	1.9	12,115	4.4
Colorectal	1,625,035	9.7	40,662	3.7	368,137	10.2	582,620	7.5	462,940	13.5	33,002	12.1
Corpus	308,779	1.8	11,905	1.1	95,453	2.6	73,360	0.9	91,282	2.7	5,588	2.0
Hodgkin's Lymphoma	81,208	0.5	10,373	0.9	18,929	0.5	32,100	0.4	17,370	0.5	1,349	0.5
Kaposi Sarcoma[2]	96,537	0.6	96,537	8.8	0	0.0	0	0.0	0	0.0	0	0.0
Kidney	324,560	1.9	12,775	1.2	85,814	2.4	84,575	1.1	103,569	3.0	5,742	2.1
Larynx	255,087	1.5	14,744	1.3	46,144	1.3	128,665	1.7	55,640	1.6	3,404	1.2
Leukaemia	422,743	2.5	26,977	2.5	89,651	2.5	183,331	2.4	88,276	2.6	6,626	2.4
Liver	962,437	5.7	88,840	8.1	50,446	1.4	772,561	9.9	66,655	1.9	6,146	2.3
Lung	2,173,842	12.9	33,795	3.1	440,479	12.2	1,115,672	14.3	464,424	13.6	26,500	9.7
Melanoma	237,912	1.4	12,200	1.1	91,778	2.5	20,364	0.3	71,660	2.1	15,458	5.7
Myeloma	136,129	0.8	7,187	0.7	37,693	1.0	38,985	0.5	40,247	1.2	3,090	1.1
Nasopharynx	116,072	0.7	13,534	1.2	3,846	0.1	98,757	1.3	5,590	0.2	435	0.2
non-Hodgkin Lymphoma	447,504	2.7	49,026	4.5	124,333	3.4	161,164	2.1	89,020	2.6	8,740	3.2
Oesophagus	736,153	4.4	41,815	3.8	49,512	1.4	613,347	7.9	53,208	1.6	4,829	1.8
Oral Cavity	424,328	2.5	29,220	2.7	57,598	1.6	259,718	3.3	70,773	2.1	7,504	2.8
Other Pharynx	203,126	1.2	6,493	0.6	27,052	0.7	122,494	1.6	41,368	1.2	2,670	1.0
Other Sites	1,515,901	9.0	153,946	14.1	323,301	8.9	672,037	8.6	262,925	7.7	26,427	9.7
Ovary	303,496	1.8	21,157	1.9	62,492	1.7	127,596	1.6	72,760	2.1	3,691	1.4
Pancreas	371,350	2.2	12,237	1.1	84,677	2.3	147,614	1.9	95,353	2.8	5,578	2.0
Prostate	1,133,141	6.7	50,493	4.6	550,187	15.2	121,261	1.6	303,030	8.8	38,125	14.0
Stomach	1,480,785	8.8	44,214	4.0	157,897	4.4	1,030,896	13.2	207,183	6.1	10,189	3.7
Testis	61,207	0.4	2,976	0.3	18,246	0.5	16,809	0.2	16,610	0.5	998	0.4
Thyroid	199,565	1.2	13,616	1.2	48,762	1.3	94,910	1.2	30,854	0.9	2,924	1.1

(1) The estimated number of new cases for the "World" exceeds the total cases estimated for the countries included in the Continent groupings above; this is because the World estimates include countries for which GLOBOCAN does not report separate country data.

(2) IARC estimated Incidence rates for Kaposi Sarcoma only for African countries

SOURCE: Estimated new cases of cancer in 2020 are derived from the authors' calculations based on 2020 population estimates from the United Nations and 2002 cancer incidence rates from the International Agency for Research on Cancer. See Appendix E—Methodology for details.

Our estimates show that the number of new cancer cases in 2020 will be 21% higher than in 2009 for high income countries, 37% higher for low income countries and 32% higher for all of the developing world (which is the low-income, upper middle-income and lower middle-income countries combined).

Regionally, Europe is projected to have the smallest proportionate increase in new cancer cases (12%). Africa is projected to have the largest proportionate increase in new cancer cases (34%). Asia is projected to have the largest absolute increase in new cancer cases (1.9m). Globally, the largest proportionate increase is projected for prostate cancer (38%), while the smallest proportionate increase is projected for cancer of the testis (13%). By contrast, the largest absolute increases are projected for lung, colorectal, stomach, and breast cancer.

Comparison of estimated new cases of cancer by cancer site and country income group, 2009-20

	World[1]				Low income countries				Lower middle income countires			
Cancer site	2020	2009	Difference	% change	2020	2009	Difference	% change	2020	2009	Difference	% change
All sites	**16,793,683**	**12,888,069**	**3,905,614**	**30.3**	**1,228,134**	**899,275**	**328,859**	**36.6**	**6,615,124**	**4,953,671**	**1,661,453**	**33.5**
Bladder	576,186	427,397	148,788	34.8	22,343	16,364	5,979	36.5	148,300	107,849	40,451	37.5
Brain Cancers	269,151	219,404	49,747	22.7	12,631	9,775	2,855	29.2	119,481	97,126	22,355	23.0
Breast	1,714,641	1,355,502	359,139	26.5	94,362	69,249	25,113	36.3	528,520	414,637	113,884	27.5
Cervix	713,346	577,965	135,381	23.4	144,772	106,551	38,221	35.9	392,306	300,752	91,554	30.4
Colorectal	1,625,035	1,217,559	407,476	33.5	46,187	33,907	12,279	36.2	421,645	312,946	108,699	34.7
Corpus	308,779	236,643	72,136	30.5	11,805	8,480	3,326	39.2	67,511	51,535	15,975	31.0
Hodgkin's Lymphoma	81,208	69,538	11,669	16.8	11,070	8,366	2,704	32.3	28,489	23,351	5,138	22.0
Kaposi Sarcoma (2)	96,537	71,855	24,682	34.3	79,199	57,846	21,353	36.9	11,894	9,035	2,859	31.6
Kidney	324,560	247,673	76,887	31.0	12,158	9,246	2,913	31.5	67,208	51,567	15,640	30.3
Larynx	255,087	193,207	61,880	32.0	31,041	21,803	9,238	42.4	99,127	72,112	27,015	37.5
Leukaemia	422,743	344,333	78,410	22.8	26,572	20,822	5,750	27.6	166,017	141,597	24,420	17.2
Liver	962,437	743,259	219,178	29.5	103,922	76,161	27,761	36.5	673,427	505,198	168,229	33.3
Lung	2,173,842	1,623,698	550,143	33.9	82,527	58,837	23,691	40.3	913,273	659,723	253,550	38.4
Melanoma	237,912	186,865	51,048	27.3	9,039	6,639	2,400	36.1	19,870	15,420	4,450	28.9
Myeloma	136,129	101,676	34,452	33.9	4,955	3,680	1,275	34.7	32,309	23,738	8,571	36.1
Nasopharynx	116,072	93,905	22,167	23.6	15,927	11,735	4,192	35.7	88,312	68,709	19,602	28.5
non-Hodgkin Lymphoma	447,504	351,904	95,600	27.2	45,052	33,995	11,057	32.5	137,278	106,431	30,847	29.0
Oesophagus	736,153	554,619	181,533	32.7	59,143	41,794	17,349	41.5	564,143	403,917	160,226	39.7
Oral Cavity	424,328	327,325	97,003	29.6	57,711	41,090	16,622	40.5	218,669	161,853	56,815	35.1
Other Pharynx	203,126	156,226	46,900	30.0	25,122	17,712	7,411	41.8	99,303	73,362	25,941	35.4
Other Sites	1,515,901	1,184,035	331,867	28.0	160,804	118,699	42,105	35.5	585,189	441,467	143,722	32.6
Ovary	303,496	240,476	63,020	26.2	23,819	17,663	6,156	34.9	112,854	88,085	24,769	28.1
Pancreas	371,350	277,290	94,060	33.9	13,823	10,114	3,710	36.7	113,011	82,723	30,288	36.6
Prostate	1,133,141	821,892	311,249	37.9	29,204	21,150	8,054	38.1	110,583	78,446	32,137	41.0
Stomach	1,480,785	1,117,116	363,668	32.6	83,339	61,329	22,010	35.9	805,308	587,646	217,663	37.0
Testis	61,207	54,324	6,883	12.7	4,157	3,236	921	28.5	14,627	12,561	2,066	16.4
Thyroid	199,565	164,236	35,329	21.5	17,461	13,045	4,416	33.9	76,469	61,882	14,587	23.6

Comparison of estimated new cases of cancer by cancer site and country income group, 2009-20 ***continued***

	Upper middle income countries				High income countries			
Cancer site	2020	2009	Difference	% change	2020	2009	Difference	% change
All sites	**2,409,521**	**1,938,748**	**470,773**	**24.3**	**5,938,265**	**4,922,418**	**1,015,847**	**20.6**
Bladder	81,771	64,070	17,702	27.6	282,192	227,205	54,986	24.2
Brain Cancers	45,440	38,783	6,658	17.2	78,678	68,674	10,004	14.6
Breast	267,322	223,578	43,745	19.6	703,787	615,497	88,291	14.3
Cervix	143,515	117,195	26,321	22.5	69,897	63,450	6,447	10.2
Colorectal	214,239	173,792	40,447	23.3	805,290	661,493	143,797	21.7
Corpus	53,964	44,846	9,118	20.3	144,309	123,157	21,151	17.2
Hodgkin's Lymphoma	15,542	14,363	1,179	8.2	25,020	23,189	1,831	7.9
Kaposi Sarcoma[2]	5,404	4,944	460	9.3	40	30	10	33.0
Kidney	59,600	50,004	9,596	19.2	153,509	127,900	25,609	20.0
Larynx	49,819	39,648	10,171	25.7	68,611	56,913	11,698	20.6
Leukaemia	62,246	53,903	8,343	15.5	140,025	118,090	21,935	18.6
Liver	48,507	37,646	10,861	28.9	158,793	130,483	28,309	21.7
Lung	283,562	229,738	53,825	23.4	801,508	645,415	156,093	24.2
Melanoma	30,515	26,014	4,501	17.3	152,035	131,723	20,312	15.4
Myeloma	18,607	14,479	4,128	28.5	71,331	58,044	13,287	22.9
Nasopharynx	8,565	6,861	1,704	24.8	9,358	7,950	1,408	17.7
non-Hodgkin Lymphoma	54,486	43,905	10,582	24.1	195,467	162,756	32,711	20.1
Oesophagus	50,299	39,478	10,822	27.4	89,126	73,467	15,659	21.3
Oral Cavity	47,978	39,153	8,825	22.5	100,455	84,895	15,561	18.3
Other Pharynx	23,403	19,074	4,329	22.7	52,248	45,069	7,180	15.9
Other Sites	281,457	219,814	61,643	28.0	411,185	341,052	70,134	20.6
Ovary	53,756	45,178	8,578	19.0	97,265	84,641	12,625	14.9
Pancreas	62,160	49,394	12,765	25.8	156,465	127,914	28,552	22.3
Prostate	187,089	133,133	53,956	40.5	736,220	573,008	163,212	28.5
Stomach	215,060	170,522	44,537	26.1	346,673	287,865	58,807	20.4
Testis	11,546	10,935	610	5.6	25,310	25,195	114	0.5
Thyroid	33,666	28,297	5,369	19.0	63,468	57,345	6,123	10.7

* Income Group Classifications: Based on World Bank's List of Economies (July 2009)

(1) The estimated number of new cases for the "World" exceeds the total cases estimated for the countries included in the Income Groups above; this is because the World estimates include countries for which GLOBOCAN does not report separate country data.

(2) IARC estimated Incidence rates for Kaposi Sarcoma only for African countries

SOURCE: Estimated new cases of cancer in 2009 and 2020 are derived from the authors' calculations based on 2009 and 2020 population estimates from the United Nations and 2002 cancer incidence rates from the International Agency for Research on Cancer. See Appendix E—Methodology for details.

Case fatality rates, 2002–Who lives? Who dies?

To complete some of the analysis necessary for determining total spending based on a global expenditure standard, we calculated case fatality rates (that is, the ratio of cancer deaths to new cancer cases, constructed from IARC data for 2002) in addition to analysing new cancer cases. The case fatality rate is a measure of the lethality of a particular cancer. When incidence and mortality rates (based on new cancer cases and cancer deaths, respectively) are relatively constant, the case fatality rate approximates the percentage of new cancer cases that will result in death (although in reality, new cancer cases and deaths during the same year are not necessarily from the same cohort). Worldwide, the number of people who died from cancer in 2002 represents 61% of the number of new cancer cases that year. Pancreatic cancer and liver cancer have the highest casefatality rates among all cancers (97% and 95%, respectively), while cancer of the testis, uterine corpus cancer, thyroid cancer, and melanoma have the lowest case fatality rates (19%, 23%, 24%, and 24%, respectively).

Case fatality rates (%) by cancer site and gender, 2002

Cancer site	Female	Male	Female and male combined	% difference (female–male)
All sites	**55.3**	**65.1**	**60.6**	**-9.8**
Bladder	42.6	39.1	39.9	3.4
Brain Cancers	72.7	73.6	73.2	-0.9
Breast	34.0	–	–	–
Cervix	55.1	–	–	–
Colorectal	50.8	50.1	50.4	0.7
Corpus	23.2	–	–	–
Hodgkin's Lymphoma	29.6	39.4	35.6	-9.8
Kaposi Sarcoma	93.0	89.0	90.2	4.1
Kidney	45.3	47.4	46.6	-2.1
Larynx	58.3	56.6	56.8	1.7
Leukaemia	71.2	71.5	71.3	-0.2
Liver	97.6	94.2	95.2	3.5
Lung	84.0	87.5	86.5	-3.5
Melanoma	21.1	26.9	24.0	-5.8
Myeloma	73.1	69.3	71.1	3.8
Nasopharynx	63.6	63.8	63.7	-0.2
non-Hodgkin Lymphoma	54.6	55.7	55.3	-1.1
Oesophagus	84.6	83.1	83.6	1.5
Oral Cavity	47.2	46.0	46.4	1.3
Other Pharynx	65.4	63.6	63.9	1.8
Ovary	57.5	–	–	–
Pancreas	98.6	95.2	96.8	3.4
Prostate	–	31.7	–	–
Stomach	75.5	74.0	74.5	1.5
Testis	–	18.5	–	–
Thyroid	21.6	29.6	23.7	-8.0

* The case fatality rate equals the ratio of the mortality rate to the incidence rate. When incidence and mortality rates are in a steady state, the case fatality rate approximates the risk, conditional on diagnosis, of dying from a particular cancer. When the incidence rate is decreasing over time or the mortality rate is increasing over time, it is possible for the case fatality rate to exceed 100%

Source: Estimated case fatality rates were calculated by the authors based on 2002 cancer incidence and mortality rates from the International Agency for Research on Cancer. See Appendix E—Methodology for details.

With the exception of pancreatic cancer, for which the case fatality rate is 90% or higher in every country income group, the case fatality rate is higher in low-income countries than high income countries for every cancer. For all cancers, the low-income country case fatality rate (74.5%) is 1.6 times that of high income countries (46.3%). Rates for middle-income countries are only slightly below those of the low-income countries. The largest differences are for prostate cancer (56 percentage points) and bladder cancer (48 percentage points), while the smallest differences are for liver cancer (4 percentage points), ovarian cancer (7 percentage points), and lung cancer (8 percentage points).

Case fatality rates (%) by cancer site and country income group, 2002

Cancer site	Low income	Lower middle income	Upper middle income	High income	Difference (low income–high income)
All sites	**74.5**	**71.7**	**63.9**	**46.3**	**28.2**
Bladder	74.4	60.6	45.9	26.7	47.7
Brain Cancers	80.5	75.3	80.5	65.5	15.0
Breast[1]	56.3	44.0	38.7	23.9	32.4
Cervix[1]	68.4	58.6	48.2	32.6	35.8
Colorectal	70.5	62.4	60.4	41.4	29.1
Corpus[1]	39.3	32.4	32.3	15.4	24.0
Hodgkin's Lymphoma	53.1	44.8	42.1	17.6	35.5
Kaposi Sarcoma	90.1	88.6	94.4	77.2	12.8
Kidney	62.7	55.5	54.0	39.2	23.5
Larynx	64.4	65.9	65.2	37.6	26.8
Leukaemia	84.8	78.0	76.5	58.8	26.1
Liver	95.1	93.7	128.9	91.2	3.9
Lung	91.1	87.5	91.8	83.3	7.8
Melanoma	57.5	53.2	39.1	16.3	41.2
Myeloma	79.0	80.9	76.0	65.7	13.2
Nasopharynx	67.5	65.3	63.3	45.9	21.7
non-Hodgkin Lymphoma	73.9	67.4	56.7	43.7	30.2
Oesophagus	94.0	81.3	93.4	84.8	9.3
Oral Cavity	55.4	54.3	48.9	27.5	28.0
Other Pharynx	76.1	74.1	68.3	42.4	33.6
Ovary[1]	62.1	61.0	54.5	54.8	7.2
Pancreas	95.1	89.7	99.3	100.2	-5.1
Prostate[2]	78.6	66.0	46.7	22.5	56.1
Stomach	81.6	80.1	81.2	58.3	23.4
Testis[2]	41.4	37.5	24.1	5.1	36.3
Thyroid	42.4	33.6	23.6	10.1	32.3

* The case fatality rate equals the ratio of the mortality rate to the incidence rate. When incidence and mortality rates are in a steady state, the case fatality rate approximates the risk, conditional on diagnosis, of dying from a particular cancer. When the incidence rate is decreasing over time or the mortality rate is increasing over time, it is possible for the case fatality rate to exceed 100%

* Income Group Classifications: Based on World Bank's List of Economies (July 2009)

(1) Female Case Fatality Rates only

(2) Male Case Fatality Rates only

SOURCE: Estimated case fatality rates were calculated by the authors based on 2002 cancer incidence and mortality rates from the International Agency for Research on Cancer. See Appendix E—Methodology for details.

The overall case fatality rate among men is 10 percentage points higher than among women, with only modest differences across country income groups. The striking overall sex difference is largely attributable to differences in the distribution of particular cancer types: 71% of cases of liver cancer and lung cancer, two common cancers with relatively high case fatality rates, occur among men. Men also have notably higher case fatality rates than women for three cancers (Hodgkin's Lymphoma, melanoma, and thyroid cancer), but these are relatively uncommon forms of cancer.

Case fatality rates (%) by cancer site, gender and country income group, 2002

	Low income		Lower middle income		Upper middle income		High income		Difference (female–male)	
Cancer site	Female	Male	Female	Male	Female	Male	Female	Male	Low income	High income
All sites	**70.1**	**79.2**	**65.4**	**77.0**	**57.3**	**70.6**	**42.2**	**49.8**	**-9.1**	**-7.6**
Bladder	79.9	71.6	56.4	61.9	48.0	45.3	31.3	25.3	8.3	6.0
Brain Cancers	79.8	81.0	76.0	74.7	79.8	81.1	63.5	67.1	-1.2	-3.6
Breast[1]	56.3	–	44.0	–	38.7	–	23.9	–	–	–
Cervix[1]	68.4	–	58.6	–	48.2	–	32.6	–	–	–
Colorectal	70.8	70.2	62.0	62.7	60.1	60.8	42.4	40.6	0.6	1.8
Corpus[1]	39.3	–	32.4	–	32.3	–	15.4	–	–	–
Hodgkin's Lymphoma	53.6	52.9	36.5	48.7	34.0	48.6	16.5	18.4	0.7	-1.9
Kaposi Sarcoma[3]	92.7	88.9	93.3	86.9	96.2	93.6	84.0	76.0	3.8	8.0
Kidney	62.0	63.2	54.8	55.8	49.0	57.7	38.6	39.6	-1.2	-1.0
Larynx	62.5	64.8	70.7	65.2	71.2	64.6	34.9	38.1	-2.3	-3.1
Leukaemia	85.7	84.2	78.0	78.0	76.9	76.2	58.2	59.3	1.5	-1.1
Liver	95.9	94.7	94.0	93.6	133.0	125.8	96.7	88.8	1.2	7.9
Lung	91.6	91.0	86.8	87.8	93.6	91.3	78.9	85.4	0.6	-6.4
Melanoma	56.1	59.3	48.6	57.9	33.7	46.0	13.3	19.2	-3.2	-5.9
Myeloma	81.6	74.8	80.1	81.4	75.1	76.8	69.7	62.3	6.8	7.4
Nasopharynx	65.8	68.4	65.3	65.3	61.9	63.9	44.4	46.4	-2.6	-2.0
non-Hodgkin Lymphoma	73.5	74.2	67.5	67.4	56.9	56.5	44.2	43.4	-0.7	0.8
Oesophagus	93.8	94.2	82.3	80.8	94.9	92.9	88.7	83.7	-0.4	5.0
Oral Cavity	55.7	55.2	54.0	54.5	45.0	50.3	27.5	27.4	0.5	0.1
Other Pharynx	77.7	75.4	72.9	74.3	69.8	68.0	43.3	42.3	2.3	1.1
Ovary[1]	62.1	–	61.0	–	54.5	–	54.8	–	–	–
Pancreas	94.8	95.4	92.2	87.9	100.1	98.6	101.8	98.8	-0.6	3.0
Prostate[2]	–	78.6	–	66.0	–	46.7	–	22.5	–	–
Stomach	84.0	80.0	79.9	80.2	81.4	81.1	61.4	56.5	4.0	4.9
Testis[2]	–	41.4	–	37.5	–	24.1	–	5.1	–	–
Thyroid	39.4	49.4	32.0	37.7	21.1	32.8	8.1	15.7	-10.0	-7.6

* The case fatality rate equals the ratio of the mortality rate to the incidence rate. When incidence and mortality rates are in a steady state, the case fatality rate approximates the risk , conditional on diagnosis, of dying from a particular cancer. When the incidence rate is decreasing over time or the mortality rate is increasing over time, it is possible for the case fatality rate to exceed 100%

* Income Group Classifications: Based on World Bank's List of Economies (July 2009)

(1) Female Case Fatality Rates only

(2) Male Case Fatality Rates only

(3) IARC estimated incidence and mortality rates for Kaposi Sarcoma only for African countries

Source: Estimated case fatality rates were calculated by the authors based on 2002 cancer incidence and mortality rates from the International Agency for Research on Cancer. See Appendix E—Methodology for details.

The costs of cancer, 2009

The global economic cost of the 12.9m new cancer cases in 2009 is estimated to be US$286bn. These costs disproportionately accrue to high income countries, which account for 94% of the total estimated costs and losses. Per-case expenditures as well as lost income are higher in these countries. Adding in estimated worldwide spending of US$19bn for cancer research yields a sum of US$305bn for the total economic burden of new cancer cases in 2009.

Costs of new cancer cases by cancer site and cost component, 2009

	Direct Costs			
Cancer site	**Medical costs[2] ($m)**	**Non medical costs[3] ($m)**	**Productivity losses[4] ($m)**	**Total costs ($m)**
Total	**150,651**	**66,247**	**68,906**	**285,804**
Bladder	4,087	2,516	1,781	8,383
Brain Cancers	2,862	1,074	536	4,473
Breast	13,108	7,624	7,696	28,428
Cervix	797	648	1,534	2,979
Colorectal	18,568	7,279	7,542	33,390
Corpus	2,118	1,507	1,566	5,192
Hodgkin's Lymphoma	728	319	479	1,527
Kaposi Sarcoma (1)	n/a	n/a	n/a	n/a
Kidney	2,421	1,422	1,876	5,719
Larynx	1,055	677	720	2,451
Leukaemia	11,085	2,132	654	13,870
Liver	3,835	1,561	4,885	10,280
Lung	29,244	11,041	12,609	52,894
Melanoma	3,806	2,186	1,160	7,152
Myeloma	2,932	1,051	220	4,204
Nasopharynx	215	108	186	509
non-Hodgkin Lymphoma	6,637	2,490	1,388	10,515
Oesophagus	2,865	1,234	2,159	6,258
Oral Cavity	2,068	1,113	1,024	4,204
Other Pharynx	1,568	701	453	2,721
Other Sites	10,556	4,693	1,865	17,113
Ovary	3,185	1,115	629	4,929
Pancreas	5,428	2,238	1,792	9,459
Prostate	15,563	7,674	774	24,011
Stomach	5,057	3,065	11,463	19,586
Testis	430	254	1,200	1,885
Thyroid	434	526	2,713	3,674

(1) Data on costs per case for Kaposi sarcoma were unavailable.

(2) Medical costs include costs of medical procedures and services associated with treatment and care of cancer including the costs of hospitalization, outpatient visits, and prescription drugs .

(3) Non-medical costs include the costs of transportation for treatment and care, costs of complementary and alternative treatments for cancer, and caregiving costs.

(4) Productivity losses include the economic value of time and output lost or foregone by cancer patients because of treatment or disability.

SOURCE: Estimated medical costs, non-medical costs, and productivity losses are derived from authors' calculations based on data from a study of Korean 2002 cancer costs (Kim et al., 2008) and inflated to 2009 US$ using the Korean consumer price index. See Appendix E—Methodology for details.

Global investment in cancer research, 2009

Source of funding	Funding ($m)	% of Global Spending
Total	**19,238**	**100.0**
Pharma Industry (top 24 companies)	4,244	22.1
USA (government)	6,461	33.6
USA (charitable)	625	3.3
USA (health-care & university systems)	149	0.8
EU (government)	1,360	7.1
EU (charitable)	1,205	6.3
EU (health-care & university systems)	1,870	9.7
Rest of World	3,322	17.3

Source: ECRM survey (www.ecrmforum.org) cited in "Responding to the challenge of cancer in Europe". Original survey data represent research funding in 2003. Funding estimates were inflated to 2009 US$ using the US Consumer Price Index.

Medical costs include the costs of diagnosis, in-patient treatment and care, out-patient treatment and care and drugs; and make up 53% of the US$286bn (worldwide cancer costs excluding research expenditures). Lost income due to cancer morbidity associated with new cancer cases makes up another 24% of the global 2009 total. The remainder is comprised of the costs of transportation to and from medical providers, the costs of complementary and alternative treatments, and the value of time associated with informal care-giving.

The estimated global costs of treating cancer are concentrated in a small number of cancer sites. Five cancers account for 55% of the aggregate cost of new cancer cases in 2009: lung (US$53bn), colorectal (US$33bn), breast (US$24bn), prostate (US$24bn), and stomach (US$20bn). Among these five cancers, medical costs vary considerably with respect to their share of total costs: from a low of 26% for stomach cancer to a high of 65% for prostate cancer. By comparison, lost productivity as a share of total costs is lowest for prostate cancer (3%).

Across cancers the relative per-case costs and productivity losses vary greatly. Factors such as the methods of treatment and care and the degree of morbidity or disability affect relative costs and the proportion that each component (medical and non-medical costs and lost productivity) contributes to the total per-case cost associated with each cancer site.

Relative per case unit costs (%) and productivity losses (%), 2009

	Relative medical cost[1]	Relative non-medical cost[2]	Relative productivity loss[3]
Bladder	59	82	69
Brain Cancers	137	117	35
Breast	64	85	51
Cervix	40	74	69
Colorectal	94	84	87
Corpus uteri	50	80	56
Hodgkin's Lymphoma	94	94	64
Kidney	61	82	85
Larynx	64	93	61
Leukaemia	300	131	34
Liver	118	109	227
Lung	141	121	132
Melanoma	83	108	35
Multiple Myeloma	166	135	29
Nasopharynx	94	107	67
non-Hodgkin Lymphoma	124	106	47
Oesophagus	127	124	145
Oral Cavity	81	99	57
Other Pharynx	120	122	42
Other Sites	105	106	36
Ovary	123	98	34
Pancreas	143	134	111
Prostate	75	84	10
Stomach	72	100	291
Testis	52	70	122
Thyroid	23	64	150
Average	100	100	100

Costs and productivity losses presented in the table are computed relative to the case-weighted average for each cost component (I.e. medical, non-medical and productivity loss). New cancer cases in 2009 were used as weights in computing the case-weighted averages.

(1) Medical costs include costs of medical procedures and services associated with treatment and care of cancer including the costs of hospitalization, outpatient visits, and prescription drugs .

(2) Non-medical costs include the costs of transportation for treatment and care, costs of complementary and alternative treatments for cancer, and care-giving costs.

(3) Productivity losses include the economic value of time and output lost or foregone by cancer patients because of treatment or disability.

SOURCE: Estimated medical costs, non-medical costs, and productivity losses are derived from authors' calculations based on data from a study of Korean 2002 cancer costs (Kim et al., 2008). See Appendix E—Methodology for details.

One striking feature of the estimated US$286bn cost is that 94% of the global total is attributable to high income countries, well in excess of their 15% share of world population. These countries have a relatively large share of global cancer cases (39%), their medical spending per cancer case is 2.5 times the world average, they account for nearly all of the world's spending on cancer research (an additional US$19bn), and their loss of income due to cancer morbidity is also well above the world average because of their high levels of income per capita (3.5 times the world average on a PPP basis).

Costs of new cancer cases by cancer site and country income group, 2009

Total costs ($m)

Cancer site	Low income	Lower middle income	Upper middle income	High income
Total	**647**	**8,209**	**8,945**	**268,002**
Bladder	8	100	194	8,081
Brain Cancers	5	113	183	4,171
Breast	37	374	754	27,263
Cervix	49	245	436	2,249
Colorectal	23	398	705	32,264
Corpus	3	44	131	5,014
Hodgkin's Lymphoma	4	24	67	1,432
Kaposi Sarcoma[1]	n/a	n/a	n/a	n/a
Kidney	4	58	192	5,465
Larynx	15	52	143	2,241
Leukaemia	20	262	414	13,175
Liver	85	1,566	279	8,349
Lung	88	1,264	1,468	50,074
Melanoma	3	12	87	7,050
Myeloma	2	25	77	4,100
Nasopharynx	12	95	30	372
non-Hodgkin Lymphoma	20	111	205	10,178
Oesophagus	47	788	242	5,181
Oral Cavity	23	108	144	3,929
Other Pharynx	16	48	84	2,573
Other Sites	72	372	821	15,848
Ovary	12	80	187	4,650
Pancreas	9	143	293	9,014
Prostate	6	37	321	23,647
Stomach	72	1,762	1,249	16,503
Testis	2	21	77	1,785
Thyroid	9	108	164	3,392

(1) Data on costs per case for Kaposi sarcoma were unavailable.

Total costs include medical costs, non-medical costs, and productivity losses.

Estimated medical costs, non-medical costs, and productivity losses are derived from authors' calculations based on data from a study of Korean 2002 cancer costs (Kim et al., 2008). See Appendix E—Methodology for details.

Income Group Classifications: Based on World Bank's List of Economies (July 2009)

Regional estimates of the cost of new cancer cases show patterns that are similar to those for country income groups. For example, Africa represents 15% of global population, contributes 6.4% of new cancer cases and accounts for 0.3% of global cancer costs.

Costs of new cancer cases by cancer site and geographic region, 2009

Total costs ($m)

Cancer site	Africa	Americas	Asia	Europe	Oceania
Total	**849**	**153,941**	**43,951**	**82,684**	**4,379**
Bladder	41	4,638	589	3,015	100
Brain Cancers	11	2,473	362	1,547	79
Breast	76	17,221	1,928	8,742	461
Cervix	73	1,311	621	923	50
Colorectal	42	16,890	5,466	10,392	599
Corpus	7	3,505	284	1,340	57
Hodgkin's Lymphoma	7	987	75	434	24
Kaposi Sarcoma[1]	n/a	n/a	n/a	n/a	n/a
Kidney	9	3,191	544	1,875	100
Larynx	12	1,232	246	934	28
Leukaemia	36	8,065	1,218	4,305	245
Liver	86	2,578	5,354	2,192	69
Lung	77	31,359	6,497	14,362	599
Melanoma	10	4,920	76	1,796	350
Myeloma	7	2,421	304	1,397	74
Nasopharynx	12	169	179	141	8
non-Hodgkin Lymphoma	29	6,712	836	2,755	182
Oesophagus	52	2,287	1,952	1,883	84
Oral Cavity	19	2,159	421	1,510	95
Other Pharynx	5	1,246	234	1,202	35
Other Sites	103	8,789	2,252	5,656	313
Ovary	13	2,653	471	1,725	67
Pancreas	13	4,809	1,643	2,866	128
Prostate	24	17,558	643	5,422	365
Stomach	67	3,633	11,022	4,701	163
Testis	3	986	95	764	36
Thyroid	15	2,149	640	803	67

(1) Data on costs per case for kaposi sarcoma were unavailable.

Total costs include medical costs, non-medical costs, and productivity losses.

Estimated medical costs, non-medical costs, and productivity losses are derived from authors' calculations based on data from a study of Korean 2002 cancer costs (Kim et al., 2008). See Appendix E—Methodology for details.

Although this report does not estimate projected cancer costs in 2020, it is fair to assume that costs would rise commensurately with the increase in the number of cases. Among the uncertainties that would significantly affect projections are the development and adoption of new therapeutic interventions and the associated future costs per case.

Identifying the cancer funding gap–The global expenditure standard for treatment and care

Further analysis shows that high income countries devote relatively more resources to cancer treatment and care and that, depending on the cancer, have modest to significantly lower case fatality rates. That result leads to the proposition of a global expenditure standard. That standard is defined by estimates of the treatment/care costs associated with the country that has the lowest case fatality rate for each cancer site. The global standard is dominated by treatment expenditure levels in the US. Based on that construct, it is possible to estimate the cost of setting treatment expenditures around the world to levels associated with the lowest case fatality rates for each site-specific cancer. New research done for this report indicates a global treatment expenditure gap of US$217bn in 2009.

The same five cancers that account for the largest share of aggregate cost of new cancer cases in 2009 also account for the largest share of the global treatment expenditure gap: lung (US$86bn), colorectal (US$39bn), breast (US$bn), prostate (US$15bn), and stomach (US$15bn). Where these five cancers accounted for 55% of aggregate costs, they account for 85% of the global expenditure gap.

Medical treatment expenditure gap by cancer site, 2009

Cancer	Lowest case fatality (%)	Median case fatality (%)	Case fatality range (%)	Total cases 2009	Global expenditure standard ($)	Treatment expenditure gap ($)	% of expenditure gap
Total	**37.5**	**73.5**	**54.1**	**11,521,235**		**216,974,263,183**	**100.00**
Bladder	17.1	41.3	76.7	415,488	30,230	8,455,043,529	3.90
Brain Cancers	41.7	77.3	55.7	214,359	32,379	4,067,739,311	1.87
Breast	18.8	43.3	55.6	1,322,960	32,964	30,426,043,069	14.02
Cervix	24.6	53.9	58.6	587,948	7,632	3,677,981,304	1.70
Colorectal	34.1	58.1	59.2	1,182,138	48,487	38,661,527,877	17.82
Corpus	11.4	25.3	64.9	228,019	25,458	3,676,334,953	1.69
Hodgkin's Lymphoma	12.5	40.7	51.1	69,268	48,291	2,606,636,803	1.20
Kaposi Sarcoma[1]	n/a	n/a	n/a	n/a	n/a	n/a	
Kidney	32.0	47.1	40.7	238,717	31,450	5,076,851,921	2.34
Larynx	28.6	60.0	66.7	190,476	32,626	5,150,552,886	2.37
Leukaemia	51.6	75.0	50.0	334,412	2,719	-10,176,665,246	-4.69
Liver	76.2	97.9	152.8	749,488	6,896	1,326,353,513	0.61
Lung	78.7	92.4	28.4	1,593,713	72,333	85,961,743,780	39.62
Melanoma	13.2	26.5	53.4	179,796	15,669	-991,646,420	-0.46
Myeloma	48.9	66.7	44.0	99,940	27,948	-145,520,369	-0.07
Nasopharynx	50.0	65.9	30.0	95,255	48,226	4,371,728,347	2.01
non-Hodgkin Lymphoma	36.0	65.0	51.0	347,087	14,503	-1,616,450,458	-0.74
Oesophagus	75.0	91.4	31.8	558,656	7,412	1,269,496,022	0.59
Oral Cavity	16.2	50.8	57.7	326,991	41,570	11,497,101,590	5.30
Other Pharynx	27.9	64.2	62.8	155,216	626	-1,470,500,249	-0.68
Other Sites[2]	n/a	n/a	n/a	n/a	n/a	n/a	
Ovary	33.3	54.8	44.2	235,568	4,533	-1,488,307,165	-0.69
Pancreas	84.2	97.0	45.8	270,145	38,574	-4,205,491,505	-1.94
Prostate	12.7	52.6	81.0	805,736	17,114	15,387,260,316	7.09
Stomach	46.2	82.6	50.4	1,107,362	10,256	13,876,927,263	6.40
Testis	3.1	18.1	46.9	51,927	11,928	101,926,360	0.05
Thyroid	4.5	23.1	66.4	160,570	63,270	1,477,595,751	0.68

(1) Data on costs per case for kaposi sarcoma were unavailable.

(2) Incidence and mortality rate data were unavailable for "other sites".

The global expenditure standard, computed separately for each cancer site, equals the medical care costs for the country with the lowest case fatality rate. See Appendix E—Methodology for details.

The treatment expenditure gap equals the net change in medical costs that would be incurred if expenditures on each new cancer case were equal to the global expenditure standard. See Appendix E—Methodology for details.

Almost 90% of the resources (US$192bn) to address the shortfall are required in low- and middle-income countries. Part of the reason for that outcome is that four of the cancers which make up the largest share of the global cost of new cancer cases in 2009 account for 47% of new cancer cases in these countries: lung, stomach, breast and colorectal.

Medical treatment expenditure gap by country income group, 2009

Income group	Treatment expenditure gap	% of expenditure gap
Total	**216,974,263,183**	**100**
Low Income	17,139,894,441	8
Lower Middle Income	123,960,107,175	57
Upper Middle Income	51,238,827,115	24
High Income	24,635,434,452	11

The treatment expenditure gap equals the net change in medical costs that would be incurred if expenditures on each new cancer case were equal to the global expenditure standard. See Appendix E—Methodology for details

The global expenditure standard, computed separately for each cancer site, equals the medical care costs for the country with the lowest case fatality rate. See Appendix E—Methodology for details.

Why cancer survival varies worldwide

Cancer survival rates vary for a number of reasons, many of them related to the age-distribution and composition of populations and varying exposure to carcinogens. They also vary because of the uneven distribution of resources available to implement cancer surveillance and control programmes around the world. In general, per case cancer treatment costs increase with diagnosis at advanced stages followed by effective treatment. The high cost of expanding and improving treatment and care as well as the lost productivity that results from cancer highlights the value of cancer prevention and early detection. The clearest illustration of that principle is that cancer cases avoided—through prevention—result in no productivity lost. For cancers that go largely untreated, even if detected at an early stage, that principle and associated value are not realised. Because early detection and secondary prevention programmes are implemented with varying effectiveness worldwide—partly because of the uneven distribution of resources—survival rates show great disparities for cancers that can be controlled through these interventions.

Uneven resource allocation also leads to differences in survival rates between the developed and developing world for cancers that respond to diagnosis and treatment at advanced stages—where per case costs can be high when resources are available. Without resources, later stage diagnosis is not followed by effective treatment, leading to lower survival rates for those countries.

It is clear that resources matter for the effective control of cancer (Levin, et al. 1999; Murthy, et al. 2008). The concept of a global expenditure standard based on treatment costs associated with the lowest case fatality rate provides a good starting point for beginning to plan the next steps in the war on cancer.

Conclusions

This report began by citing some of the staggering facts and figures about new cancer cases and cancer deaths worldwide. The disease remains the second largest cause of death around the world, with some predictions that it will move into the top spot in 2010. In human terms, cancer takes a heavy toll around the world through death, disability and suffering (for those diagnosed with the disease and those whose lives are otherwise touched by it, including families, caregivers and medical workers). Our estimates indicate there will be 12.9m new cancer cases around the world in 2009 and 16.8m new cases in 2020. High income countries will account for 39% of new cases in 2009 and 37% of new cases in 2020. Our estimates are that there will be 7.8m new cases of cancer in the low and middle income countries of the developing world in 2009 and 10.3m new cases in 2020, adding 2.5m new cases to the annual increase. By comparison, we predict that the annual number of new cancer cases in the developed world will be 1m higher in 2020 (5.9m) than in 2009 (4.9m). The increasing burden of cancer in the developing world has been pointed out by researchers previously (for example, Boyle and Levin [eds.] 2008). This added burden in the resource scarce low and middle income countries of the developing world is noteworthy and particularly troubling because the impact of infectious and communicable diseases remains very high there.

In economic terms, cancer is likewise debilitating. The disease consumes resources—in the way of medical and non-medical spending as well as lost productivity—at a staggering rate. Our estimates are that new cancer cases will account for at least US$286bn in total costs in 2009, with US$217bn in medical and non-medical costs and US$69bn in lost productivity. An additional $19bn will be spent worldwide on cancer research, with the US contributing the largest share. While high income countries of the developed world account for 94% of the US$286bn in 2009, cancer's impact is felt around the world.

Near the beginning, this report also mentions the silence and misinformation associated with cancer. The extent of both is greater in the developing world, but neither scourge has been eradicated from the developed world either, where cultural differences still impact large populations (Lagnado. *In Some Cultures, Cancer Stirs Shame*. Wall Street Journal. October 4, 2008. Available at: http://online.wsj.com/article/SB122304682088802359.html). Misinformation—or no information—and superstition prevent too many people from seeking treatment when they have cancer. In too many other cases, the disease goes undetected or undiagnosed. For other cases, treatment is either ineffective or nonexistent. Clearly there is much work that remains to be done.

A time for optimism

Despite the challenges, there is plenty of room for optimism. Of all the chronic diseases, cancer may be the most preventable (Danaei, et al. 2005). In addition, the knowledge to detect and treat the disease and to improve the quality of life for those with cancer has vastly improved in the past decade (Ngoma, 2006; Boyle and Levin [eds.], 2008). These breakthroughs in cancer control represent a combination of

new technologies, policies and programmes, and are relevant worldwide. In the developing world, where the burden of cancer is growing rapidly, implementing effective cancer surveillance and cancer control programmes has the potential to change the course of the disease in the future and lessen some of the burden. The level of complexity required to treat advanced stage cancers remains high, but prevention and the combination of early detection and secondary treatment are primary and secondary lines of defense, respectively, that mitigate some of the need for more technically sophisticated interventions. Palliative care and survivorship interventions to improve quality of life provide a range of useful and valuable tools throughout the course of life for those affected by cancer. In combination, the range of cancer control interventions represents an extensive arsenal. The world is full of opportunities to apply it.

Where to start—greater global visibility for cancer initiatives

The greatest challenge to effective action against the towering wave of cancer incidence and deaths may be that related to silence and misinformation. Despite the growing burden, despite the accumulated knowledge of epidemiologists, other researchers and millions of individuals affected by or living with cancer, the relative anonymity of the disease is a large—but not insurmountable—problem. Two recent studies examining development assistance for global health initiatives (Ravishankar, et al. 2009) and international health agency resource allocation to address health and disease issues (Stuckler, et al. 2008) provide detail relating to HIV/AIDS, tuberculosis and malaria allocations, but cancer funding is buried elsewhere—either part of "non-communicable diseases", or "unallocable", or "other". This is not the fault of the researchers. Some specialists among the public health community wonder why cancer and other non-communicable diseases are not targeted by the United Nations Millennium Development Goals. For whatever reason, cancer remains in the background. As a new National Academy of Science (NAS) report states: *cancer should be raised onto (the) global health agenda* (IOM. 2009).

Cancer and other chronic diseases are often not effectively recognized or targeted in systematic fashion at the national level, especially where resources are scarce or skewed towards other areas. The international health community has identified this challenge already, but the global community still needs to act. Disparities between funding allocations and share of total burden of disease show up in the data (Stuckler, et al. 2008). Likewise, much of the academic literature relates to specific cancers or specific countries. Again, this is a result of how funding is distributed. There is evidence, however, that the situation is starting to change, with the challenge of cancer and other chronic diseases beginning to draw the attention of large parts of the global community. Evidence of new initiatives and new instances of collaboration and cooperation among many of the stakeholders is growing (Bliss; 2009). Related efforts appear to be in the early stages of development as compared with global initiatives around some of the major infectious diseases. Awareness of the challenges posed by the growing burden of cancer should continue to expand through education and advocacy rather than remain within the domain of experts.

Cancer surveillance—effective cancer control strategies require monitoring

Appropriations for the collection and analysis of data—any data—are often among the last budget lines to be raised and the first to be reduced or eliminated, particularly when resources are scarce. When it comes to cancer-related data, which is truly in short supply given its necessity for effective cancer surveillance, there may be other explanations as well: for example, a lack of understanding of or appreciation for the value of data by some its effective "gatekeepers"; lack of strong, supportive constituencies (consider the size disparities that may exist between the research and policy communities of data users and voters or legislator who often authorize or finance its collection); the fact that direct interventions are valued more highly than data; conscious avoidance of the facts that may be uncovered (*Who Counts?* Lancet. 2007); and, of course, lack of adequate funding.

Great efforts are made all the time to work with the data that does exist. The result has been many successes in the research and policy arenas—this report acknowledges all that has been done before. It utilizes and builds upon many important aspects of that prior work. It is still the case, however, that much data is incomplete or inaccurate.

Large portions of the world's population are not covered by cancer registries (Parkin and Fernandez. 2006). This is particularly true where the estimates and predictions indicate the burden of disease from cancer is growing most rapidly. Data from the International Agency for Research on Cancer (IARC) indicates that less than 20% of the world's population is covered by cancer registration, and, in 2000, only 30% by mortality registration systems. In Africa, cancer incidence data covers 8% of the population, while medically certified cause of death programmes cover less than 0.1% of the population (of no solace is the higher proportion of population covered by accurate death registration schemes in Sub-Saharan Africa—about 0.25% [Sitas, et al. 2006]). In Asia, 7% of the population is covered by cancer incidence data and 8.5% is covered by medically certified death data. In Latin America, 10% of the population is covered by cancer incidence statistics. Where they exist, death records are often inaccurate owing to uncoordinated and fragmented vital registry systems—and this is not exclusively a problem of the developing world (Bowman and Hargrove. A third of cause of deaths are dead wrong. Scripps Howard News Service. August 1, 2009; Mathers, et al. 2005. Available at: http://public.shns.com/projects/dead-wrong).

More and better data are required to improve cancer surveillance. Good data—as accurate and complete as possible within the scope of available resources—is important for understanding trends and developing patterns; for making accurate projections; and ultimately for deciding upon the effective deployment of resources for cancer control (WHO. 2002).

Since the effect of improved health outcomes on economic growth and development is now well established, those who are concerned with the latter ought to be as attentive to the former. Some suggest that the collection of public health data ought to rank with the collection of national economic statistics (*Who Counts?* Lancet. 2007).

Successful cancer control programmes are built upon effective strategies and evidence

Additional funding, improved data collection and cancer surveillance are necessary but not sufficient as a response to the growing cancer burden. The body of knowledge—both research and recommendations—for addressing the burden of cancer as well as other diseases in developing countries and the developed world continues to grow (Bishop, et al. 1995; Brown, et al. 2006; Coleman, et al. 2008; Daar, et al. 2007; IOM. 2009; Mellstedt. 2006; Omar, et al. 2007; PAHO. 2007;WHO. 2002; WHO. 2007).

While it should be self-evident that for greatest effectiveness, cancer control programmes need to be structured to reflect the resources available, the variety of outcomes around the world indicates at least in part that actions and outcomes are not always considered together. Even countries with similar characteristics—similar demographic and economic profiles and approximately equal resource availability—may show disparities in outcomes because of the way resources are deployed and programmes implemented (Gakidou, et al. 2008). As previously described, cancer detection without effective secondary prevention is unlikely to improve outcomes. Unintentionally, it may even lead to discouragement, where the number of reported new cancer cases increases while survival rates decline—a result that that may reflect improved cancer detection and reporting, not a change in the quality of treatment interventions.

In areas where resource availability is especially low, strategies for effective cancer control programmes may have to be unique or require particularly creative problem solving. Even so, there are often case studies available and lessons from the past. They may be related to other diseases or may come from other disciplines. Much of what has already been learned about controlling or reducing the burden of infectious and communicable disease in resource scarce parts of the world may be transferable to cancer control, with appropriate modification. Even where that does not appear to be the case at first glance, lessons from relatively recent history can be relevant. For some infectious diseases that account for a large share of the overall burden of disease—such as HIV/AIDS, tuberculosis and malaria— interventions, control programmes around containment and treatment, and implementation strategies have changed dramatically within a decade. In some cases, that is the result of changes in technology and economics—for example, antiretroviral therapy (ART) based on combined antiretroviral (ARV) drug interventions created opportunities to roll out and scale up HIV/AIDS treatment programmes. Even before that occurred, however, while per case treatment was still prohibitively expensive for many locations, lower cost interventions to control the spread of the disease were already in existence. Other useful lessons and case studies are based on rapid, on-site learning and evidence of innovative programme success. Partners in Health, specialises in effectively addressing "untreatable" health problems in extremely challenging settings. Axios International provides strategic advisory and technical assistance services to improve healthcare in low and middle income countries. These are two examples of organizations that have been pioneers in the delivery of effective programmes.

In general, successful cancer control programmes are more likely to be designed and implemented when a systems-based approach is used and the multiple facets of the challenge, including outcome targets and programme priorities, are considered. In turn, such programmes can be integrated into a

comprehensive health framework appropriate for the available level of resources (Jamison, et al. [eds.] 2006; WHO. 2002; WHO. 2007). There are many positive benefits—spillovers—that extend beyond the disease focus of individual programmes. Comprehensive planning allows for leverage of opportunities across programmes to capture more of the value of such benefits. For example, cancer screening programmes and cancer and other vaccination programmes all intend to expose large populations to healthcare workers with similar if not identical skills. Likewise, maternal health programmes in resource scarce locations often provide great opportunities to reach children (who are with their mothers when visited by healthcare workers or when visiting healthcare facilities). Combined programmes can address multiple health targets without extensive duplication of effort or resource consumption. Especially where resources are scarce, the opportunities around exposing target populations to the healthcare system should be leveraged for maximum value and effectiveness. Much can be accomplished by exploring pilot programmes, sharing information about effective programmes and scaling up based on such evidence.

Cancer is a costly disease, but effective resource allocation yields positive outcomes

Analysis conducted for this report estimates the global costs associated with new cancer cases in 2009—US$217bn in medical and non-medical costs, US$19bn for research and US$69bn in lost productivity. In addition, we break new ground by determining how much spending would have to increase to achieve a global expenditure standard based on per case medical costs in the country with the lowest case fatality rate for each cancer investigated. The overall cost to achieve that global standard is US$217bn.

That analysis should be valuable to a variety of stakeholders for a number of reasons. It is both pragmatic—it answers questions and provides a set of targets for funding—as well, perhaps, as provocative. We state—and explain—why our estimates for the cost of cancer are conservative. Differences between our results and other's relating to both the costs of cancer and the funding "gap" based on a global expenditure standard for treatment—whether from current analysis or future studies—will arise. Many will be explained through the choice of assumptions and other components of each research strategy. If a lively, open debate develops, that would be a positive outcome; it would surely advance the state of the analysis and extend the body of knowledge in these areas—where more needs to be done.

As documented in the literature, programmes already exist around the world to turn knowledge into effective actions in the fight against cancer, based on a broad range of resource availability. At the same time, comprehensive, detailed data on global expenditures and flows of funds related to cancer control by donors and governments are not readily available. More complete—and accurate—statistics relating to development assistance and government spending for cancer control are necessary. Disbursements and allocation of resources for effective cancer funding require greater transparency.

The developed world offers many lessons relating to the burden of cancer and cancer control strategies

The challenges posed by the burden of cancer are very different today than a generation ago for many reasons. The dramatic increase in the burden of cancer in the developing world occurred largely within

that time period (Boyle and Levin [eds.] 2008). The factors affecting high, low and middle income countries vary as do the combinations of factors between countries in the same income groups (Danaei, et al. 2005).

The many successes—as well as failures—relating to cancer control strategies in the developed world during the past generation—and before that—provide a number of lessons. This is noteworthy as the effort to fight cancer in the developing world grows. Resource allocations may be different based on level of resource availability, and not every lesson will have the same relevance for every potential application. The information about prior—as well as current—successes and failures provides an extensive set of case studies.

There is ample evidence for strengthening tobacco controls and other efforts to manage preventable cancers before the incidence of such disease crests. That is especially true where the latency period is long between exposure to risk factors such as tobacco and evidence of resulting disease in the epidemiologic data. The same is true of prevention strategies around alcohol and obesity, as well as other lifestyle and behavioral risks, exposures to some environmental carcinogens and implementation of effective vaccine strategies (Boyle and Levin. op cit; Ngoma. 2006).

Survivorship and palliative care—the quality of life can be improved for those affected by cancer throughout their lives

Issues of access to heathcare extend beyond the medical or economic rationale into the area of ethics. There are many voices in the dialog on healthcare around the world that demand good health and access to healthcare be considered basic human rights. Measures of the quality of life are inarguably imperfect, as is the economic framework for quantifying them. There is almost unanimity, however, in the acceptance that some level of palliative care is appropriate and should be available to all those affected by cancer no matter the level of resource availability.

Guidelines for establishing priorities and setting minimum levels of palliative care based on resource availability exist (WHO. 2002). In the US, recent developments and the focus on survivorship have led to the creation of a *National Action Plan for Cancer Survivorship* which focuses on coordinated public health initiatives to improve the quality of life for cancer survivors. While the interventions and programmes at opposite ends of the resource scale may be very different, the need is very clear—to improve the quality of life for those affected by cancer.

As has happened in the past for cancer and other diseases, evolution is such that successful lessons from one location will be transferred, replicated and scaled up elsewhere. At issue is how quickly that occurs. Expanded global attention to the challenges posed by cancer has the potential to co-ordinate analysis and disseminate learning at an accelerated pace. It may also lead to more innovation with respect to low-cost treatment models that are replicable and sustainable, Such developments would improve the quality of life for many—as well as reduce inefficiencies in resource allocation—more rapidly than would otherwise be the case.

Appendix A—Country data

These tables show the estimated number of new cancer cases in 2009 and 2020, as well as cost estimates for 2009. Tables are for all cancers and the three leading cancers, based on number of new cases: lung, breast and colorectal cancer.

Estimated new cases of cancer in 2009 and 2020 are derived from the authors' calculations based on 2009 and 2020 population estimates from the United Nations and 2002 cancer incidence rates from the International Agency for Research on Cancer. See Appendix E—Methodology for details.

Estimated costs include medical, non-medical and productivity losses. Estimated costs are derived from the authors' calculations based on data from a study of Korean 2002 cancer costs (Kim, et al. 2008) and inflated to 2009 US$ using the Korean consumer price index. See Appendix E—Methodology for details.

New cancer cases (2009, 2020) and costs (2009)

All cancers by country

	Estimated new cases			Cost of new cases
	New cases in 2009	New cases in 2020	% increase	Total cost in 2009 ($)
Total:	12,714,112	16,191,044	27.3	285,803,583,618
Afghanistan	17,660	25,035	41.8	6,091,802
Albania	8,146	10,004	22.8	19,230,922
Algeria	24,988	34,983	40.0	57,485,127
Angola	11,904	16,382	37.6	8,828,542
Argentina	111,132	133,451	20.1	488,938,632
Armenia	7,365	8,116	10.2	8,523,438
Australia	104,419	134,852	29.1	3,601,105,147
Austria	40,907	47,906	17.1	1,468,383,598
Azerbaijan	13,687	17,332	26.6	14,040,810
Bahamas	644	911	41.5	14,849,842
Bahrain	761	1,398	83.7	11,812,516
Bangladesh	121,441	170,319	40.2	51,168,508
Barbados	807	1,151	42.7	9,929,674
Belarus	30,689	31,928	4.0	71,021,909
Belgium	55,497	63,824	15.0	2,201,219,269
Belize	426	638	49.6	1,779,562
Benin	5,714	8,216	43.8	2,966,095
Bhutan	565	769	36.1	445,668
Bolivia	14,091	19,259	36.7	17,759,884
Bosnia Herzegovina	14,603	16,217	11.0	39,584,538
Botswana	2,048	2,490	21.5	6,049,962
Brazil	365,638	504,824	38.1	1,553,826,537
Brunei Darussalam	416	658	58.3	8,798,975
Bulgaria	24,418	24,291	-0.5	80,673,911
Burkina Faso	8,896	12,845	44.4	3,806,657
Burundi	10,780	14,942	38.6	863,690
Cambodia	12,770	17,672	38.4	8,670,115
Cameroon	16,157	20,954	29.7	13,761,897
Canada	163,400	214,948	31.5	6,580,751,609
Cape Verde	348	498	43.1	676,525
Central African Republic	4,034	4,925	22.1	1,437,586
Chad	7,825	10,637	35.9	2,300,138
Chile	43,746	60,673	38.7	255,943,206
China	2,627,721	3,536,449	34.6	5,786,829,242
Colombia	88,810	130,969	47.5	272,083,689
Comoros	755	1,090	44.3	321,526
Congo	51,384	71,311	38.8	14,095,190
Congo Brazzaville	2,112	2,828	33.9	1,558,586
Costa Rica	7,173	10,627	48.2	47,844,423
Cote d'Ivoire	13,150	16,836	28.0	10,948,361
Croatia	22,847	24,648	7.9	184,364,414
Cuba	26,071	33,159	27.2	109,916,868
Cyprus	2,421	3,026	25.0	42,503,178
Czech Republic	50,903	59,100	16.1	537,653,654

	Estimated new cases			Cost of new cases
	New cases in 2009	New cases in 2020	% increase	Total cost in 2009 ($)
Denmark	27,292	31,587	15.7	1,433,363,184
Djibouti	881	1,189	34.9	1,029,873
Dominican Republic	16,896	23,166	37.1	63,207,781
Ecuador	21,629	30,308	40.1	51,207,307
Egypt	59,789	80,593	34.8	111,830,512
El Salvador	9,400	12,680	34.9	34,673,092
Equatorial Guinea	431	561	30.2	1,252,640
Eritrea	3,988	5,637	41.3	1,002,643
Estonia	5,540	5,689	2.7	34,681,399
Ethiopia	87,607	121,265	38.4	12,366,025
Fiji	818	1,002	22.6	2,444,148
Finland	23,769	28,467	19.8	798,879,545
France	297,907	347,952	16.8	12,858,839,673
Gabon	1,327	1,729	30.2	5,783,236
Georgia	10,379	10,786	3.9	9,766,667
Germany	456,667	504,304	10.4	20,252,234,954
Ghana	16,719	22,657	35.5	7,004,817
Greece	42,145	47,183	12.0	955,361,789
Guam	267	371	38.9	0
Guatemala	14,043	19,565	39.3	33,989,635
Guinea	6,824	9,513	39.4	4,821,511
Guinea-Bissau	983	1,342	36.4	118,287
Guyana	1,112	1,464	31.6	1,422,118
Haiti	12,574	16,493	31.2	7,527,853
Honduras	7,433	10,458	40.7	12,022,003
Hungary	52,729	56,809	7.7	551,118,207
Iceland	1,260	1,625	29.0	65,524,250
India	1,023,571	1,369,412	33.8	656,216,740
Indonesia	220,901	295,887	33.9	203,964,817
Iran, Islamic Republic	60,028	81,476	35.7	211,762,846
Iraq	21,307	32,038	50.4	12,018,063
Ireland	15,396	20,031	30.1	629,373,542
Israel	25,906	34,209	32.1	714,737,739
Italy	322,986	361,887	12.0	10,472,835,763
Jamaica	4,648	5,654	21.6	17,419,502
Japan	596,253	687,967	15.4	30,840,792,562
Jordan	4,656	6,926	48.8	17,455,931
Kazakhstan	39,136	47,130	20.4	85,276,920
Kenya	34,197	48,144	40.8	19,468,216
Korea, Democratic Republic	59,791	70,927	18.6	41,127,553
Korea, Republic	143,778	195,466	36.0	2,846,966,828
Kuwait	1,808	3,392	87.7	36,833,247
Kyrgyzstan	6,927	8,983	29.7	3,580,061
Lao People Democratic Republic	4,109	5,664	37.9	1,754,496
Latvia	7,858	8,049	2.4	43,866,614

New cancer cases (2009, 2020) and costs (2009)—

All cancers by country *continued*

	Estimated new cases			Cost of new cases
	New cases in 2009	New cases in 2020	% increase	Total cost in 2009 ($)
Lebanon	7,261	9,192	26.6	75,235,198
Lesotho	1,994	2,065	3.6	1,099,532
Liberia	2,181	3,088	41.6	452,761
Libya	4,505	6,590	46.3	22,724,949
Lithuania	11,834	12,553	6.1	67,235,942
Luxembourg	2,205	2,696	22.3	144,436,129
Macedonia	6,223	7,172	15.3	18,535,966
Madagascar	18,761	26,736	42.5	5,647,976
Malawi	11,883	15,892	33.7	2,351,699
Malaysia	33,438	48,924	46.3	169,035,136
Mali	7,567	10,496	38.7	3,738,914
Malta	1,592	1,980	24.3	27,483,008
Mauritania	2,108	3,031	43.8	1,249,408
Mauritius	1,675	2,285	36.4	7,497,088
Mexico	147,739	208,788	41.3	1,284,051,689
Moldova	9,417	9,730	3.3	7,036,100
Mongolia	3,757	5,581	48.5	4,359,121
Morocco	25,290	33,877	34.0	44,893,872
Mozambique	19,114	23,465	22.8	6,495,590
Myanmar	57,626	77,658	34.8	260,313,964
Namibia	1,371	1,711	24.8	2,854,047
Nepal	21,869	29,938	36.9	7,175,350
New Zealand	20,976	27,056	29.0	471,264,012
Nicaragua	6,580	9,332	41.8	8,591,600
Niger	8,620	12,854	49.1	2,108,341
Nigeria	92,242	121,927	32.2	49,814,400
Norway	22,577	27,611	22.3	1,600,568,023
Oman	1,531	2,438	59.3	17,451,114
Pakistan	175,810	241,066	37.1	101,257,200
Panama	5,035	7,195	42.9	31,572,921
Papua New Guinea	6,110	8,752	43.2	4,164,022
Paraguay	8,681	12,110	39.5	13,887,221
Peru	56,147	76,373	36.0	140,818,954
Philippines	119,837	172,606	44.0	140,512,304
Poland	149,414	172,209	15.3	1,155,137,564
Portugal	43,319	48,682	12.4	885,004,518
Puerto Rico	12,900	15,398	19.4	57,779,280
Qatar	854	1,299	52.1	34,325,281
Romania	60,876	64,207	5.5	184,280,094
Russian Federation	402,463	416,584	3.5	1,522,998,980
Rwanda	12,595	17,020	35.1	3,164,929
Samoa	225	300	33.4	547,974

	Estimated new cases			Cost of new cases
	New cases in 2009	New cases in 2020	% increase	Total cost in 2009 ($)
Saudi Arabia	18,985	30,751	62.0	230,860,828
Senegal	8,372	11,421	36.4	7,217,028
Serbia and Montenegro	33,894	36,217	6.9	98,863,586
Sierra Leone	3,879	4,928	27.1	1,249,207
Singapore	13,374	21,069	57.5	353,636,655
Slovakia	20,475	24,395	19.1	127,616,941
Slovenia	8,746	10,176	16.3	167,906,192
Solomon Islands	592	860	45.2	527,354
Somalia	7,733	11,148	44.2	1,788,035
South African Republic	74,320	86,625	16.6	295,488,523
Spain	185,986	219,658	18.1	4,453,520,178
Sri Lanka	22,433	28,256	26.0	23,746,027
Sudan	24,948	34,327	37.6	13,567,441
Suriname	618	796	28.8	2,287,407
Swaziland	967	997	3.0	1,549,407
Sweden	45,986	52,817	14.9	1,900,632,949
Switzerland	37,620	44,804	19.1	2,702,854,428
Syrian Arab Republic	22,122	33,179	50.0	34,612,770
Tajikistan	4,453	6,226	39.8	1,341,619
Tanzania	41,946	56,881	35.6	13,413,490
Thailand	104,846	136,537	30.2	299,685,279
The Gambia	1,032	1,435	39.1	646,135
The Netherlands	78,792	97,058	23.2	3,477,648,318
Togo	4,344	6,142	41.4	1,629,128
Trinidad and Tobago	2,538	3,275	29.0	17,584,067
Tunisia	9,372	12,613	34.6	29,171,885
Turkey	78,387	108,600	38.5	388,578,113
Turkmenistan	5,508	7,543	37.0	10,240,684
Uganda	27,417	38,991	42.2	8,175,707
Ukraine	141,982	140,392	-1.1	177,817,384
United Arab Emirates	2,765	4,752	71.9	80,658,898
United Kingdom	297,747	344,025	15.5	11,265,851,099
United States of America	1,646,299	2,078,404	26.2	142,830,848,156
Uruguay	13,288	14,914	12.2	89,392,385
Uzbekistan	23,901	33,040	38.2	15,515,157
Vanuatu	156	228	46.5	302,597
Venezuela	40,263	58,247	44.7	187,369,624
Viet Nam	94,468	132,971	40.8	70,495,396
Yemen	14,759	21,658	46.7	10,779,187
Zambia	12,382	15,370	24.1	4,577,293
Zimbabwe	17,285	20,124	16.4	27,014,876

New cancer cases (2009, 2020) and costs (2009)

Lung cancer by country

	Estimated new cases			Cost of new cases
	New cases in 2009	New cases in 2020	% increase	Total cost in 2009 ($)
Total:	1,593,713	2,080,871	30.6	52,893,803,601
Afghanistan	961	1,359	41.4	449,420
Albania	1,346	1,661	23.3	4,659,229
Algeria	2,306	3,525	52.8	7,835,432
Angola	326	456	39.7	417,620
Argentina	11,527	13,883	20.4	79,116,068
Armenia	1,155	1,327	14.9	1,890,614
Australia	10,171	13,637	34.1	490,597,683
Austria	4,267	5,115	19.8	230,231,822
Azerbaijan	1,535	2,044	33.2	2,061,425
Bahamas	42	62	46.5	1,471,726
Bahrain	97	213	120.1	1,755,510
Bangladesh	13,903	20,369	46.5	8,611,849
Barbados	33	50	52.7	645,374
Belarus	4,329	4,670	7.9	13,376,037
Belgium	8,349	9,848	18.0	479,862,603
Belize	23	35	51.5	142,265
Benin	75	111	48.4	62,711
Bhutan	36	51	41.1	41,099
Bolivia	527	734	39.5	1,054,681
Bosnia Herzegovina	2,302	2,601	13.0	8,975,343
Botswana	62	78	26.2	386,979
Brazil	25,481	36,648	43.8	156,569,751
Brunei Darussalam	49	85	72.9	1,324,521
Bulgaria	3,322	3,294	-0.8	16,375,946
Burkina Faso	208	304	46.3	115,757
Burundi	127	181	41.8	22,112
Cambodia	1,039	1,550	49.2	928,541
Cameroon	175	230	31.2	306,324
Canada	24,873	33,627	35.2	1,430,895,511
Cape Verde	4	7	59.4	12,804
Central African Republic	65	79	21.8	40,210
Chad	152	205	35.1	66,499
Chile	3,454	4,931	42.7	28,715,177
China	484,678	676,323	39.5	993,932,331
Colombia	5,787	9,118	57.5	22,835,009
Comoros	13	20	49.1	8,451
Congo	792	1,104	39.3	367,413
Congo Brazzaville	42	58	38.2	40,415
Costa Rica	365	580	59.1	2,883,050
Cote d'Ivoire	421	532	26.2	554,563
Croatia	3,556	3,923	10.3	39,703,302
Cuba	4,760	6,205	30.4	27,795,677
Cyprus	207	262	26.7	5,597,250
Czech Republic	6,898	8,010	16.1	108,918,760

	Estimated new cases			Cost of new cases
	New cases in 2009	New cases in 2020	% increase	Total cost in 2009 ($)
Denmark	3,882	4,553	17.3	288,108,665
Djibouti	15	21	39.8	27,338
Dominican Republic	1,160	1,643	41.6	6,219,025
Ecuador	1,004	1,456	45.0	2,995,495
Egypt	3,446	4,817	39.8	9,594,110
El Salvador	287	394	37.4	1,384,658
Equatorial Guinea	9	11	29.3	37,626
Eritrea	67	95	41.4	25,245
Estonia	785	822	4.8	6,599,626
Ethiopia	1,484	2,082	40.3	364,180
Fiji	8	10	21.0	36,398
Finland	2,227	2,795	25.5	109,816,168
France	31,045	36,292	16.9	2,046,572,177
Gabon	54	74	35.4	406,269
Georgia	1,337	1,423	6.4	1,766,682
Germany	48,803	55,151	13.0	3,147,730,543
Ghana	232	325	40.1	153,146
Greece	6,984	7,913	13.3	217,119,144
Guam	53	77	45.2	0
Guatemala	950	1,325	39.6	2,814,228
Guinea	306	430	40.5	291,046
Guinea-Bissau	13	17	34.7	2,511
Guyana	47	63	34.2	90,754
Haiti	336	451	34.0	278,648
Honduras	494	713	44.5	975,175
Hungary	9,403	10,091	7.3	142,284,542
Iceland	139	182	31.5	10,829,380
India	52,739	72,686	37.8	49,799,903
Indonesia	27,007	37,912	40.4	31,953,374
Iran, Islamic Republic	2,431	3,463	42.4	9,961,952
Iraq	2,105	3,298	56.7	1,761,291
Ireland	1,879	2,509	33.5	104,482,750
Israel	1,674	2,267	35.4	68,242,014
Italy	41,621	47,508	14.1	1,851,886,414
Jamaica	377	468	24.1	2,207,458
Japan	78,133	93,222	19.3	4,491,006,862
Jordan	348	552	58.6	1,795,201
Kazakhstan	6,108	7,666	25.5	17,145,761
Kenya	584	844	44.6	505,691
Korea, Democratic Republic	8,792	10,367	17.9	5,238,087
Korea, Republic	21,750	31,264	43.7	398,123,698
Kuwait	173	389	124.7	4,297,270
Kyrgyzstan	711	977	37.4	464,284
Lao People Democratic Republic	428	612	43.1	239,170
Latvia	1,137	1,204	5.9	8,893,130

New cancer cases (2009, 2020) and costs (2009)

Lung cancer by country *continued*

	Estimated new cases			Cost of new cases
	New cases in 2009	New cases in 2020	% increase	Total cost in 2009 ($)
Lebanon	713	915	28.4	10,549,116
Lesotho	72	72	0.6	63,330
Liberia	20	29	42.3	5,992
Libya	288	441	52.7	2,154,819
Lithuania	1,553	1,689	8.8	11,959,160
Luxembourg	280	349	24.7	26,730,419
Macedonia	836	979	17.2	3,599,247
Madagascar	332	484	45.5	149,919
Malawi	90	115	27.2	41,278
Malaysia	4,287	6,766	57.8	26,945,510
Mali	75	94	25.1	33,089
Malta	163	211	30.0	4,075,103
Mauritania	29	44	51.4	26,676
Mauritius	133	195	47.0	840,899
Mexico	11,316	16,956	49.8	122,427,502
Moldova	1,070	1,149	7.4	1,132,151
Mongolia	348	520	49.3	330,359
Morocco	2,764	3,915	41.6	7,124,293
Mozambique	173	211	22.1	72,560
Myanmar	8,594	12,032	40.0	52,935,047
Namibia	47	59	26.7	177,397
Nepal	1,237	1,728	39.7	592,163
New Zealand	1,941	2,585	33.2	62,498,550
Nicaragua	313	467	49.4	523,598
Niger	206	321	55.9	55,657
Nigeria	644	855	32.8	683,294
Norway	2,247	2,782	23.8	241,266,401
Oman	102	178	75.3	1,583,591
Pakistan	12,504	18,093	44.7	10,517,298
Panama	322	480	48.8	2,708,682
Papua New Guinea	61	92	50.1	68,681
Paraguay	568	825	45.3	1,275,810
Peru	2,231	3,125	40.1	6,954,872
Philippines	18,475	27,720	50.0	28,360,948
Poland	27,334	32,117	17.5	301,135,447
Portugal	3,649	4,157	13.9	107,285,120
Puerto Rico	804	971	20.8	5,926,884
Qatar	74	122	65.2	4,122,365
Romania	9,260	9,826	6.1	40,724,202
Russian Federation	65,308	68,843	5.4	326,380,671
Rwanda	70	93	32.6	28,164
Samoa	12	18	47.6	44,976

	Estimated new cases			Cost of new cases
	New cases in 2009	New cases in 2020	% increase	Total cost in 2009 ($)
Saudi Arabia	917	1,650	79.8	14,891,437
Senegal	58	80	37.9	78,041
Serbia and Montenegro	5,824	6,251	7.3	25,261,921
Sierra Leone	53	67	26.4	27,110
Singapore	2,067	3,627	75.5	63,248,220
Slovakia	2,859	3,507	22.7	25,631,249
Slovenia	1,225	1,466	19.6	33,605,495
Solomon Islands	28	43	49.4	35,722
Somalia	136	200	47.2	48,152
South African Republic	5,556	6,625	19.2	35,491,886
Spain	23,298	28,054	20.4	798,212,387
Sri Lanka	1,239	1,568	26.5	2,085,762
Sudan	213	300	41.3	205,450
Suriname	44	60	35.3	248,108
Swaziland	33	33	0.8	85,120
Sweden	3,240	3,738	15.4	209,390,118
Switzerland	3,907	4,702	20.4	419,343,965
Syrian Arab Republic	1,897	3,081	62.4	4,380,485
Tajikistan	266	386	45.1	104,899
Tanzania	270	370	36.6	180,912
Thailand	13,658	18,643	36.5	45,099,610
The Gambia	30	44	47.5	17,184
The Netherlands	11,141	14,135	26.9	716,962,746
Togo	56	81	44.6	34,043
Trinidad and Tobago	126	169	34.4	1,457,269
Tunisia	1,354	1,904	40.7	5,939,571
Turkey	17,273	24,851	43.9	111,971,515
Turkmenistan	485	685	41.2	1,230,291
Uganda	400	565	41.1	265,959
Ukraine	21,493	21,689	0.9	35,214,186
United Arab Emirates	161	318	97.2	6,239,330
United Kingdom	43,019	50,639	17.7	2,197,304,763
United States of America	237,096	308,270	30.0	29,455,662,864
Uruguay	1,433	1,625	13.4	15,074,162
Uzbekistan	2,113	3,080	45.8	1,819,385
Vanuatu	14	21	53.2	32,762
Venezuela	3,441	5,164	50.1	23,226,177
Viet Nam	13,103	19,415	48.2	11,005,264
Yemen	405	613	51.4	478,189
Zambia	206	253	22.8	159,062
Zimbabwe	626	742	18.4	1,759,648

New cancer cases (2009, 2020) and costs (2009)

Breast cancer by country

	Estimated new cases			Cost of new cases
	New cases in 2009	New cases in 2020	% increase	Total cost in 2009 ($)
Total	**1,322,960**	**1,593,992**	**20.5**	**28,428,097,620**
Afghanistan	2,245	3,216	43.2	541,869
Albania	1,085	1,313	21.0	1,857,462
Algeria	3,675	4,918	33.8	6,607,246
Angola	1,152	1,587	37.7	642,013
Argentina	19,174	22,745	18.6	62,800,454
Armenia	1,132	1,164	2.9	973,518
Australia	13,218	16,017	21.2	377,837,261
Austria	5,023	5,624	12.0	144,066,847
Azerbaijan	1,627	1,873	15.1	1,170,779
Bahamas	102	135	32.2	2,006,345
Bahrain	118	175	47.8	1,416,651
Bangladesh	10,466	14,461	38.2	3,422,972
Barbados	132	160	21.1	1,393,705
Belarus	3,056	3,070	0.4	4,740,070
Belgium	7,923	8,572	8.2	252,878,286
Belize	29	46	56.8	102,183
Benin	900	1,268	40.9	346,762
Bhutan	57	77	33.5	35,374
Bolivia	947	1,291	36.4	960,660
Bosnia Herzegovina	1,835	1,999	9.0	3,636,111
Botswana	238	279	17.4	674,979
Brazil	47,343	62,769	32.6	157,364,603
Brunei Darussalam	34	50	47.9	495,520
Bulgaria	3,020	2,956	-2.1	7,188,550
Burkina Faso	1,458	2,078	42.5	428,820
Burundi	563	754	33.8	45,827
Cambodia	1,324	1,730	30.7	646,825
Cameroon	1,990	2,575	29.4	1,297,616
Canada	22,946	27,922	21.7	717,668,064
Cape Verde	62	85	37.6	88,496
Central African Republic	267	324	21.2	67,992
Chad	578	791	36.8	112,542
Chile	4,656	6,103	31.1	20,351,980
China	145,472	179,548	23.4	176,821,281
Colombia	7,019	9,862	40.5	16,097,879
Comoros	55	80	45.5	16,191
Congo	1,971	2,698	36.9	425,521
Congo Brazzaville	318	425	33.5	159,820
Costa Rica	698	975	39.8	3,376,864
Cote d'Ivoire	1,795	2,325	29.6	1,166,397
Croatia	2,511	2,567	2.2	14,686,646
Cuba	2,533	3,171	25.2	8,236,484
Cyprus	420	506	20.6	6,160,438
Czech Republic	5,401	5,957	10.3	41,477,672
Denmark	4,106	4,530	10.3	166,150,042
Djibouti	61	82	35.0	52,880
Dominican Republic	1,677	2,188	30.5	5,494,277
Ecuador	1,492	2,024	35.7	2,690,851
Egypt	8,438	10,961	29.9	12,410,195
El Salvador	420	577	37.3	1,191,405
Equatorial Guinea	32	41	29.5	57,545
Eritrea	304	432	41.9	54,196
Estonia	569	562	-1.2	2,656,825
Ethiopia	6,870	9,547	39.0	748,209
Fiji	122	145	18.7	268,004
Finland	3,882	4,098	5.6	113,305,596
France	46,192	51,059	10.5	1,535,292,360
Gabon	101	129	27.4	360,138
Georgia	1,721	1,744	1.3	1,163,871
Germany	59,864	64,015	6.9	2,089,246,140
Ghana	2,550	3,422	34.2	805,185
Greece	4,960	5,469	10.3	82,870,189
Guam	47	63	32.9	0
Guatemala	1,252	1,800	43.8	2,421,188
Guinea	505	699	38.3	211,592
Guinea-Bissau	157	215	37.4	13,489
Guyana	98	122	24.9	100,906
Haiti	170	220	29.4	79,648
Honduras	675	966	43.2	865,370
Hungary	5,732	5,957	3.9	41,395,026
Iceland	190	229	20.5	8,192,996
India	99,397	130,625	31.4	48,796,462
Indonesia	30,581	39,829	30.2	21,577,718
Iran, Islamic Republic	5,680	7,239	27.5	13,368,930
Iraq	3,168	4,793	51.3	1,572,052
Ireland	2,184	2,726	24.8	73,455,613
Israel	4,023	5,046	25.4	88,763,479
Italy	39,561	43,016	8.7	987,000,828
Jamaica	593	733	23.5	1,741,835
Japan	33,419	34,966	4.6	1,284,790,196
Jordan	698	1,061	52.0	1,956,264
Kazakhstan	3,700	4,158	12.4	5,306,420
Kenya	3,082	4,304	39.6	1,321,824
Korea, Democratic Republic	2,823	3,389	20.1	1,260,370
Korea, Republic	6,529	7,489	14.7	84,664,099
Kuwait	283	485	71.4	4,642,827
Kyrgyzstan	598	743	24.1	194,465
Lao People Democratic Republic	259	349	34.8	79,185
Latvia	937	919	-2.0	3,638,714

New cancer cases (2009, 2020) and costs (2009)

Breast cancer by country *continued*

	Estimated new cases			Cost of new cases
	New cases in 2009	New cases in 2020	% increase	Total cost in 2009 ($)
Lebanon	1,147	1,513	31.9	9,261,732
Lesotho	104	108	4.0	47,602
Liberia	209	293	40.6	31,336
Libya	581	858	47.8	2,284,025
Lithuania	1,118	1,147	2.6	4,732,038
Luxembourg	302	358	18.6	15,434,340
Macedonia	753	843	12.0	1,577,486
Madagascar	1,313	1,886	43.7	283,134
Malawi	461	600	30.1	112,537
Malaysia	3,904	5,303	35.8	14,657,520
Mali	717	1,010	40.8	197,303
Malta	257	294	14.4	3,387,118
Mauritania	340	480	41.0	145,660
Mauritius	243	290	19.3	900,646
Mexico	13,987	19,408	38.8	97,348,349
Moldova	1,350	1,292	-4.3	703,125
Mongolia	81	109	34.5	49,568
Morocco	3,476	4,470	28.6	4,784,130
Mozambique	278	340	22.3	60,257
Myanmar	4,999	6,573	31.5	16,041,822
Namibia	187	232	23.8	324,287
Nepal	2,524	3,431	36.0	628,138
New Zealand	2,806	3,402	21.2	53,636,215
Nicaragua	496	708	42.5	500,292
Niger	1,006	1,499	49.0	173,413
Nigeria	16,372	21,550	31.6	7,472,591
Norway	2,789	3,205	14.9	162,658,567
Oman	109	164	50.9	818,834
Pakistan	32,627	43,709	34.0	15,038,219
Panama	482	673	39.5	2,399,481
Papua New Guinea	363	529	45.6	174,844
Paraguay	885	1,203	35.9	1,081,052
Peru	4,593	6,137	33.6	8,995,473
Philippines	16,469	23,141	40.5	13,996,349
Poland	15,685	16,696	6.4	86,851,642
Portugal	4,837	5,302	9.6	76,573,794
Puerto Rico	1,547	1,793	15.9	7,957,013
Qatar	76	122	59.9	1,990,501
Romania	7,383	7,795	5.6	15,628,217
Russian Federation	46,031	46,066	0.1	114,180,048
Rwanda	383	495	29.2	83,237
Samoa	25	32	26.4	38,150

	Estimated new cases			Cost of new cases
	New cases in 2009	New cases in 2020	% increase	Total cost in 2009 ($)
Saudi Arabia	1,906	2,998	57.2	16,924,099
Senegal	799	1,124	40.7	408,419
Serbia and Montenegro	4,529	4,729	4.4	9,528,392
Sierra Leone	618	785	27.1	146,005
Singapore	1,588	2,011	26.7	32,392,799
Slovakia	2,042	2,275	11.4	9,125,484
Slovenia	1,054	1,151	9.1	14,712,469
Solomon Islands	48	71	47.2	30,665
Somalia	558	806	44.4	88,949
South African Republic	7,716	8,940	15.9	23,982,609
Spain	18,124	20,904	15.3	339,905,902
Sri Lanka	2,770	3,246	17.2	2,271,915
Sudan	3,206	4,410	37.5	1,411,099
Suriname	72	91	26.0	185,389
Swaziland	50	52	3.4	65,406
Sweden	6,925	7,505	8.4	244,981,803
Switzerland	5,318	6,073	14.2	303,191,350
Syrian Arab Republic	3,040	4,635	52.5	3,758,322
Tajikistan	361	479	32.8	70,755
Tanzania	2,766	3,734	35.0	763,130
Thailand	6,898	8,240	19.5	12,493,050
The Gambia	45	62	37.7	15,018
The Netherlands	11,423	12,925	13.1	404,546,601
Togo	673	949	41.0	194,139
Trinidad and Tobago	400	475	18.8	2,397,754
Tunisia	1,059	1,360	28.4	2,454,309
Turkey	8,224	10,977	33.5	26,773,543
Turkmenistan	430	549	27.6	519,246
Uganda	1,545	2,166	40.2	472,488
Ukraine	15,520	14,948	-3.7	13,470,281
United Arab Emirates	242	430	77.6	4,735,500
United Kingdom	43,629	48,371	10.9	1,347,199,212
United States of America	240,721	286,595	19.1	16,097,364,800
Uruguay	2,046	2,255	10.2	10,433,250
Uzbekistan	2,165	2,863	32.2	942,106
Vanuatu	20	30	48.7	23,678
Venezuela	4,519	6,249	38.3	16,347,217
Viet Nam	6,815	9,261	35.9	3,167,501
Yemen	2,276	3,359	47.6	1,273,880
Zambia	448	543	21.2	154,788
Zimbabwe	804	902	12.2	1,211,242

New cancer cases (2009, 2020) and costs (2009)

Colorectal cancer by country

	Estimated new cases			Cost of new cases
	New cases in 2009	New cases in 2020	% increase	Total cost in 2009 ($)
Total	**1,182,138**	**1,487,361**	**25.8**	**33,389,841,917**
Afghanistan	753	1,073	42.4	264,856
Albania	918	1,169	27.4	1,919,943
Algeria	1,509	2,094	38.8	3,758,938
Angola	307	429	39.7	245,622
Argentina	12,299	14,973	21.7	50,509,036
Armenia	330	373	13.1	352,796
Australia	14,962	19,784	32.2	501,561,823
Austria	5,815	6,912	18.9	189,555,292
Azerbaijan	430	556	29.2	404,957
Bahamas	51	74	44.2	1,248,814
Bahrain	56	101	81.1	887,577
Bangladesh	1,174	1,641	39.7	583,518
Barbados	83	119	42.7	1,096,069
Belarus	3,309	3,499	5.7	6,239,551
Belgium	6,841	8,023	17.3	242,497,983
Belize	10	15	56.5	39,400
Benin	251	363	44.8	145,963
Bhutan	21	29	36.6	18,115
Bolivia	822	1,149	39.8	1,068,003
Bosnia Herzegovina	1,848	2,089	13.0	4,411,050
Botswana	67	82	23.2	282,475
Brazil	27,058	38,235	41.3	112,786,011
Brunei Darussalam	40	67	67.3	748,620
Bulgaria	3,123	3,179	1.8	8,872,609
Burkina Faso	184	277	50.4	77,894
Burundi	243	342	40.7	27,677
Cambodia	778	1,106	42.1	513,281
Cameroon	506	673	33.1	589,458
Canada	21,143	28,586	35.2	798,350,287
Cape Verde	15	23	50.7	32,032
Central African Republic	79	94	19.5	33,761
Chad	179	243	35.6	53,693
Chile	3,159	4,442	40.6	17,002,351
China	180,723	246,273	36.3	255,808,293
Colombia	5,448	8,235	51.2	15,434,910
Comoros	26	38	47.7	10,447
Congo	734	1,011	37.7	233,087
Congo Brazzaville	84	114	35.5	59,515
Costa Rica	505	768	52.0	3,029,829
Cote d'Ivoire	428	545	27.6	416,932
Croatia	3,075	3,388	10.2	21,657,907
Cuba	2,708	3,554	31.2	9,794,775
Cyprus	293	378	28.9	4,721,797
Czech Republic	8,403	10,007	19.1	81,253,131
Denmark	3,978	4,734	19.0	185,225,875
Djibouti	29	40	38.6	33,767
Dominican Republic	1,028	1,434	39.5	3,942,350
Ecuador	1,100	1,562	42.0	2,424,654
Egypt	2,291	3,111	35.8	4,624,809
El Salvador	312	431	38.2	1,052,077
Equatorial Guinea	10	13	29.0	29,501
Eritrea	129	184	42.8	31,869
Estonia	680	708	4.0	3,490,036
Ethiopia	2,815	3,948	40.2	404,347
Fiji	23	30	28.8	71,451
Finland	2,463	3,032	23.1	81,020,625
France	38,625	46,691	20.9	1,499,460,101
Gabon	45	59	31.0	226,613
Georgia	594	627	5.5	516,938
Germany	72,505	80,399	10.9	2,959,922,448
Ghana	736	1,005	36.6	345,677
Greece	4,104	4,635	12.9	79,132,701
Guam	24	36	45.6	0
Guatemala	675	952	41.2	1,580,349
Guinea	193	274	41.8	107,197
Guinea-Bissau	43	59	36.8	6,048
Guyana	94	129	37.6	129,581
Haiti	600	803	33.7	332,555
Honduras	360	517	43.7	565,587
Hungary	8,125	8,946	10.1	72,057,950
Iceland	143	191	33.6	7,142,667
India	39,704	53,712	35.3	26,132,678
Indonesia	23,841	33,026	38.5	21,150,161
Iran, Islamic Republic	4,345	5,862	34.9	14,236,741
Iraq	851	1,310	54.0	604,645
Ireland	2,211	2,927	32.4	84,855,548
Israel	3,522	4,828	37.1	90,566,194
Italy	41,966	47,336	12.8	1,236,808,988
Jamaica	351	432	23.3	1,174,682
Japan	109,960	126,892	15.4	4,679,883,540
Jordan	372	576	54.8	1,389,486
Kazakhstan	1,369	1,685	23.2	2,394,284
Kenya	1,190	1,698	42.7	735,417
Korea, Democratic Republic	5,706	6,773	18.7	2,661,498
Korea, Republic	13,709	18,904	37.9	192,317,750
Kuwait	132	259	96.6	2,833,579
Kyrgyzstan	240	318	32.9	102,594
Lao People Democratic Republic	225	318	41.4	88,505
Latvia	893	918	2.8	4,148,228

New cancer cases (2009, 2020) and costs (2009)

Colorectal cancer by country *continued*

	Estimated new cases			Cost of new cases
	New cases in 2009	New cases in 2020	% increase	Total cost in 2009 ($)
Lebanon	180	232	28.7	1,782,426
Lesotho	46	47	3.1	29,016
Liberia	80	114	42.3	17,450
Libya	211	310	46.7	1,152,138
Lithuania	1,258	1,352	7.5	6,146,604
Luxembourg	305	374	22.4	17,874,262
Macedonia	690	821	19.0	1,790,652
Madagascar	632	913	44.5	184,245
Malawi	207	279	34.9	61,759
Malaysia	3,802	5,870	54.4	17,035,309
Mali	330	459	39.3	134,072
Malta	180	229	27.4	2,963,208
Mauritania	94	138	46.6	61,801
Mauritius	133	189	42.6	564,236
Mexico	7,428	10,759	44.8	63,589,865
Moldova	1,149	1,242	8.1	744,370
Mongolia	73	114	55.1	62,596
Morocco	1,582	2,121	34.1	2,944,085
Mozambique	149	183	22.7	42,429
Myanmar	1,876	2,535	35.1	7,814,699
Namibia	51	64	26.2	130,166
Nepal	795	1,098	38.2	271,251
New Zealand	3,231	4,276	32.3	70,773,063
Nicaragua	301	444	47.5	364,246
Niger	365	553	51.6	85,326
Nigeria	4,582	6,104	33.2	3,171,758
Norway	3,504	4,352	24.2	238,155,271
Oman	72	115	59.9	801,381
Pakistan	6,377	8,705	36.5	4,415,945
Panama	371	551	48.6	2,164,474
Papua New Guinea	190	274	44.0	135,701
Paraguay	450	660	46.7	620,869
Peru	2,942	4,096	39.2	6,431,569
Philippines	10,221	15,190	48.6	10,435,216
Poland	17,409	20,986	20.5	114,992,393
Portugal	5,770	6,587	14.1	106,098,536
Puerto Rico	1,508	1,833	21.6	7,741,859
Qatar	62	105	68.8	2,072,875
Romania	6,414	6,859	6.9	16,415,024
Russian Federation	49,439	52,459	6.1	152,524,673
Rwanda	203	270	33.1	51,754
Samoa	17	23	32.1	36,310

	Estimated new cases			Cost of new cases
	New cases in 2009	New cases in 2020	% increase	Total cost in 2009 ($)
Saudi Arabia	1,342	2,278	69.7	16,085,886
Senegal	219	299	36.7	176,454
Serbia and Montenegro	4,057	4,418	8.9	10,418,381
Sierra Leone	170	217	27.3	62,144
Singapore	2,134	3,585	68.0	47,861,184
Slovakia	3,288	4,047	23.1	18,309,334
Slovenia	1,292	1,549	19.9	22,429,887
Solomon Islands	25	37	46.9	21,826
Somalia	258	378	46.5	58,257
South African Republic	4,013	4,902	22.2	16,141,273
Spain	25,153	29,939	19.0	531,757,615
Sri Lanka	913	1,175	28.7	991,907
Sudan	1,081	1,514	40.1	723,808
Suriname	49	65	32.8	164,569
Swaziland	23	24	4.6	42,615
Sweden	5,816	6,809	17.1	233,398,644
Switzerland	4,885	5,927	21.3	333,865,570
Syrian Arab Republic	2,055	3,217	56.5	3,197,484
Tajikistan	107	151	41.4	31,550
Tanzania	1,002	1,367	36.5	411,933
Thailand	6,902	9,379	35.9	14,673,052
The Gambia	26	36	39.0	12,549
The Netherlands	10,841	13,664	26.0	451,123,621
Togo	185	264	42.8	79,435
Trinidad and Tobago	216	290	34.2	1,504,312
Tunisia	657	898	36.8	2,001,829
Turkey	6,092	8,506	39.6	26,087,919
Turkmenistan	92	127	38.3	162,668
Uganda	982	1,374	39.9	389,274
Ukraine	17,045	17,141	0.6	17,465,886
United Arab Emirates	262	488	85.9	7,520,548
United Kingdom	38,770	45,402	17.1	1,345,769,376
United States of America	189,940	245,474	29.2	15,789,381,424
Uruguay	1,755	1,977	12.6	10,997,121
Uzbekistan	757	1,054	39.2	453,581
Vanuatu	3	5	54.7	5,654
Venezuela	2,757	4,115	49.3	12,330,922
Viet Nam	7,585	10,794	42.3	4,434,755
Yemen	817	1,218	49.0	697,124
Zambia	275	329	19.5	140,681
Zimbabwe	514	595	15.8	1,012,613

Appendix B
Cancer epidemiology: background and useful definitions

Data on the distribution of cancers and related statistics are collected by cancer registries and other organisations that record vital events such as deaths and causes of death. Cancer registries exist around the world and typically collect information about populations in a limited geographic territory, whether entire countries or smaller regions. Efforts are subsequently made to collect, validate and collate data from registries and other sources to develop large-area and worldwide statistical estimates. One result is GLOBOCAN 2002, an extensive cancer data repository maintained and made available by the International Agency for Research on Cancer (IARC), which is part of the World Health Organization (WHO). Since data are always collected and compiled after the events to which they relate, researchers are forced to use figures that are typically several years old. Variation in the quality of data reporting as well as lack of coverage of significant populations and geographies also requires substantial estimation efforts to fill out the database.

IARC makes available data on the incidence of and mortality due to cancers. Data are "age-standardised" and are provided as rates (that is, number of new cases and deaths per 100,000, respectively). Since age is a major factor affecting cancer risk, it is necessary to use age-standardised data when comparing populations with different age profiles.

Burden of disease—The burden of disease is a measure of the size of a health problem in a geographic area. There are a variety of measures that can be used to look at disease burden, both in epidemiologic and economic terms—for example, deaths and disability as a result of disease (epidemiology) or associated costs (economic) such as medical care, other expenditures and lost productivity or earnings due to death and disability. The global burden of disease reflects comprehensive, worldwide analysis of the burden for all diseases and causes of death and disability. Measuring the disease burden helps policymakers determine where health-related investments should be targeted.

Incidence—Incidence is the number of new cancer cases within a specific population during a given period of time (usually annually). As with related statistics, incidence is expressed either as the actual number of new cases within a certain period—that is, the volume of new patients—or as a rate (namely, per 100,000 persons per year). As a rate, incidence approximates the average risk of developing cancer in the specified time period.

Mortality—Mortality is the number of deaths within a specific population during a given period of time. Mortality is expressed either as the actual number of deaths within a given period or as a rate—per 100,000 persons per year. As a rate, mortality measures the average risk of dying of cancer. Mortality is the product of incidence of and fatality for a cancer.

Case fatality rate—The case fatality rate is the mortality rate divided by the incidence rate for a specific period of time. The case fatality rate is an approximate measure of the likelihood of dying from a particular cancer. If the case fatality rate is 0.8, then approximately 80% of new cases will result in death.

Survival—Survival is the probability of surviving. It is typically stated as a rate over a particular period of time since diagnosis with cancer (for example, 1, 3, 5-year survival rates). One minus the survival rate is the fatality rate.

Prevalence—Prevalence is the number of people alive within a specific population at a point in time who have a particular cancer. Prevalence is calculated based on incidence and survival.

Crude rate—Crude rates for incidence or mortality are calculated by dividing the number of new cancer cases, or deaths, by the number of people in the population under observation. Rates are usually expressed per 100,000 persons per year.

Age-standardised rate—Age-standardised rates reflect the rate—for example, incidence (number of new cases) or mortality (number of deaths)—that a population would have if it had a standard age structure. Because populations vary in age structure, directly comparing incidence or mortality—or associated crude rates—does not provide meaningful information relating to relative risk for the populations. For example, older populations are likely to have higher overall incidence and mortality rates. That does not mean, however, that an older population is necessarily at greater relative risk for the development of new cancers or cancer deaths than another population with a younger age structure. Age standardisation allows for the comparison of two populations with different age structures. The most frequently used standard population for comparisons is the world standard population.

Appendix C
An overview of the spectrum of cancer control

Cancer control refers to efforts aimed at reducing the number of new cancer cases and associated deaths and disability (that is, *mortality* and *morbidity*), as well as improving the quality of life for cancer patients and their families. There are five primary areas that constitute the spectrum of cancer control interventions:

- primary prevention;
- early detection and secondary prevention;
- diagnosis and treatment;
- survivorship; and
- palliative care.

Within each area is a set of available interventions, representing almost a continuum (adapted from *Cancer Control Continuum*. National Cancer Institute. 2007. Available at: http://cancercontrol.cancer.gov/OD/continuum.html)—thus, the *spectrum* of cancer control. Some interventions are public health initiatives and focus on communities or other population groups. Other interventions relate to individuals. The determination as to which intervention is appropriate depends on a number of factors, including population targets, cancer type, availability of resources, and cost effectiveness. For therapeutic interventions (that is, other than prevention), the extent to which a cancer has spread is important for determining the nature of treatment, as well as assessing prognosis. Cancers are classified into stages to describe the extent of their spread. Different staging systems are used to classify cancers for different purposes.

The combination of interventions in place for a country or other location represents the cancer control strategy for that geography. This is a brief overview of interventions and objectives relating to each primary area of cancer control:

Primary prevention—While not all cancers can be avoided or prevented, several can. These include cancers caused by cigarette smoking and other forms of tobacco consumption and cancers related to chronic, heavy alcohol consumption. For other cancers, it is possible to reduce or eliminate many cancer-related risk factors, such as obesity, physical inactivity and poor nutrition. Primary prevention is meant to reduce or eliminate exposure to such cancer-causing factors, including environmental carcinogens and lifestyle behaviours. Primary prevention includes public health strategies that apply to the individual—for example, immunisation and chemoprophylaxis against infectious agents linked to specific cancers, treatment of those infections and dietary interventions—and to whole populations. The latter includes tobacco and alcohol control programmes (which may extend to public policies such as so-called "sin" taxes—to discourage particular behaviours).

For particular cancers—including oesophageal, liver, lung and pancreatic cancer—where early detection and treatment have not proved effective, primary prevention is the most useful intervention. For these cancers, survival rates show little difference between the developed and developing world.

Early detection and secondary prevention—Early detection and secondary prevention can reduce the incidence of several highly invasive cancers—for example, cervical and colorectal cancer—through population-based screening programmes meant to identify and treat or remove precancerous lesions. Such programmes are also useful for detecting particular cancers—for example, breast and large bowel cancer—at an early stage, when they are most

responsive to treatment.

These population-based screening programmes are only effective, however, if they are combined with treatment strategies, which may be limited based on the availability of resources (either funding or skilled medical/technical staff). As a result, the effectiveness of early detection programmes varies, and differences in survival rates for cancers that can be controlled through early detection and secondary prevention interventions are particularly evident when comparing outcomes for developed and developing countries.

Diagnosis and treatment—Cancer treatment has three primary modes: surgery, chemotherapy and radiotherapy (through radiation). Each mode may be used separately or in some combination, depending on the cancer type and stage. Many interventions in this category are expensive (at least in relative terms), and many require the use of specialised equipment by specially trained staff. As a result, many diagnostic and treatment options are only available through specialised cancer centres. Other treatments are offered through inpatient hospital stays. Combination, multimodal treatments that are particularly complex require specialised facilities, equipment and staff, so access is a particular problem worldwide.

In addition to the issues of access and availability, the effectiveness of treatment is influenced by the stage at which cancers are diagnosed. Survival rates are similarly affected. As a result of these factors, disparities in outcomes are evident, particularly between high income countries and low- and medium-income countries. These challenges are compounded by the expensive nature of the interventions.

Survivorship—The National Cancer Institute (NCI) of the US National Institutes of Health (NIH) points out that the number of cancer survivors is a "large and growing force" (NCI. 2007). As more people live with cancer and as the lifetime risk of experiencing cancer grows, the focus on survivorship gains additional importance. An individual is considered a cancer survivor from the time of diagnosis through the balance of his or her life. Family and caregivers are also affected by the survivor experience. Accordingly, the NCI includes them in the definition of survivors.

Throughout the course of their experience, from diagnosis through treatment and for the rest of their lives, survivors face many physical, psychological, social and spiritual challenges. Survivor interventions include counseling and other means of coping as well as targeted strategies to promote good health and improve quality of life. In the US, survivorship is sometimes described as living "with, through and beyond" cancer (Centers for Disease Control and Prevention Division of Cancer Prevention and Control. Cancer Prevention and Control: Cancer Survivorship. Available at: http://www.cdc.gov/cancer/survivorship/).

The focus on survivorship began in the US fairly recently, and is not yet worldwide, however awareness of survivor needs is growing. A body of academic literature on survivorship and related issues around the world has begun to accumulate, with many peer reviewed journals publishing such work. Since 2007, a journal devoted exclusively to such issues (Journal of Cancer Survival) has appeared. Based on the number and names of organizations that address issues relating to survivorship, as determined by searching the Internet, the community is already quite large and growing.

Palliative care—Palliative care is meant to alleviate the physical and psychological symptoms of those affected by cancer and to address quality-of-life issues related to the disease. More recently, the scope of intervention has been extended to include consideration of the well-being of patients' families and caregivers.

Even survivorship and palliative care are subject to challenges. For example, pain relief efforts in many countries are hindered by laws prohibiting the use of narcotics. Furthermore, where resources are scarce and allocation issues extensive, survivor strategies and palliative care have often not been among the top healthcare priorities.

Appendix D
Data sources

1. IARC/GLOBOCAN 2002 data

The GLOBOCAN 2002 database was compiled by the International Agency for Research on Cancer (IARC) and presents estimates of incidence, prevalence, and mortality from 27 cancers for all countries in the world. Data sources include cancer registries worldwide. Some are nationally representative, and others represent subnational samples. IARC[i] makes public the process used to collect, check, analyze, and report data on cancer incidence, prevalence, and mortality for GLOBOCAN 2002. The following is their description of that process.

Data drawn from cancer registries is converted into preliminary databases, where it is validated and check for errors. All errors or queries are sent back to the registry for clarification or corrected. All data, including incidence, mortality, and population data, are appropriately formatted and converted into the Descriptive Epidemiology Group (DEP) database. The DEP is part of IARC and performs all validation procedures. Data may then be used for statistical analysis and comparison, and may ultimately be featured in publications such as *Cancer Incidence in Five Continents* or *International Incidence of Childhood Cancer*, or in worldwide estimates of incidence, mortality and prevalence such as GLOBOCAN 2002.[ii]

Three major components used in GLOBOCAN 2002 estimates [ii]

Component	Submission	Notes
Incidence data:	A listing of cases	For each incident record, the minimum items required are: a registration number, sex, age/birth date, date of incidence, site of the tumour, morphology, behavior, and the basis of diagnosis
Mortality data:	A tabulation of number of deaths coded in ICD[1] three-digit categories by sex and five year age group.	
Population data:	The number of persons at risk in the area covered by the registry, also by sex and five year age group and the source: census, estimates, etc.	Source: UN World Population Prospects 2002

Data validation [ii]

Component	Validation procedure	Definition used in GLOBOCAN 2002
Incidence data:	Incidence data is converted to ICD-O-3 if necessary, then checked using the IARCcrgTools/CHILD-CHECK programmes (a Windows-based programme)	The number of new cases arising per 100,000 persons per year.
Mortality data:	Consistency check of sex/site combination and valid ICD code.	The number of deaths per 100,000 persons per year.
Population data:	An arithmetic check is carried out to ensure consistency between totals for all ages and to compare with data supplied previously.	The number of people alive who have had cancer diagnosed within the last 5 years[iii,iv]

Data issues and notes

Multiple primary sites
IARC rules permit one cancer per body site per lifetime.[v,vi]

Timeliness of data
More recent incidence or mortality data than what is recorded in GLOBOCAN 2002 may be locally available.[i]

Estimating incidence and mortality in countries lacking data components IARC's published estimates apply two types of corrections to mortality data: adjustment for quantified under-recording of deaths and a redistribution of deaths recorded as "uterus cancer" to specific sites of cervix or corpus uteri.[iii]

For countries in which data components are not available, incidence estimates are made based on the following (in order of priority)[iii,iv]:

- National incidence data from good quality cancer registries.
- National mortality data, with estimation of incidence from regression models that may be specific to country, region, or developing countries as a whole.
- Local or regional incidence data from regional cancer registries within country.
- Frequency data when only relative frequency of different cancers (by age and sex) are available.
- In the case of no data available, country specific rates are estimated using data from neighboring populations (this is the case in countries such as Afghanistan, Ghana, Madagascar)[iii]

For countries in which data components are not available, mortality estimates are made based on methods analogous to those of incidence (see above); mortality estimates are based on estimates of incidence and use country/region-specific survival.[iii]

Over- and under-estimates
GLOBOCAN 2002 estimates of incidence and mortality come from a period of time two to five years prior to 2002.[i] These estimates are used along with 2002 population data to estimate prevalence. Therefore, for cancer sites where rates are increasing globally (breast, prostate) there will be an underestimate of new cases and for cancer sites where rates are globally decreasing (stomach) there will be an overestimate of new cases.[iii]

Shibuya et al. suggest that when mortality data or incidence data are incomplete, there is a likely under-estimation of cancer deaths. Fallah and Kharazmi (2008) report under-estimation in cancer incidence for developing countries due to under-registration of cancer deaths in elderly population.[vii] A study from north-eastern Libya demonstrated that the pattern of incidence of lung, breast, colon, rectum, and bladder cancers is different from estimates based on data from neighbouring countries. Using a population-based cancer registry established in 2002, the estimated overall cancer incidence rate was higher than GLOBOCAN 2002—therefore, in the case of Libya, GLOBOCAN 2002 methods resulted in under-estimation of overall cancer incidence. For some individual cancers, (i.e. colorectal) incidence rates are higher than GLOBOCAN 2002, for others (i.e. bladder) rates are lower than GLOBOCAN 2002.[viii]

Completeness of mortality and registry data
IARC provides methods and software for checking validity of data. Parkin and Bray (2007) present both semi-quantitative and quantitative methods to evaluate overall completeness of a registry database.[ix] A DCP2 report demonstrates that available datasets on mortality varies by world region. For example, the region of Latin America and the Caribbean has 286 datasets on death registration data, while Sub-Saharan Africa has 30 and the Middle East and North Africa has 46. For datasets on child/adult mortality, Sub-Saharan Africa has 190, while Europe has 22.[x]

A 2007 series in the UK medical journal, Lancet, discussed the importance of vital registration systems and challenges that countries/regions face, and provided summaries of available data by region.

2. World Bank national income classifications

Income group classifications are drawn from the World Bank's List of Economies (July 2009), which classifies all World Bank member economies, and all other economies with populations of more than 30,000. For operational and analytical purposes, economies are divided among income groups according to 2008 gross national income (GNI) per capita, calculated using the World Bank Atlas method. The groups are: low income, US$975 or less; lower middle income, US$976–3,855; upper middle income, US$3,856–11,905; and high income, $11,906 or more. The high income countries are alternatively classified as developed countries—that is, the developed world—while low income, lower middle income and upper middle income countries combined as a single group are alternatively classified as developing countries—the developing world.

3. IARC regional and continent classifications

IARC regional definitions were taken from the IARC website (http://www-dep.iarc.fr/). They can be found in the GLOBOCAN 2002 Data Sources and Definitions. IARC regions were aggregated, according to region name, up to continents. The continent group "Oceania" includes all regions not identified as being part of other continents (Africa, America, Asia, and Europe): Australia/New Zealand, Caribbean, Melanesia, Micronesia, and Polynesia.

4. Medical and Non-Medical Costs per Case of Cancer

Estimates of the medical cost per case (which include hospital inpatient costs, outpatient visits and procedures, and prescription drugs) and non-medical costs per case (which include transportation for medical treatment, costs of alternative and homeopathic treatments, and the imputed costs of care giving) were obtained from a study of Korean 2002 cancer costs (Kim et al, 2008). The source of data for the Korean study is a data set of claims for medical services in Korea in 2002 obtained from the Health Insurance Review Agency; these data are relatively comprehensive since a compulsory national health insurance programme has been in place since 1989. This dataset contained claims for 534,801 persons with cancer listed as their primary diagnosis. These medical claims data were matched with data from hospital- and population-based cancer registries that have been operating since 1980. The registries contain data on age, gender, primary diagnosis and date of diagnosis. A match of the claims data and the registry data yielded 311,759 cancer patients for use in the cost analyses.

The Korean cost data are prevalence-based because included in the average are the costs of cases for all people living with a cancer diagnosis. There are two different but complementary measures of cancer cases in a population: prevalence and incidence. Cancer prevalence measures the number of people with a cancer diagnosis living in a specified population at a point in time. Prevalence is often measured with respect to a specific diagnosis window. For example, five-year prevalence measures the number of people who have been diagnosed within the last five years and are still alive. Cancer incidence measures the number of cases of cancer diagnosed in a specific time period among a specified population. The incidence data we use to estimate the costs of cancer care are new cancer cases diagnosed during a single calendar year. The ratio of prevalence to incidence is equivalent to the ratio of survivors (including the newly diagnosed) to newly diagnosed patients. A higher survival rate will be associated with a higher ratio of prevalence to incidence. For example, lung cancer has a relatively low survival rate; its ratio of prevalence to incidence for lung cancer in the United States in 2005 was 2.4. By contrast, breast and colorectal cancer have relatively high survival rates; the ratio of prevalence to incidence in the US in 2005 was 11.9 for breast cancer and 8.0 for colorectal cancer (National Cancer Institute website).

Most cost of illness studies of cancer are prevalence-based: they estimate costs per case based on medical claims from a population with a diagnosis some time in the past (namely, they are not limited to cancer cases diagnosed in the preceding year). As such, the cost estimates are averages for patients with new cancer diagnoses (within the past year) and patients who were diagnosed more than one year before. As noted in the discussion on prevalence

and incidence measures, the distribution of years since diagnosis varies considerably by cancer site and according to survival rates. In addition, the costs of medical care for cancer patients vary considerably by the elapsed time since diagnosis; this time path for medical care costs also varies by cancer. Previous researchers have defined three phases in cancer treatment: initial, continuing, and terminal (Brown et al, 2002; Warren et al, 2008). The initial phase is typically defined as the first six or 12 months following diagnosis; medical care in the initial phase includes surgery, radiation, and chemotherapy. The continuing phase may last for many years and includes surveillance services to detect recurrence and services and drugs to prevent recurrence.

The terminal (i.e., post-recurrence) phase is usually no more than 12 months long and typically involves palliative care. The cost of cancer care varies considerably over these three stages. Costs of care in the initial phase tend to be relatively high; annual costs in the continuing phase are relatively low; and costs in the terminal phase are again relatively high. For example, cancer-related expenditures for patients with colorectal cancer in 1996 by phase were: initial phase (first six months)—US$18,100; continuing phase—US$1,500; terminal phase (last 12 months)—US$15,200 (Brown et al, 2001). Because costs of cancer care vary enormously by phase, estimates of the costs per case for cancer patients will vary considerably for some cancer sites depending on whether the costs are for cases of recently-diagnosed cancer (incidence) or for cases of cancer diagnosed over a longer timeframe (prevalence). For cancers with low survival rates, it will matter less whether costs per case are based on cancer prevalence or cancer incidence. The difference between prevalence- and incidence-based estimates of average costs per case will depend on the length of the continuing phase. The length of the continuing phase can be inferred from survival data. The National Cancer Institute publishes tables, by cancer site, of survival rates by year of diagnosis. For men and women diagnosed with colorectal cancer during the time period 1975-79, 47% were still alive ten years following diagnosis and 44% of them were still alive 20 years after diagnosis. If the initial phase is six months, and the terminal phase is 12 months, then the average continuing phase length would likely be in the interval of eight to 12 years.

As noted, the cost per case data we use to estimate the medical care costs of cancer is prevalence-based. Since we measure cancer cases by incidence, this could lead us to under-estimate the costs of cancer care for cancer sites with long survival periods. When one plots the costs of cancer care for a single case of cancer over time, the resulting pattern is typically a U-shaped curve: high in the initial phase, low in the continuing phase, and high in the terminal phase. Incidence-based estimates of cancer costs per case will be based on just the first part of the U-shaped curve (the initial phase); prevalence based estimates of cancer costs per case will be based on the average height of the entire U-shaped curve. The longer the continuing phase (the bottom part of the U-shaped curve), the lower will be the prevalence-based average cancer cost per case. Because we use incidence data for our estimate of cancer costs, we would prefer to use an incidence-based measure of cancer costs per case; however, only prevalence-based cost per case data are available for all of the cancer sites.

A spot check of the data suggests that our cost per case estimates are reasonable approximations to the costs of addressing (medically and non-medically) recently diagnosed cases. More specifically, Warren and colleagues estimate the costs of cancer care among cancer patients aged 65 years and older for the initial phase of several types of cancer. The ratio of initial care costs for lung cancer to initial care costs for breast cancer in 2002 was 1.9 (Warren et al, 2008). The same ratio computed from the data presented in the study by Kim and colleagues (on which our medical care cost estimates are based, see Kim et al, 2008) was 2.2. Although the two studies (Kim et al, 2008 and Warren et al, 2008) were conducted on different populations, it seems reasonable to infer that that the relative medical care costs per case of lung and breast cancer were not sensitive to the choice of prevalence or incidence measures.

5. Productivity losses per case of cancer

Our estimated productivity losses per case of cancer are based on the morbidity costs of cancer as measured in the study of the economic burden of cancer in Korea (Kim et al, 2008). In this study, morbidity costs of cancer are defined as "the time and economic output lost or foregone by the patient from his/her usual activities and work as a result of cancer and its treatment (p. 137)." In this Korean study, morbidity costs are computed as the product of the estimated number of days lost from work multiplied by the average age- and gender-specific daily wage. The number of days lost from work for each person is approximated by the sum of inpatient hospital days and one-half of the number of outpatient visits. For cancer patients who were unable to work because of their illness, average age- and gender-specific average annual earnings were used as estimates of morbidity costs. Kim and colleagues report both the number of lost days and the per patient morbidity costs in Table 4.

Ideally, in estimating the productivity losses per case of cancer, one would have a more exact measure of the number of days lost per patient. It is likely that inpatient days and one half of outpatient visits is a lower bound on the total number of days lost because of cancer-related ill health. Data from another study of the burden of illness born by cancer patients was used to adjust the Korean morbidity data (an explanation of this adjustment can be found in Appendix E—Methodology). Yabroff and colleagues analysed matched case-control survey data collected through the 2000 National Health Interview Survey (Yabroff et al, 2008). The authors' analyses of the burden of illness in cancer survivors are based on survey responses from 1,823 cancer survivors and 5,469 age-, gender- and educational attainment-matched controls. In addition to identifying the respondents' cancer site and date of diagnosis, the survey asked questions about the number of days lost from work in the previous 12 months. In the analysis of days lost from work, results for the following common cancer sites were presented separately: breast, colorectal, and prostate. Cancers with five-year survival rates were grouped together (lung, esophagus, liver, pancreas, and stomach). Survey responses from individuals with multiple cancers were grouped separately. Survey responses from individuals with cancers from all other sites (besides breast, colorectal, prostate, and short-survival cancers) were grouped separately.

6. Total health expenditures per capita

Data for each country on total health expenditures per capita in 2002 was obtained from Annex Table 2 Selected Indicators of health expenditure ratios, 1999-2003, the World Health Report 2006.

7. Gross national income per capita, 2002

For each country, estimates of gross national income (GNI) per capita (in US dollars) were obtained from the UN Statistics Division, National Accounts Estimates of Main Aggregates.

(http://data.un.org/Data.aspx?q=GNI+per+capita+2002&d=SNAAMA&f=grID:103;currID:USD;pcFlag:1;yr:2002&c=2)

8. United Nations 2009 and 2020 population estimates

Population estimates for each country by gender and age groupings (medium variant) were obtained from World Population Prospects: The 2006 Revision, published by the UN. More information on the UN's population estimates may be obtained at its population division website: http://www.un.org/esa/population/

Appendix E
Methodology

Estimated New Cases of Cancer in 2009 and 2020

Estimated 2002 incidence rates (IR), in the form of the number of new cancer cases per 100,000 relevant population, were obtained from the International Agency for Research on Cancer (IARC) for each cancer, gender, and age category in each country (see Appendix D for a description of these data). Each cancer/gender/age/country incidence rate was multiplied by the United Nations 2009 estimate of the number of people (in units of 100,000) in each age and gender category in each country (see Equation E1 below). IRs were available for 5 age groups: 0 to 14, 15 to 44, 45 to 54, 55 to 64, and 65 and older. The total number of new cases of cancer in each country was computed as the following aggregation:

$$\text{Total New Cases}_i = \Sigma_j \Sigma_k \Sigma_l IR_{ijkl} * POP_{ikl} \qquad \text{Eqn. E1}$$

Where i indexes country
j indexes cancer
k indexes gender
l indexes age category
IR_{ijkl} = incidence rate for cancer j, gender k, and age category l in country i
POP_{kli} = population of gender k, in age category l in country i

Incidence rates for Kaposi Sarcoma were available only for countries on the African continent. Incidence rates for four cancers were available only for women: breast, corpus cervi, corpus uteri, and ovary. Incidence rates for two cancers were available only for men: prostate and testis. IARC published incidence rates for 26 unique cancer sites. In addition, it published incidence rates for the aggregation: "All Sites But Non-Skin Melanoma". This latter category includes not only the 26 separately listed cancer sites, but all other cancers exclusive of non-skin melanoma. New cancer cases for "other sites" was imputed by subtracting the sum of cancer cases for all 26 unique sites from the total "All Sites But Non-Skin Melanoma" (see Equation E2).

$$\text{Other Sites Cases}_i = \Sigma_k \Sigma_l [Cases_{Aikl} - \Sigma j\ Cases_{ijkl}] \qquad \text{Eqn. E2}$$

Where i indexes country
j indexes cancer
k indexes gender
l indexes age category
$Cases_{Aikl}$ = number of cases from "All Sites but Non-Skin Melanoma" for gender k, and age category l in country i
$Cases_{ijkl}$ = number of cases of cancer j, gender k, and age category l in country i

We estimated the number of new cases of cancer in 2020 using the same method we used to estimate new cancer cases in 2009. To compute the 2020 estimate of new cancer cases, we substituted the UN 2020 population estimates for the UN 2009 population estimates.

Estimated Case Fatality Ratios

We computed estimated case fatality rates for each cancer and gender in each country. Each case fatality rate was computed as the mortality rate (number of deaths per 100,000 relevant population) divided by the incidence rate (number of new cases of cancer per 100,000 relevant population; see Equation E3). All-ages mortality and incidence rates were used to calculate case fatality rates. When incidence and mortality rates are in a steady state, then the case fatality ratio approximates the percentage of people with a particular cancer who will die from that cancer. One minus the case fatality rate is the survival rate. Estimated case fatality rates were computed according to:

$$\text{Case Fatality Rate}_{ijk} = MR_{ijk} / IR_{ijk} \qquad \text{Eqn. E3}$$

Where i indexes country
j indexes cancer
k indexes gender
IRijk = all-ages incidence rate for cancer j and gender k in country i
MRijk = all-ages mortality rate for cancer j and gender k in country i

For cancers that afflict both males and females, we computed combined (male+female) case fatality rates. These were obtained by weighting the gender-specific incidence and mortality rates by the number of new cases of each type of cancer in 2002 (see Equation E4)

$$\text{Case Fatality Rate ij} = \{[\Sigma k\,(MRijk^{*}\ casesijk)] / [\Sigma k\,(IRijk^{*}\ cases\ ijk]\} / [\Sigma k\ cases\ ijk] \qquad \text{Eqn. E4}$$

Where i indexes country
j indexes cancer
k indexes gender
IRijk = all-ages incidence rate for cancer j and gender k in country i
MRijk = all-ages mortality rate for cancer j and gender k in country i
cases ijk = number of new cases of cancer j for gender k in country i in 2002

Estimated Costs and Productivity Losses of New Cancer Cases

We estimated the direct (medical plus non-medical) costs and productivity losses deriving from new cancer cases in 2009 and 2020. We first located an estimate of the medical and non-medical cost per case for each type of cancer in 2002 (Kim S.G, 2008, The economic burden of cancer in Korea in 2002). These costs data are prevalence-based while our estimate of cancer cases is incidence-based. See Appendix D for descriptions of these data and for an explanation of the difference between, and the consequences of, incidence-based costs and prevalence-based costs. These medical and non-medical costs per case were then inflated to 2009 dollars using the Korean consumer price index. Next, we adjusted the Korean cost per case data to reflect the cross-country variation in medical treatment costs. The costs of medical treatment vary from country to country because of variation in a number of factors including, but not limited too: national income, decisions by physicians and insurance companies about treatment intensity, insurance coverage, and the general health of the population. To adjust for this cross-country variation, we multiplied the 2009 medical and non-medical cost per case by an adjustment factor equal to the ratio of each country's Total Health Expenditures per Capita (THE) to Korea's Total Health Expenditures per Capita. Equation E5 shows the calculations undertaken to compute the total medical and non-medical costs associated with new cancer cases in 2009 in each country.

$$\text{Medical cost}_i = \Sigma j\ CPC_j * (THE_i / THE_{Korea})\ cases_{ij} \qquad \text{Eqn. E5}$$

Where i indexes country
j indexes cancer
CPC_{Ki} = estimated Korean medical cost per case in 2009 US$
THE_i = total health expenditures per capita for country i in 2002
THE_{Korea} = total health expenditures per capita for Korea in 2002
$cases_{ik}$ = number of new cases of cancer j (male + female) in country i in 2009

We estimated non-medical costs of new cancer cases in 2009 using the same method we used for medical costs except we substituted the estimated non-medical costs per case of cancer for the medical costs per case of cancer.

The Korean study also provided us with 2002 estimates of productivity losses per case (measured in the form of lost wages) associated with different types of cancer (see Appendix D for a description of these data). We inflated these losses to 2009 using the Korean consumer price index. In the Korean study, productivity losses per case were computed as the average lost wages per day multiplied by the annual number of lost days of work per case. The number of lost days of work was in turn estimated as the number of inpatient hospital days plus one half times the number of outpatient visits. A study by Yabroff et al suggested that the Korean estimates of the number of days lost from work, based solely on the number of days receiving healthcare services, was low. The Yarbroff study used survey data from cancer patients to obtain a self-reported estimate of work days lost because the patient was either too sick to work or because the patient was seeking medical care (see Appendix D for a description of these data); the estimate of days lost per case for each cancer equals the average days lost reported by cancer patients minus the average days lost reported by matched case-controls. The number of lost work days by cancer site reported in the Yabroff study was an average for all patients with a particular type of cancer, including patients who had been diagnosed within the past year and patients who had been diagnosed more than ten years previously. Since our cost estimates are annual for newly diagnosed cases of cancer, we computed an adjustment factor to reflect the relatively high costs of cancer in the first year following diagnosis. The computation of this adjustment factor for time since diagnosis is shown in Equation E7. Finally, the value of a single day's wages varies considerably across countries. We adjusted our productivity loss estimates for this variation by multiplying the productivity loss per case of cancer by the ratio of each country's gross national income per capita to Korea's gross national income per capita. Productivity losses were computed only for cancer among people aged 15 to 64.

$$\text{Productivity Loss}_i = \Sigma_j\ PLPC_{Kj} * (GNI_i / GNI_{Korea}) * DAYSj * cases\ ij \qquad \text{Eqn. E6}$$

Where

$$DAYS_j = (D_{j,yabroff} / D_{j,kim}) * [D_1 / (D_m * n_m)] \qquad \text{Eqn. E7}$$

i indexes country
j indexes cancer
m indexes categories for number of years since diagnosis (<=1, 2-5, 6-10 11+)
$PLPC_{Kj}$ = estimated Korean productivity loss per case in 2009 US$
GNI_i = gross national income per capita for country i in 2002
GNI_{Korea} = gross national income per capita for Korea in 2002
$DAYS_j$ = an adjustment for work days lost per case of cancer j
$D_{j,yabroff}$ = average number of work days lost per case of cancer j in Yabroff study
$D_{j,korea}$ = average number of work days lost per case of cancer j in Kim study
D_1 = average number of work days lost within 1 year of diagnosis

D_m = average number of work days lost within m years of diagnosis
n_m = number of observations in category m of years since diagnosis
$cases_{ik}$ = number of new cases of cancer j (male + female) in country i in 2009

Medical costs, non-medical costs, and productivity losses were calculated for new cancer cases in 2020 using the methods described above. We substituted the estimated number of new cancer cases in 2020 for the estimated number of new cancer cases in 2009.

Estimated Medical Treatment Expenditure Gap

The medical treatment expenditure gap is computed as the difference between the estimated 2009 cost of medical treatment and the estimated cost of medical treatment that would be incurred if every cancer patient were treated in the country with the lowest-case fatality rate for each patient's cancer type. To compute the expenditure gap, we first identified, for each cancer type, the country with the lowest-case fatality rate (to be ranked on case fatality for a particular cancer site, countries must have had at least 500 cases of cancer for that cancer site in 2002). Next, we computed the cost per case of medical treatment for each cancer in the country with the lowest-case fatality rate according to Equation E5. Thus we obtained a global medical expenditure standard for each cancer site. For each cancer site, the expenditure gap was computed as the difference between the global expenditure standard and each country's medical cost per case multiplied by the number of cases for each cancer site in that country (see Equation E8).

$$\text{Treatment Expenditure Gap}_i = \Sigma_j (GES_j - MCPC_{ij}) * cases_{ij} \qquad \text{Eqn. E8}$$

Where
i indexes country
j indexes cancer
GES_j = global medical expenditure standard for cancer site j
$MCPC_{ij}$ = 2009 estimated medical cost per case for cancer site j in country i
$cases_{ik}$ = number of new cases of cancer j (male + female) in country i in 2009

Appendix F
Notes

(A) This report relies on a number of conventions in terminology. Throughout the text are references to types of cancers by *site* or *site-specific* cancers. In addition, the phrases *developing world* and *developed world* are widely used.

Types of cancers *by site* and *site-specific* cancers are used interchangeably to refer to the twenty-six specific cancers (for example, bladder, colorectal, leukaemia, oesophagus, etc.) and the "other sites" classification for which estimates of incidence and cost were calculated as part of this study.

Where *developing world* and *developed world* are used, the reference is to Income Group Classifications drawn from the World Bank's List of Economies (July 2009), which classifies all World Bank member economies, and all other economies with populations of more than 30,000 (See Appendix D). High income countries correspond to the developed countries—that is, the developed world. Low income, lower middle income and upper middle income countries combined as a single group correspond to the developing countries—that is, the developing world.

(B) The analyses reported herein rely on national estimates of cancer incidence and mortality prepared by IARC and reported in GLOBOCAN 2002. The IARC estimates rely, in turn, on incidence and mortality data recorded in cancer registry and vital registration systems. For many countries, these data are known to be incomplete or imperfect in other ways. For example, the degree of detail and quality of such data vary from high-quality nationally representative statistics in the Nordic countries to an absence of cancer incidence or mortality data in several developing countries (such as Afghanistan, Madagascar and Ghana). Statistical models are used by IARC to address the gaps in the underlying data. IARC relies on five categories of methods to arrive at estimates of cancer incidence and mortality, which are based on the best available country-level data. The choice of model depends on the degree of detail and accuracy of available data. Notwithstanding IARC's procedures, there are reasons to believe that in countries without reliable and nationally-representative incidence and mortality data, the number of cases is underestimated, although the magnitude is unknown. [1, 2, 3, 4, 5]

(C) Our aggregate cost estimates rely on data on the per case medical and non-medical costs of addressing each type of cancer, irrespective of time since initial diagnosis. We assume that the underlying cost data provide accurate measures of the corresponding per case medical and non-medical costs for cancer cases diagnosed in the preceding year. This assumption is based on evidence that cancer costs fall as one proceeds from the initial to the continuing treatment phase, and then rise as one proceeds from the continuing to the terminal treatment phase (see Brown et al., 2002; Warren et al, 2008). Further support for our assumption is derived from a comparison of data reported in Warren et al, 2008 and Kim et al, 2008 on the cost of treating lung cancer and breast cancer among recently diagnosed cases and cases not restricted in that manner.

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Appendix G
Multiple regression analyses

The cancer incidence and case fatality rates exhibit considerable variation across countries and cancer sites. To gain a better understanding of the patterns in these two cancer indicators, we conduct a multiple regression analysis (ordinary least squares) in which we try to account for cross-country variation in cancer incidence rates and case fatality rates. There are two dependent variables for each cancer site as well as for "all sites":

- Cancer incidence rate (males and females combined)
- Case fatality rate (males and females combined)

[Note that for the "Female-Only" cancers (Breast, Cervix, Corpus Uteri, and Ovary), we report Female Incidence Rate regressions and Case Fatality Rate regressions; for the "Male-Only" cancers (Prostate and Testis), we report Male Incidence Rate and Male Case Fatality Rate regressions.]

The explanatory variables are as follows:

- Per capita income in 2008 (data from the World Bank's *World Development Indicators*, with two dummies to correct for missing or earlier year per capita income data.)
- Per cent of population ages 65+ (data from UN Population Division for 2009)
- Region dummies (using IARC taxonomy, with Melanesia, Micronesia and Polynesia treated as one region, and Australia and New Zealand treated as the reference category/omitted region)

The regressions are based on all the IARC data. All of the incidence regressions are based on 172 country observations. Many of the case fatality regressions are based on smaller country samples (due to missing mortality data).

Incidence Rate Regressions:

- An EXPECTED PATTERN of higher per capita income countries having higher incidence rates is generally observed. One reason this pattern is expected is because there is believed to be underreporting of cancer cases in developing countries. There are, however, a few notable exceptions—Cervix and Larynx being the two significant and negative results. Presumably the Cervix result is because of more pap smears with early detection of cell changes in higher-income countries. The Larynx result might be related to smoking, which is a risk factor for this form of cancer, though we do not see the same pattern in the lung cancer data. Larynx cancer is also caused by the same virus that causes a form of cervical cancer—HPV16—so perhaps oral sex is the common risk factor that explains the qualitatively similar results involving cervix and larynx cancer. The literature on cancer epidemiology also reveals that the Cervix and the Larynx have similar cell biology.
- An EXPECTED PATTERN of older populations having higher cancer incidence rates is generally observed, but with a few exceptions—Cervix and Liver being the two significant and negative results. The fact that cervical cancer tends to declare itself in middle age may explain that result. The liver cancer result is more puzzling but may be connected with Hepatitis B and Hepatitis C—both of which are major risk factors for liver cancer. Hepatitis B, the more common of the two, is vaccine preventable.
- The regional dummies show some very interesting patterns. Generally, it appears that the US and Canada (Northern America) are comparable in incidence rates to Australia and New Zealand with two notable exceptions: Colorectal cancer and Melanoma exhibit lower incidence rates in Northern America, while Lung and Uterus cancer exhibit higher incidence rates in Northern America.

- ☐ The Colorectal difference is not due to differential meat consumption in Northern America vs. Australia. It may reflect differential screening (the US is a world leader in colonscopy) and early detection.
- ☐ The Melanoma differential presumably reflects a more protective ozone layer in Northern America and the fact that UV radiation naturally reaches greater peaks during summertime in the Southern hemisphere. In addition, New Zealanders may have skin characteristics that make them more susceptible to sunburn.
- ☐ The Lung cancer differential might be reflective of higher smoking rates and pollution levels.
- ☐ The Uterus cancer differential does not have an obvious explanation (risk factors are obesity, age>50, taking estrogen or other female hormones, family history, and use of tamoxifen for the treatment of breast cancer).

Case Fatality Rate Regressions:

- An EXPECTED PATTERN of higher per capita income countries having lower-case fatality rates is generally observed, with no significant positive exceptions.
- The one possibly counter-intuitive result is the pattern between the case fatality rate and the proportion of older people. It appears that an "aging" population tends to have lower-case fatality rates. Perhaps this reflects lower rates of cell multiplication at older ages. It may also reflect greater political support among older populations for the treatment of cancer.

Incidence rate regressions

DEPENDENT VARIABLE:		Incidence Rate																					
INDEPENDENT VARIABLE:	n	Per Capita Income 2008	Pct.of Pop. 65 plus	Regional Dummies - Australia/New Zealand is omitted																			
				Caribbean	Central America	Eastern Africa	Eastern Asia	Eastern Europe	Mela/ Micro/ Polynesia	Middle Africa	Northern Africa	Northern America	Northern Europe	South America	South Central Asia	South Eastern Asia	Southern Africa	Southern Europe	Western Africa	Western Asia	Western Europe		
CANCER SITE		Coefficient	t_Stat	Coefficient	t_Stat	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
All Sites	172	0.001457	3.05	702.96	3.55	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-		sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-
Bladder	172	0.000101	2.34	57.63	3.22				sig-		sig-												
Brain Cancers	172	0.000002	0.11	7.78	1.19	sig-	sig-	sig-	sig-		sig-	sig-	sig-			sig-	sig-	sig-	sig-		sig-	sig-	
Breast (1)	172	0.000393	4.52	183.03	5.09	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-		sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-
Cervix (1)	172	-0.000220	-3.00	-76.96	-2.53	sig+		sig+								sig+			sig+				
Colorectal	172	0.000501	6.59	170.64	5.42	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-
Corpus uteri (1)	172	0.000007	0.34	33.79	3.93				sig-			sig-	sig-	sig+				sig-	sig-		sig-		
Hodgkin's Lymphoma	172	-0.000001	-0.07	-4.49	-1.21			sig-	sig-		sig-	sig-						sig-	sig-		sig-		
Kaposi	172	-0.000019	-0.19	-20.74	-0.51			sig+				sig+							sig+				
Kidney	172	0.000020	0.83	43.26	4.37	sig-	sig-	sig-	sig-		sig-	sig-	sig-			sig-	sig-	sig-	sig-	sig-	sig-	sig-	
Larynx	172	-0.000075	-3.45	18.67	2.07					sig+										sig+			sig+
Leukaemia	172	0.000042	2.20	12.61	1.59	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-		sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-
Liver	172	-0.000106	-0.92	-108.88	-2.28				sig+														
Lung	172	-0.000004	-0.03	189.48	4.47	sig-	sig-	sig-				sig-	sig-	sig+					sig-		sig-		
Melanoma	172	0.000150	5.36	-0.65	-0.06	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-
Multiple Myeloma	172	0.000046	4.88	7.31	1.87	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-		sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-
Nasopharynx	172	0.000045	2.72	-8.55	-1.25								sig+					sig+					
non-Hodgkin Lymphoma	172	0.000139	5.62	5.49	0.54	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-		sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-
Oesophagus	172	-0.000012	-0.23	-39.92	-1.90			sig+	sig+														
Oral Cavity	172	-0.000027	-0.47	-0.04	0.00																		
Other Pharynx	172	0.000004	0.19	2.70	0.30																		sig+
Ovary (1)	172	0.000020	1.28	13.86	2.19	sig-			sig-			sig-	sig-						sig-		sig-	sig-	
Pancreas	172	0.000027	1.35	40.28	4.85								sig-						sig-		sig-		
Prostate (2)	172	0.000490	5.34	58.13	1.53		sig-	sig-	sig-	sig-	sig-	sig-	sig-		sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-	sig-
Stomach	172	-0.000159	-1.66	67.11	1.69		sig+		sig+							sig+							
Testis (2)	172	0.000047	4.80	8.20	2.04	sig-	sig-	sig-	sig-		sig-	sig-	sig-				sig-	sig-	sig-		sig-	sig-	
Thyroid	172	0.000029	1.45	1.97	0.24			sig-				sig-	sig-						sig-		sig-		

(1) Regression Results reported for regressions of female incidence rate on the independent variables listed above.

(2) Regression Results reported for regressions of male incidence rate on the independent variables listed above.

There are 2 additional independent variables not shown above. (1) pcia08_miss - a dummy that takes a value of 1 if a country's per capita income was not available (for 2008 or even an earlier year). Such countries were assigned the average per capita income for countries in their income group. (2) pcia08_early - a dummy that takes a value of 1 if the per capita income reported for the country was from 2007 or 2006.

Case fatality rate regressions

DEPENDENT VARIABLE:		Case Fatality Rate																					
INDEPENDENT VARIABLE:	n	Per Capita Income 2008	Pct.of Pop. 65 plus	Regional Dummies - Australia/New Zealand is omitted																			
				Caribbean	Central America	Eastern Africa	Eastern Asia	Eastern Europe	Mela/ Micro/ Polynesia	Middle Africa	Northern Africa	Northern America	Northern Europe	South America	South Central Asia	South Eastern Asia	Southern Africa	Southern Europe	Western Africa	Western Asia	Western Europe		
CANCER SITE		Coefficient	t_Stat	Coefficient	t_Stat	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
All Sites	172	-0.000002	-4.77	-0.7051	-4.23	sig+	sig+	sig+	sig+	sig+	sig+	sig+	sig+		sig+	sig+	sig+	sig+	sig+	sig+	sig+	sig+	sig+
Bladder	168	-0.000002	-2.67	-0.3493	-0.97			sig+			sig+	sig+	sig+				sig+		sig+		sig+	sig+	
Brain Cancers	166	-0.000001	-1.45	-0.9186	-2.22																		
Breast (1)	172	-0.000002	-4.57	-0.6125	-3.16			sig+		sig+	sig+	sig+	sig+		sig+				sig+		sig+	sig+	
Cervix (1)	172	-0.000001	-1.92	-1.3347	-6.20			sig+		sig+	sig+	sig+	sig+		sig+			sig+	sig+		sig+		sig+
Colorectal	172	-0.000003	-4.72	-0.6288	-2.74			sig+		sig+		sig+	sig+		sig+				sig+		sig+	sig+	sig+
Corpus uteri (1)	172	-0.000001	-1.66	-0.2364	-0.74	sig+	sig+						sig+				sig+					sig+	
Hodgkin's Lymphoma	170	-0.000003	-2.81	-0.8939	-1.94	sig+						sig+	sig+										
Kaposi	45	-0.000007	-1.69	2.1856	1.37																		
Kidney	170	-0.000002	-3.38	-0.6327	-2.42			sig+			sig+		sig+		sig+		sig+	sig+	sig+		sig+	sig+	sig+
Larynx	164	-0.000003	-4.01	-0.0558	-0.20			sig+		sig+		sig+	sig+					sig+	sig+		sig+		
Leukaemia	172	-0.000001	-0.98	-0.4352	-1.56	sig+	sig+	sig+	sig+	sig+	sig+	sig+	sig+		sig+	sig+	sig+	sig+	sig+		sig+	sig+	
Liver	172	0.000002	1.16	-0.8354	-1.23	sig+	sig+								sig+	sig+							
Lung	172	0.000000	-0.82	-0.2084	-1.57									sig-									
Melanoma	164	-0.000004	-4.37	0.3144	0.92		sig+	sig+			sig+	sig+	sig+				sig+	sig+	sig+		sig+	sig+	
Multiple Myeloma	164	0.000001	0.95	0.1119	0.29	sig+	sig+	sig+			sig+	sig+	sig+			sig+	sig+	sig+	sig+		sig+		
Nasopharynx	162	0.000000	0.29	-0.3381	-0.83	sig+		sig+		sig+		sig+	sig+					sig+	sig+		sig+		
non-Hodgkin Lymphoma	172	-0.000002	-2.89	-0.6119	-2.41			sig+				sig+	sig+						sig+		sig+		
Oesophagus	170	0.000000	0.83	-0.4171	-2.32	sig+		sig+		sig+		sig+	sig+	sig+	sig+	sig+	sig+		sig+		sig+		
Oral Cavity	172	-0.000002	-2.75	-0.7578	-3.23	sig+	sig+	sig+	sig+	sig+	sig+	sig+	sig+		sig+	sig+	sig+	sig+	sig+		sig+	sig+	sig+
Other Pharynx	168	-0.000002	-2.05	-0.2755	-0.63			sig+		sig+	sig+	sig+	sig+		sig+	sig+		sig+	sig+		sig+	sig+	
Ovary (1)	172	0.000000	-0.47	-0.0750	-0.37			sig+				sig+	sig+						sig+		sig+		
Pancreas	171	0.000001	1.39	-0.1254	-0.33																		
Prostate (2)	172	-0.000003	-4.21	-0.2804	-1.01	sig+	sig+	sig+	sig+	sig+	sig+	sig+	sig+		sig+	sig+	sig+	sig+	sig+	sig+	sig+	sig+	sig+
Stomach	172	-0.000002	-3.56	-0.5821	-3.22			sig+	sig-			sig+	sig+		sig+				sig+		sig+		
Testis (2)	171	-0.000005	-4.59	-0.1665	-0.40			sig+			sig+	sig+	sig+				sig+		sig+		sig+	sig+	
Thyroid	171	-0.000002	-1.99	-1.4746	-3.81			sig+			sig+	sig+	sig+						sig+		sig+		sig+

(1) Regression Results reported for regressions of female case fatality rate on the independent variables listed above.

(2) Regression Results reported for regressions of male case fatality rate on the independent variables listed above.

There are 2 additional independent variables not shown above. (1) pcia08_miss - a dummy that takes a value of 1 if a country's per capita income was not available (for 2008 or even an earlier year). Such countries were assigned the average per capita income for countries in their income group. (2) pcia08_early - a dummy that takes a value of 1 if the per capita income reported for the country was from 2007 or 2006.

Appendix H
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