THE CANCER ATLAS

Third Edition

Ahmedin Jemal
Lindsey Torre
Isabelle Soerjomataram
Freddie Bray

American Cancer Society®

uicc
global cancer control
A MEMBERSHIP ORGANISATION
FIGHTING CANCER TOGETHER

International Agency for Research on Cancer
World Health Organization

Published by the American Cancer Society, Inc.
250 Williams Street
Atlanta, Georgia 30303 USA
www.cancer.org

ISBN 978-1-60443-265-7

Printed in the United States of America.

This edition was printed by OneTouchPoint.

Library of Congress Control Number:2019949680

Managing Editor: John M. Daniel
Editorial Coordinator: Rabia Khan

Suggested Citation:
Jemal A, Torre L, Soerjomataram I, Bray F (Eds). *The Cancer Atlas*. Third Ed. Atlanta, GA: American Cancer Society, 2019. Also available at: www.cancer.org/canceratlas.

Design:
Language Dept. www.languagedept.com
526 W26th St., Studio 7B
New York, New York 10001 USA

The Cancer Atlas can be found online at www.cancer.org/canceratlas. The online version of the Atlas provides additional resources and information unique to the online interactive version.

THE CANCER ATLAS

Third Edition

Ahmedin Jemal
Lindsey Torre
Isabelle Soerjomataram
Freddie Bray

American Cancer Society®
uicc global cancer control
A MEMBERSHIP ORGANISATION FIGHTING CANCER TOGETHER
International Agency for Research on Cancer
World Health Organization

CONTENTS

What's New!

This fully updated edition presents the most recent cancer patterns and evidence on cancer prevention and control.

Use this cancer color guide to find data on the top global cancers throughout the book.

For the companion digital experience visit canceratlas.cancer.org

CANCER COLOR GUIDE

- Bladder
- Brain, central nervous system
- Breast
- Cervix
- Colorectum
- Esophagus
- Gallbladder
- Kaposi sarcoma
- Kidney
- Leukemia
- Lip, oral cavity
- Liver
- Lung
- Lymphoma
- Melanoma
- Non-Hodgkin lymphoma
- Ovary
- Pancreas
- Prostate
- Stomach
- Thyroid
- Uterus
- Other

PART ONE 16

RISK FACTORS

PART TWO 34

THE BURDEN

REGIONAL DIVERSITY

PART THREE 68

TAKING ACTION

*The findings and conclusions in this publication are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

APPENDIX

“

This much is clear: we simply must do better to ensure everyone can benefit from advances in the fight against cancer. As you will see in the pages of this *Cancer Atlas, Third Edition,* progress is not only possible, but also achievable.

— Gary Reedy

GARY REEDY

Chief Executive Officer, American Cancer Society

Over the last several decades, the world has seen incredible progress in the fight against cancer. Thanks to advances in cancer prevention, early detection, treatment, and support for those facing the disease, more people than ever before have reason to hope. For example, the cancer mortality rate in the United States has declined 27% since 1991, averting more than 2.6 million cancer deaths.

Despite extraordinary advances in what we know about cancer, not everyone has benefitted from this progress equally. Cancer is a growing burden among people living in low- and middle-income countries, and many people living in these areas cannot access the information or interventions that could save their lives. By 2040, considering only population growth and aging, the global cancer burden is expected to grow to 27.5 million new cancer cases per year, up from 17 million new cases in 2018. When we consider lifestyle factors such as smoking, unhealthy diet, and physical inactivity, the number of new cancer cases will likely be considerably larger.

This much is clear: we simply must do better to ensure everyone can benefit from advances in the fight against cancer. As you will see in the pages of this *Cancer Atlas, Third Edition,* progress is not only possible, but also achievable. For example, cervical cancer death rates have declined by 70% or more in many high-income countries that began prioritizing cervical cancer screening in the 1970s. This type of dramatic progress should not be limited to women living in high-income nations. Interventions such as HPV vaccination and cervical cancer screening can be implemented even in low-resource settings, where nearly nine out of 10 deaths from cervical cancer occur. Public and private sector leaders must work to ensure that women have access to screening and girls and boys have access to HPV vaccination. Tobacco control is another area of tremendous potential. Tobacco use remains the leading preventable cause of cancer deaths worldwide, and tobacco control remains vitally important to preventing cancer. We have the tools— taxation, smoke-free environments, restrictions on product marketing, graphic warning labels on packaging, and more—that are proven to reduce tobacco use and save millions of lives. But they can only work if leaders around the world prioritize, embrace, and implement them.

The American Cancer Society is proud to work with partners in the United States and around the globe to save lives, celebrate lives, and lead the fight for a world without cancer. Together with our 1.5 million volunteers, we convene partners to create awareness and impact; fund cancer research breakthroughs; build communities to support people facing cancer; and provide direction by empowering people with the information they need. In the USA, the American Cancer Society Cancer Action Network, our nonprofit, nonpartisan advocacy affiliate, works at the state and federal levels of government to ensure patients can obtain and maintain quality, affordable, and comprehensive health insurance that enables access to cancer care— from prevention through treatment. Globally, we collaborate with our partners to increase access to information that is relevant and culturally appropriate, as well as to increase access to prevention, early detection, treatment, and palliative care that is affordable and universally available. For example, the American Cancer Society collaborates with public and private sector partners to expand access to essential cancer treatment medications across sub-Saharan Africa to make high-quality treatment more affordable and accessible. Only by increasing access to care can we truly realize progress against cancer for all.

While we face great challenges in this work, we also have the proven interventions, dedicated global partners, and momentum we need to truly address the global cancer burden. This *Cancer Atlas, Third Edition* is an important source of information to help the global cancer community achieve our shared goal of a world without cancer. Working together with leaders around the world, we can ensure that recent progress does not stop, but instead accelerates and benefits everyone.

CARY ADAMS

Chief Executive Officer, Union for International Cancer Control

The last time I wrote a foreword for *The Cancer Atlas* was in 2014. I started by referencing the landmark High-Level Meeting (HLM) on Non-communicable Diseases (NCDs) which took place in September 2011 in New York. Since that first meeting, which confirmed the importance of cancer and other NCDs in the global health agenda, there have been new milestones. NCDs have been debated at two further HLMs (2014 and 2018) and, through the concerted advocacy efforts of the cancer and NCD communities, a target to reduce premature deaths caused by NCDs was included in the Sustainable Development Goals (SDGs) adopted in September 2015 by the UN General Assembly. On top of the "25 by 25" target of the Global Action Plan on NCDs, we now have global commitments to reduce premature deaths caused by NCDs by one third by 2030.

At the same time, The Union for International Cancer Control (UICC) and its members around the world advocated for an updated resolution on cancer to guide Member States on the steps they should take to improve cancer control in their own countries. Member States welcomed this view and adopted a Cancer Resolution (70.12) at the 70th session of the World Health Assembly (WHA) in 2017, once more signalling the need to place cancer as a priority in all national health plans. These efforts over the last years appear to be working. In research conducted by UICC with the World Health Organisation, NCI, and other partners in late 2017, we discovered that the number of countries with operational cancer plans had increased from 66% in 2013 to 81%—a significant improvement. This progress increases our confidence that 2030 will indeed see more cancers prevented, detected early, and treated successfully.

As I write this piece, the health community is preparing for a HLM on Universal Health Coverage in New York in September 2019. It is imperative that cancer features in that discussion and that countries re-confirm their commitment to improve cancer control globally. Such a commitment on the back of three HLMs on NCDs and the WHA Cancer Resolution will provide the impetus to significantly gear up national responses as we enter what we hope will be a decade of action.

The UICC and its 1100 members in 170 countries continue to press for national action to ensure that the global wins we have secured are properly followed through by national governments. The International Agency for Research on Cancer (IARC) forecasts an increasing cancer burden, primarily due to the aging and growing world population, and that this burden will fall on parts of the world least able to cope with the increase. We will ensure that governments take tobacco control seriously, encourage healthy behaviors, implement vaccination and screening programs, improve cancer registries, and invest in the infrastructure required to treat the most common cancers.

The Cancer Atlas has proved to be an outstanding publication in the past, helping the cancer community communicate the progress we have or have not made, the challenges we face and the areas of focus for future years. Its beautifully crafted presentations of facts and evidence help us construct compelling messages to better articulate the problem and present solutions. This new edition will once again be circulated widely and inspire those of us who want to see change happen.

We all know that there is much to do. The next decade will test the tenacity of the community as we press for change, helping governments fulfil the promise of their global commitments to cancer control. *The Cancer Atlas* is a key resource for researchers, advocates, patients and cancer planners. My thanks to ACS, IARC and the many others who have contributed to such a wonderful resource for our community.

The next decade will test the tenacity of the community as we press for change, helping governments fulfill the promise of their global commitments to cancer control. The Cancer Atlas *is a key resource for researchers, advocates, patients and cancer planners.*

ELISABETE WEIDERPASS

Director, International Agency for Research on Cancer

Cancer is an issue of sustainable development. It is associated with high morbidity, disability, and mortality, and thus places an overwhelming social and economic burden on individuals, communities, and societies. The global burden of cancer is increasing, due to demographic transitions and changes in exposures to risk factors as a result of globalization. In 2018, there were estimated to be more than 17 million new cases of cancer and more than 9 million deaths from cancer worldwide, and about 70% of all cancer deaths occurred in low- and middle-income countries.

Cancer can be treated, but better still, it can be prevented. The cost of treating patients is ballooning, while at least 40% of all cancer cases could be prevented based on current knowledge, by minimizing exposure to risk factors and implementing effective prevention strategies. Cancer mortality can also be reduced through early detection and adequate, affordable, and timely treatment. Apart from economic considerations—prevention is much more cost-effective than treatment alone— a major advantage of prevention lies in the avoidance of suffering altogether.

The International Agency for Research on Cancer (IARC), the specialized cancer agency of the World Health Organization (WHO), has a pivotal role in the production and evaluation of knowledge for cancer prevention worldwide, to guide the formulation of global policies of high public health relevance to fight against cancer. IARC's overarching objectives are to ensure leadership on interdisciplinary cancer prevention research for the public good, to promote international collaboration, and to contribute to the capacity-building of the international scientific community in cancer prevention research, with the ultimate goal of tackling the global cancer burden. Through a closely interwoven network of collaborations, IARC plays its part in cancer prevention in support of WHO programs in the countries that are most in need.

Building on the success of the second edition of *The Cancer Atlas*, published in 2014, this third edition along with its website provides an accessible, easily manageable, and comprehensive state-of-the-art resource to shape strategies for cancer prevention. *The Cancer Atlas* presents a global overview of the latest available data on cancer burden and trends—notably drawing on the IARC Global Cancer Observatory—as well as the associated risk factors and measures of cancer prevention and control that have been proven to be effective. The publication is targeted at cancer researchers, public health professionals and advocates, governments, and society as a whole.

Facing the cancer problem is a prerequisite for addressing social and economic inequities, stimulating economic growth, and accelerating sustainable development. I hope that this book will find widespread use, because prevention is, and should continue to be, the first line of attack in tackling the challenges posed by the global cancer epidemic.

Facing the cancer problem is a prerequisite for addressing social and economic inequities, stimulating economic growth, and accelerating sustainable development. I hope that this book will find widespread use, because prevention is, and should continue to be, the first line of attack in tackling the challenges posed by the global cancer epidemic.

AHMEDIN JEMAL

Dr. Jemal is the Scientific Vice President of the Surveillance & Health Services Research Program at the American Cancer Society. He also holds an appointment as adjunct Professor of Epidemiology at the Rollins School of Public Health, Emory University. Dr. Jemal's principal research interests include cancer disparities and the social determinants of health and health services and outcomes research. His main goal at the American Cancer Society has been to build a strong team of cancer surveillance and health services researchers to promote the application of evidence-based cancer prevention and control in the USA and worldwide. Dr. Jemal has published more than 350 articles in peer-reviewed journals.

LINDSEY TORRE

Ms. Torre is an epidemiologist in the Surveillance and Health Services Research group at the American Cancer Society. She concentrates on global cancer surveillance and has authored over 20 peer-reviewed publications, including book chapters and American Cancer Society service publications. She is the lead author of Global Cancer Facts & Figures, 3rd and 4th editions, an editor of *The Cancer Atlas, Second* and *Third Edition*, and a contributor to the annual American Cancer Society Facts & Figures publication. She also conducts and collaborates on research focused on global cancer control, with particular emphasis on risk factors, disparities, and cancer in women.

Ms. Torre received a BS in International Political Economy from Georgetown University and an MSPH in Global Epidemiology from the Rollins School of Public Health, Emory University.

ISABELLE SOERJOMATARAM

Dr. Soerjomataram is Deputy Head of the Section of Cancer Surveillance at the International Agency for Research on Cancer (IARC). She is a medical epidemiologist with a special interest in prevention of cancer and improving cancer outcomes. She took a position at IARC in 2011, where she is currently assessing international variation in the cancer burden and survival using mainly population-based datasets and how policy can mitigate the rising burden of cancer.

In addition to her research activities, she is co-coordinating several large projects. One seminal project involving over than 60 experts in France estimates the proportion of cancer attributable to known lifestyle and environmental risk factors. She is also leading global estimation of attributable fractions for cancers related to various risk factors. In addition, she leads cancer survival projects in high-, and low-, and middle-income settings assessing the effectiveness of the local health system as well as influence of major risk factors such as obesity.

FREDDIE BRAY

Dr. Bray is Head of the Cancer Surveillance Section at the International Agency for Research on Cancer (IARC) in Lyon, France. His areas of research revolve around the descriptive epidemiology of cancer, including the estimation of the global cancer burden and the analysis of time trends of cancer including predictions of the future scale and profile of cancer globally linked to human development transitions.

In support of the overwhelming need for high quality cancer surveillance systems given their current paucity and an ever-increasing cancer problem, Dr. Bray leads the Global Initiative for Cancer Registration (*http://gicr.iarc.fr*), an international multi-partner program designed to ensure a sustainable expansion of the coverage and quality of population-based cancer registries in low- and middle-income countries through tailored, localized support and advocacy to individual countries.

The editors of *The Cancer Atlas, Third Edition* would like to thank the American Cancer Society and the International Agency for Research on Cancer for their support of this edition. We would also like to thank the Union for International Cancer Control for its generous support of the dissemination of this edition.

Many individuals have donated their time and expertise in the preparation of the *Atlas*. In particular, we would like to thank Rabia Khan at the American Cancer Society for invaluable logistical and editorial support, and Mathieu Laversanne at the International Agency for Research on Cancer for supplying datasets and analytical support. For their individual contributions to the *Atlas*, we would like to thank Shacquel Woodhouse, Vanika Jordan, Kimberly D. Miller, Ann Goding Sauer, Ka Kit Liu, Liora Sahar, Katina Lett, Qiana Davis, Blake Sanders, Kenny Oxley, Lorraine McCawley, Luke Ndekhedehe, Kathy Pourmehr, and Derek Ricard at the American Cancer Society.

We would also like to express our deep appreciation for our authors and peer reviewers. Our peer reviewers include:

- **Ben Anderson,** University of Washington, Department of Surgery
- **Carmen Audera-Lopez,** World Health Organization
- **Afsan Bhadelia,** Harvard School of Public Health, Health Systems Group
- **Graham Colditz,** Washington University Institute for Public Health and School of Medicine
- **Sally Cowal,** American Cancer Society
- **Susan Devesa,** National Cancer Institute
- **Paul Dickman,** Karolinska Institutet, Department of Medical Epidemiology and Biostatistics
- **Paul Doria-Rose,** National Cancer Institute (USA)
- **Brenda Edwards,** National Cancer Institute (USA)
- **Michael Eriksen,** Georgia State University, School of Public Health
- **Silvia Franceschi,** International Agency for Research on Cancer
- **Patricia Ganz,** University of California - Los Angeles, School of Public Health
- **Sumit Gupta,** University of Toronto, Institute of Health Policy, Management and Evaluation
- **Rolando Herrero Acosta,** International Agency for Research on Cancer
- **Andre Ilbawi,** World Health Organization
- **Mazda Jenab,** International Agency for Research on Cancer
- **Sonali Johnson,** Union for International Cancer Control
- **Tim Key,** University of Oxford, Cancer Epidemiology Unit
- **Bart Kiemeney,** Radboud University, Cancer Epidemiology Group
- **Betsy Kohler,** North American Association of Central Cancer Registries
- **Martha Linet,** National Cancer Institute (USA)
- **Joe Lipscomb,** Emory University, Winship Cancer Institute
- **Loraine D. Marrett,** University of Toronto, School of Public Health
- **Franco Merletti,** University of Turin, Department of Medical Sciences – Cancer Epidemiology Unit
- **Max Parkin,** University of Oxford , African Cancer Registry Network
- **Neil Pearce,** London School of Hygiene and Tropical Medicine, Department of Non-communicable Disease Epidemiology
- **M.R. Rajagopal,** Pain and Palliative Care Clinic, Medical College, Calicut
- **Jonathan Samet,** University of Southern California, Institute for Global Health
- **Bernard Stewart,** University of New South Wales – Sydney, School of Women's and Children's Health
- **Robert Smith,** American Cancer Society
- **Julie Torode,** Union for International Cancer Control
- **David Whiteman,** QIMR Berghofer
- **Christopher Wild,** International Agency for Research on Cancer
- **Walter Willett,** Harvard University, School of Public Health
- **Martin Wiseman,** World Cancer Research Fund International
- **K. Robin Yabroff,** American Cancer Society

A number of individuals and organizations provided additional expertise on specific chapters:

- **Laia Bruni,** Catalan Institute of Oncology
- **Jeffrey Drope,** American Cancer Society
- **Robert Eckford,** Campaign for Tobacco Free Kids
- **Michal Stoklosa,** American Cancer Society
- **Cesar Victora,** Federal University of Pelotas, Brazil

Finally, for their diverse talents and design expertise, we would like to thank the team at Language Dept.: **Sarah Asip, Jenn Cash, Jesse Lankford, Jenna Park, Tanya Quick, Rachel Shim, Nikki Taliaferro,** and **Jada Vogt.**

THIRD EDITION

The Cancer Atlas aims to open readers' eyes to the facts and figures of cancer: the scale and magnitude globally, the major causes, and the different ways the disease can be prevented and treated. It is a comprehensive global overview that equally highlights the distinct patterns and inequities in the present cancer burden, the associated risk factors, and the prospects for cancer prevention and control.

This third edition unites these topics under the theme of "Access Creates Progress," drawing attention not only to the problem at hand, but also the means of tackling the cancer burden through access to information and services—addressing not only the immediate causes of cancer but also the underlying drivers of disease and disparities.

This third edition of *The Cancer Atlas* maintains the structure of the previous editions, with chapters grouped into three sections: Risk Factors, The Burden, and Taking Action.

The first section, **RISK FACTORS**, highlights regional and international variations in many of the major risk factors for cancer, including tobacco use, infections, excess body weight, and ultraviolet radiation. Tobacco smoking continues to be the predominant cause of cancer in most high-income countries, while infections still play a major role in many sub-Saharan African and Asian countries. The importance of excess body weight as a major risk factor for cancer continues to escalate in most parts of the world, including many economically transitioning countries.

The second section, **THE BURDEN**, describes the geographic diversity in cancer occurrence worldwide and, in separate chapters, for each of the major world regions. This burden is also described in terms of the national Human Development Index, the primary measure of a country's societal and economic development used in this book. Profiles of cancer survival and cancer survivorship are expanded in this third edition, and global cancer survival statistics are presented for the first time in print, while pressing issues such as the financial burden of cancer are highlighted. A new chapter on cancer in Indigenous populations describes the specific challenges facing these underserved populations around the world.

The final section, **TAKING ACTION**, describes major interventions across the cancer continuum, from the prevention of risk factors to early detection, treatment, and palliative care, highlighting disparities in the availability and implementation of these interventions across the world. It also portrays the multiple organizations working in cancer control and the importance of policies and legislation and building synergies between diseases and health systems for broad implementation of known interventions. In this edition, a new chapter on universal health care and "Access Creates Progress" text boxes in chapters throughout the book highlight successful strategies to address the cancer burden.

In summary, *The Cancer Atlas* is intended to deliver a rapid but comprehensive grasp of the global essentials of cancer. This book and its accompanying website *(canceratlas.cancer.org)* were carefully designed to ensure user-friendly, accessible, and downloadable descriptions and graphics can be easily used by cancer control advocates, government and private public health agencies, and policymakers, as well as patients, survivors and the general public. *The Cancer Atlas* is an illustrative guide to cancer's diversity and disparities, but also a positive vehicle for the promotion and delivery of cancer prevention and cancer control worldwide.

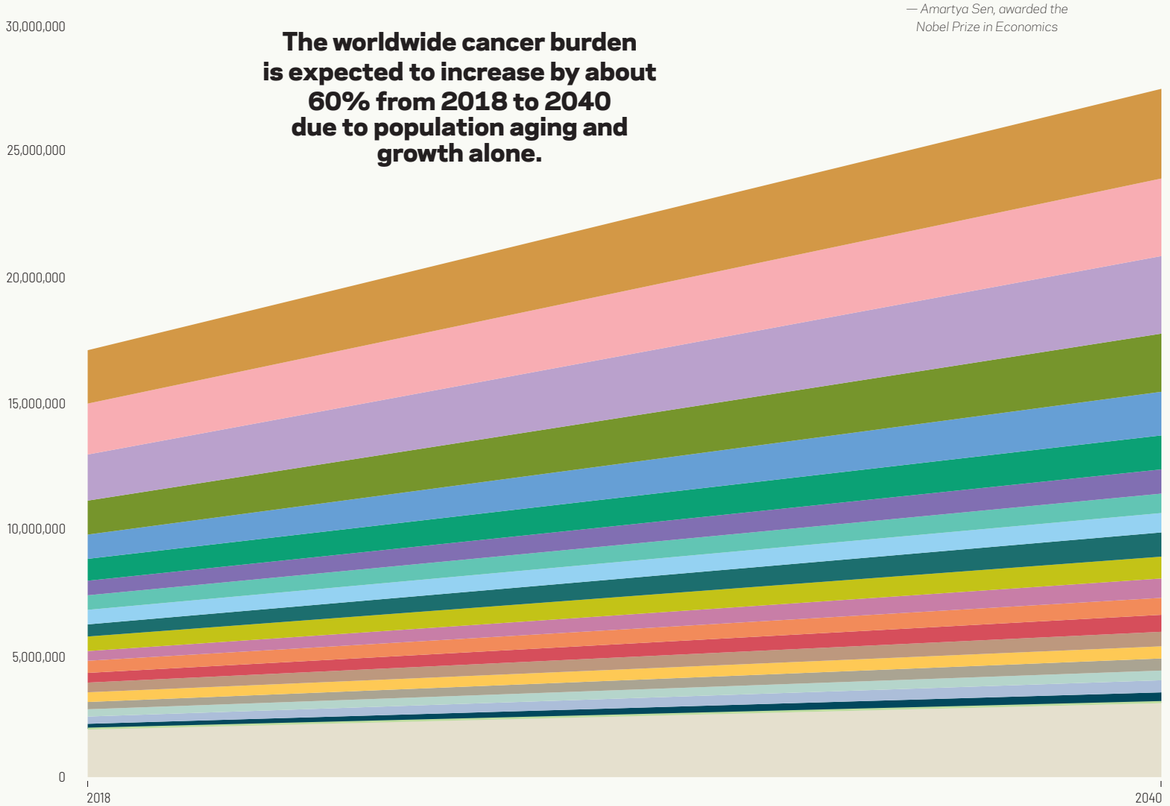
ACCESS CREATES PROGRESS

"

…a major difference can be made in the incidence, management, and [control] of cancer, even in the poorer countries of the world… [and] this can be done in cost-effective and affordable ways. Understanding and determination are the deficiencies most in need of change.

— Amartya Sen, awarded the Nobel Prize in Economics

Estimated increase in the number of cancer cases by site worldwide from 2018 to 2040



CANCER COLOR GUIDE

Lung	Liver	Non-Hodgkin lymphoma	Lip, oral cavity	Kaposi sarcoma
Breast	Esophagus	Pancreas	Brain, central nervous system	Other
Colorectum	Cervix	Leukemia	Ovary	
Prostate	Thyroid	Kidney	Melanoma	
Stomach	Bladder	Uterus	Gallbladder	

RISK FACTORS

This section describes the prevalence of major cancer risk factors around the world. Tobacco smoking remains the predominant cause of cancer in most high-income countries, while infections play a major role in many low-income countries.

There are still 1.1 billion smokers worldwide and tobacco causes more preventable cancer deaths than any other risk factor.

ACCESS CREATES PROGRESS

Progress in tobacco control legislation over the last decade means **1.5 billion people in 55 countries are now protected by smoke-free legislation.**

OVERVIEW OF RISK FACTORS

Many of the known risk factors for cancer can be prevented.

Tobacco use, infectious agents, unhealthy diet, excess body weight, physical inactivity, and alcohol consumption account for the majority of cancer deaths caused by known risk factors.

Smoking causes multiple cancer types (see *03, Tobacco*), and smokeless tobacco causes cancers of the oral cavity, esophagus, and pancreas. In 2017, smoking was responsible for an estimated 2.3 million cancer deaths globally (24% of all cancer deaths), with an additional 190,000 cancer deaths due to smokeless tobacco and secondhand smoke.

Infectious agents can cause a wide range of cancer types. **FIGURE 2.1** However, there is large variation across countries in the proportion of cancers caused by infectious agents, ranging from around 4% in many very high-income countries to more than 50% in several sub-Saharan African countries. As such, in many low-income countries infection-related cancers are a leading cause of cancer deaths (see *04, Infection*). **FIGURE 2.2**

Unhealthy diet, excess body weight, and physical inactivity cause multiple types of cancer (see *05, Diet and Nutrition*) and are emerging risk factors for cancer worldwide. The cancer burden associated with these risk factors is expected to grow in most parts of the world, particularly in parts of the Middle East and several other low- and middle-income countries in parts of Asia and Oceania because of the obesity epidemic. Further, alcohol drinking is responsible for 4.2% of all cancer deaths globally, with marked variation across countries. **MAP 2.1**

Other risk factors known to cause cancer include excessive exposure to ultraviolet radiation from the sun and indoor tanning, which cause skin cancer (see *06, UV Radiation*); some reproductive and hormonal factors (see *07, Reproductive and Hormonal Factors*); and occupational exposures to hazardous substances and environmental pollutants such as air pollution, arsenic, and aflatoxin. **FIGURE 2.3, 2.4** (see *08, Environmental Pollutants and Occupational Exposures*) The risk factors for cancer, however, are not limited to the above; for example, medical radiation and radiation from naturally-occurring high radon levels in residential places can cause cancer.

Infectious agents such as *H. pylori*, HPV, and hepatitis B and C viruses are responsible for a substantial proportion of cases for some cancer sites.

FIGURE 2.1 *Types of cancer caused by infectious agents*

INFECTIOUS AGENT	CANCER TYPE
Helicobacter pylori	Stomach
Human papillomavirus (HPV)	Genital organs (cervix, vulva, vagina, penis), anus, oral cavity, oropharynx, tonsil
Hepatitis B virus (HBV)	Hepatocellular carcinoma (liver)
Hepatitis C virus (HCV)	Hepatocellular carcinoma (liver), non-Hodgkin lymphoma
Epstein-Barr virus (EBV)	Nasopharynx, some types of lymphoma
Kaposi sarcoma herpes virus (KSHV)	Kaposi sarcoma, primary effusion lymphoma
Schistosoma haematobium	Urinary bladder
Clonorchis sinensis, Opisthorchis viverrini	Cholangiocarcinoma (bile ducts)
Human T-cell lymphotropic virus, type 1	Adult T-cell leukemia (blood) and lymphoma
Human immunodeficiency virus (HIV)*	Kaposi sarcoma, lymphoma, cervix, anus, conjunctiva of the eye

*Due to increased replication of oncogenic viruses (e.g., EBV and KSHV), mainly through immunosuppression.

FIGURE 2.2

Prevalence (%) of human papillomavirus (HPV) infection (all ages) and HPV vaccination (ages 10–20 years) among females by continent

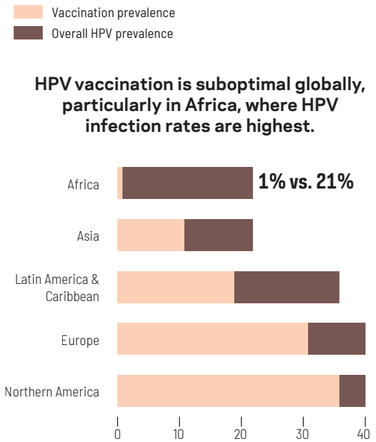
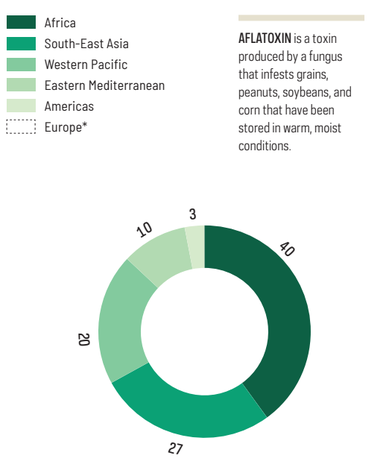


FIGURE 2.3

Distribution (%) of global aflatoxin-related liver cancer by WHO region



AFLATOXIN is a toxin produced by a fungus that infests grains, peanuts, soybeans, and corn that have been stored in warm, moist conditions.

*Zero percent of aflatoxin-related liver cancer in Europe

MAP 2.1

Proportion (%) of cancer deaths caused by alcohol drinking in men ages 15 years or older, 2016

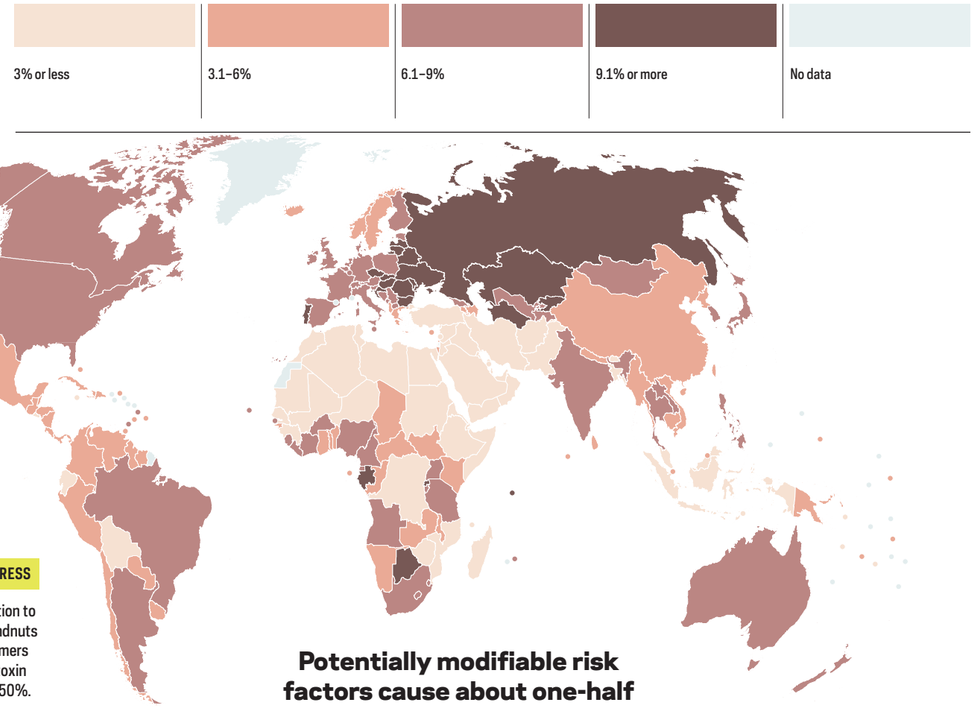
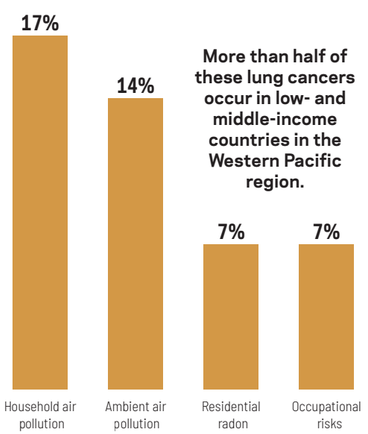


FIGURE 2.4

Proportion (%) of lung cancers caused by select environmental and occupational factors other than tobacco use worldwide



Note: Does not include tobacco use. Some cancers may be attributable to two or more risk factors.

THE EUROPEAN CODE AGAINST CANCER

ECAC is an initiative of the European Commission, developed by the World Health Organization's International Agency for Research on Cancer (IARC). The ECAC aims to inform people about actions they can take for themselves or their families to reduce their risk of cancer.

12 Ways To Reduce Your Cancer Risk

1. Do not smoke or use any form of tobacco.
2. Make your home smoke free. Support smoke-free policies in your workplace.
3. Take action to be a healthy body weight.
4. Be physically active. Limit the time you spend sitting.
5. Have a healthy diet:
   - *Eat plenty of whole grains, pulses, vegetables and fruits.*
   - *Limit foods high in sugar or fat (high-calorie) and avoid sugary drinks.*
   - *Avoid processed meat; limit red meat and foods high in salt.*
6. Limit alcohol consumption. Not drinking is better for cancer prevention.
7. Avoid too much sun. Use sun protection. Do not use sunbeds.
8. In the workplace, follow health and safety instructions to protect yourself from harmful substances.
9. Know if you are exposed to radiation from naturally high radon levels in your home. Take action to reduce high radon levels.
10. For women:
    - *If you can, breastfeed your baby.*
    - *Limit use of hormone replacement therapy.*
11. Ensure your children take part in vaccination programs for hepatitis B virus and human papillomavirus.
12. Take part in organized cancer screening programs for cancers of the bowel, female breast, and cervix.

RISKS OF TOBACCO

Tobacco use is the leading preventable cause of cancer worldwide. Fortunately, reductions in smoking yield large reductions in cancer incidence and mortality.

An estimated 1.3 billion people use tobacco products worldwide. The majority (about 1.1 billion) use smoked tobacco products, chiefly as manufactured or hand-rolled cigarettes. Other smoked products include pipes, cigars, bidi, hookah, and/or kreteks; smokeless products include snuff, chewing tobacco, and betel. Novel tobacco products, especially recently redesigned e-cigarettes, increasingly dominate tobacco use among youth in some high-income countries (HIC). FIGURE 3.1

Eighty percent of the world's smokers live in low and middle income countries (LMIC). The enormous global health and economic burden from tobacco use is increasingly borne by LMIC, due to population aging and the massive numbers of people who continue to smoke. Although smoking prevalence and per-capita consumption are decreasing worldwide, the rate of decrease is slower in LMIC than in HIC, and among women than men in HIC.

All smoked and traditional smokeless tobacco products cause cancer. Although lung cancer is the most common cancer caused by cigarette smoking, at least 19 other cancer sites or subsites are designated as causally related to smoking. FIGURE 3.2 Even this list may be incomplete, as it does not include breast cancer or advanced prostate cancer, two sites for which the evidence has been labeled suggestive but not conclusive. Cigar and pipe smoking cause cancers of the lung and upper aerodigestive tract, including the oral cavity, oropharynx, hypopharynx, larynx and esophagus; secondhand smoke causes lung cancer. Smoked tobacco products cause even more deaths from vascular and respiratory conditions than from cancer. Cessation of smoking dramatically reduces risks compared to continued smoking.

FIGURE 3.1

Cigarette and e-cigarette use (%) among high schoolers, United States, 2011–2018

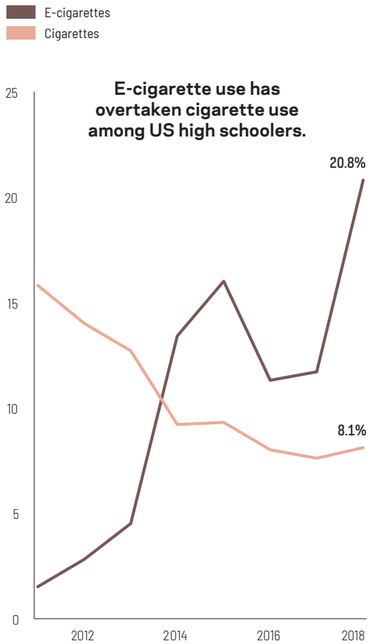
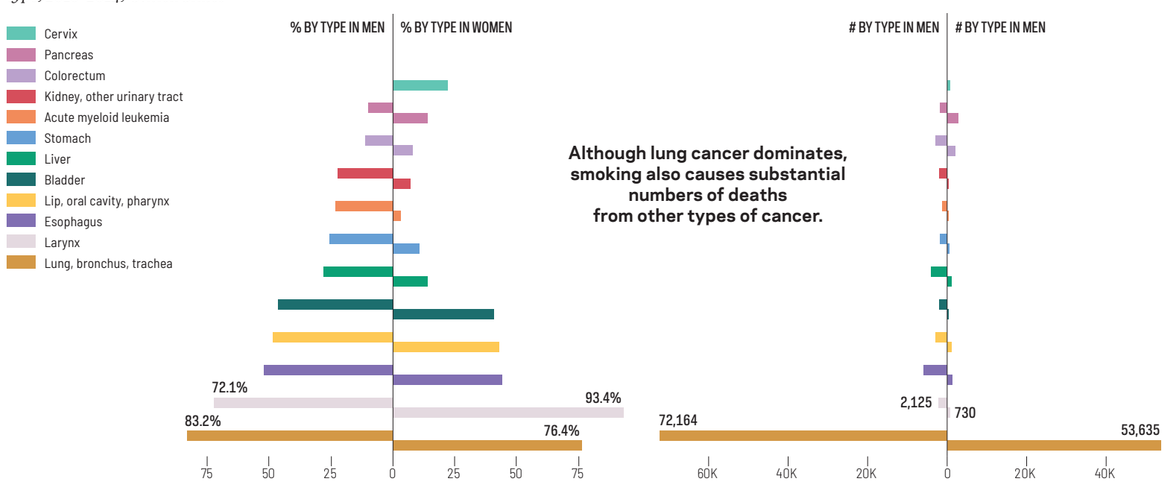


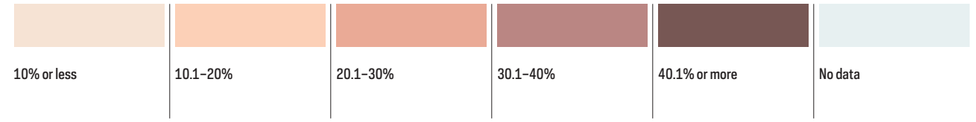
FIGURE 3.2

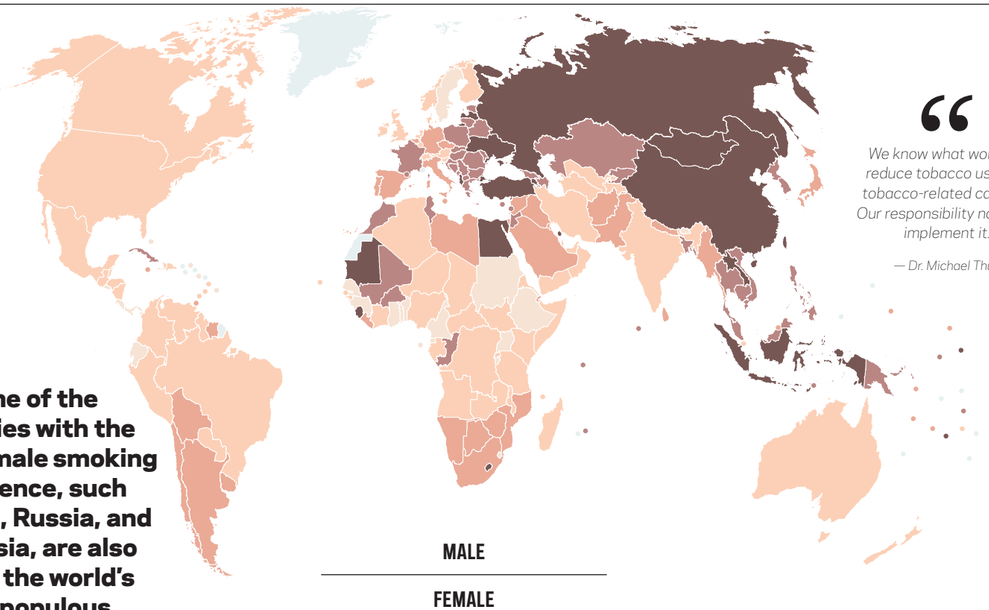
Annual smoking-attributable cancer deaths by type, 2010–2014, United States



MAP 3.1

Prevalence (%) of daily smoking for men and women

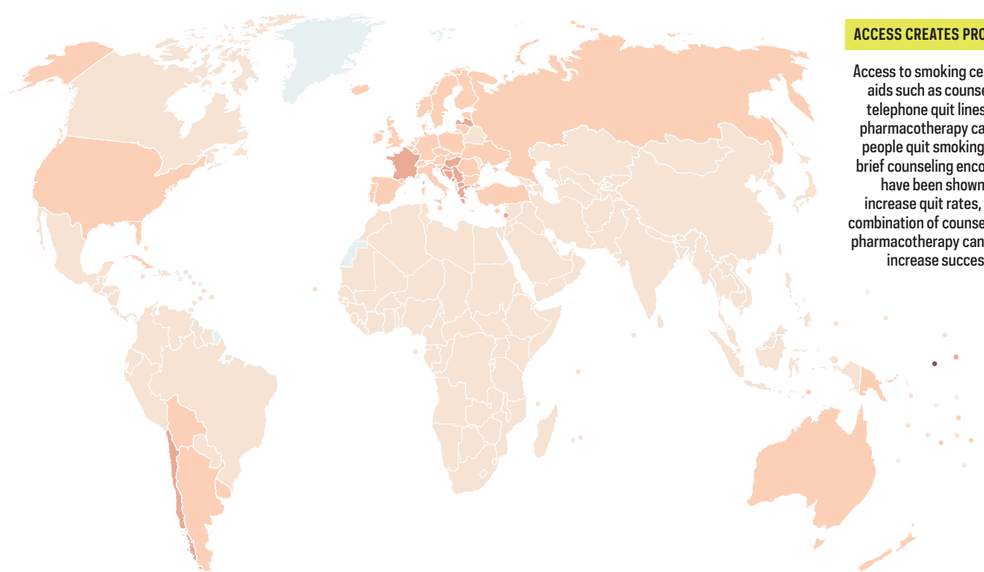




Some of the countries with the highest male smoking prevalence, such as China, Russia, and Indonesia, are also among the world's most populous.

"We know what works to reduce tobacco use and tobacco-related cancers. Our responsibility now is to implement it.

— Dr. Michael Thun



ACCESS CREATES PROGRESS

Access to smoking cessation aids such as counseling, telephone quit lines, and pharmacotherapy can help people quit smoking. Even brief counseling encounters have been shown to increase quit rates, and a combination of counseling and pharmacotherapy can further increase success.

INFECTION

Infections are an important cause of many cancers worldwide, especially in economically transitioning countries.

Infectious agents are responsible for an estimated 15% of all new cancer cases annually worldwide, of which two-thirds occur in less developed countries (where they account for up to one quarter of all cancer). **FIGURE 4.1** The four most important cancer-causing infections worldwide are *Helicobacter pylori* (770,000 cases globally in 2012), human papillomavirus (HPV) (640,000), hepatitis B virus (HBV) (420,000), and hepatitis C virus (HCV) (170,000), which together account for more than 90% of all infection-related cancers. **FIGURE 4.2** *Helicobacter pylori* causes 90% of stomach cancers, half of which occur in China alone. HPV infection is a necessary cause of cervical cancer, which is the leading cause of cancer death among women in many less-developed regions of the world because of lack of screening. HPV infection is also responsible for a proportion of vulvar (25%), vaginal (78%), anal (88%), penile (50%), oropharyngeal (31% on average, but much higher in North America and Northern Europe), oral cavity (2.2%) and laryngeal cancer (2.4%). **FIGURE 4.3**

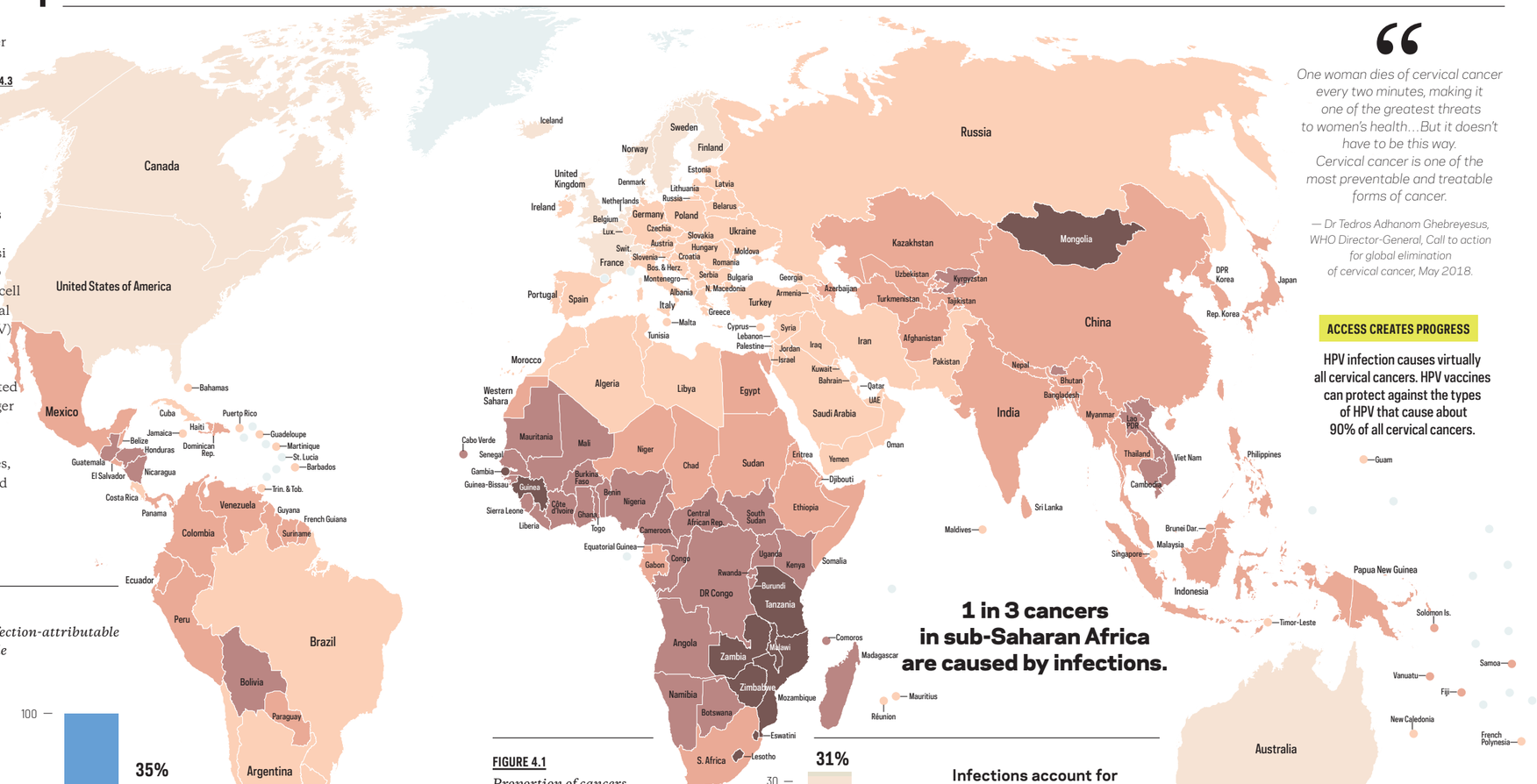
Worldwide, HBV and HCV infections account for 56% and 20% of liver cancer deaths, respectively. However, these proportions substantially vary by region, with HBV the predominant cause of liver cancer in less developed countries (2/3 of cases) and HCV in more developed settings (44%). Other infections that cause cancer include Epstein-Barr virus (120,000 cases, estimated conservatively), Kaposi sarcoma-associated herpesvirus (HHV-8; 40,000 cases, mainly in sub-Saharan Africa), human T-cell lymphotropic virus, liver flukes, and schistosomal infections. Human immunodeficiency virus (HIV) infection also indirectly causes infection-related cancers through immunodepression. In the US, for instance, the proportion of infection-associated cancer in people with HIV (40%) is 10 times larger than in the general US population (4%).

Powerful prevention tools exist for infection-related cancer, including HPV and HBV vaccines, screening for HPV-driven cervical precancer, and drugs to treat HBV, HCV, *Helicobacter pylori*, and HIV infections.

MAP 4.1

Proportion of cancers attributable to infections (%), by country

5.0% or less | 5.1–15% | 15.1–25% | 25.1–40% | 40.1% or more | No data



1 in 3 cancers in sub-Saharan Africa are caused by infections.

> *One woman dies of cervical cancer every two minutes, making it one of the greatest threats to women's health…But it doesn't have to be this way. Cervical cancer is one of the most preventable and treatable forms of cancer.*
>
> *— Dr Tedros Adhanom Ghebreyesus, WHO Director-General, Call to action for global elimination of cervical cancer, May 2018.*

ACCESS CREATES PROGRESS

HPV infection causes virtually all cervical cancers. HPV vaccines can protect against the types of HPV that cause about 90% of all cervical cancers.

FIGURE 4.2

Leading cancer-causing infections worldwide, by sex (%)

Human papillomavirus
Helicobacter pylori
Hepatitis B virus
Hepatitis C virus
Other agents

Human papillomavirus, *Helicobacter pylori*, and Hepatitis B and C viruses account for the majority of infection-related cancers worldwide.

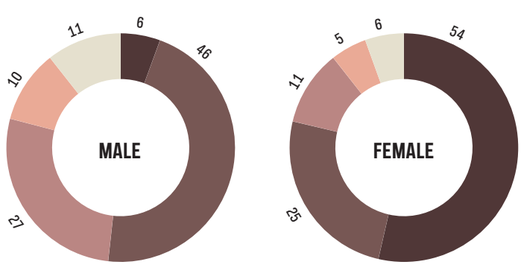
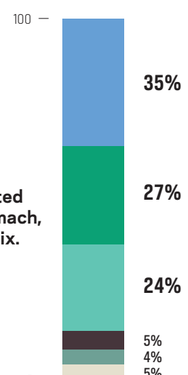


FIGURE 4.3

Most common infection-attributable cancers worldwide

Stomach
Liver
Cervix
Head and neck
Other anogenital
Other



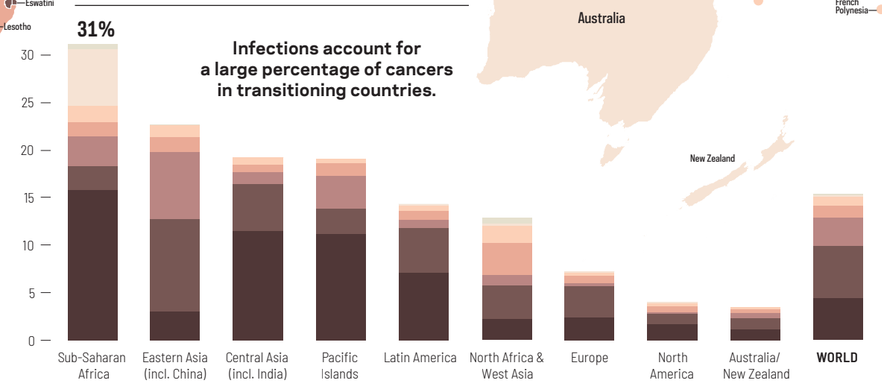
The main infection-related cancers are stomach, liver, and cervix.

FIGURE 4.1

Proportion of cancers attributable to infections (%), by agent and region

Other agents
Human herpes virus-8
Epstein-Barr virus
Hepatitis C virus
Hepatitis B virus
Helicobacter pylori
Human papillomavirus

Infections account for a large percentage of cancers in transitioning countries.



BODY WEIGHT, PHYSICAL ACTIVITY, DIET & ALCOHOL

Excess body weight, alcohol consumption, unhealthy diet and physical inactivity are important modifiable cancer risk factors.

Excess body weight (i.e., overweight and obesity) increases risk of 13 types of cancer, and in 2012 accounted for 3.6% of all new cancer cases among adults worldwide. The global prevalence of excess body weight has increased: in 2016 an estimated 39% of men and 40% of women aged 18 years and older, and 27% of boys and 24% of girls aged 5–18 years, were obese. **MAP 5.1** High amounts of sugar-sweetened beverages, and sedentary behaviors, including screen-time, increase risk of excess body weight, whereas aerobic physical activity, including walking, reduces risk. **FIGURE 5.1**

Alcohol consumption is known to cause cancers of the oral cavity, pharynx, larynx, esophagus, liver, colon, rectum, and female breast. Worldwide, in 2016, 4.2% of cancer deaths were attributed to alcohol consumption. **FIGURE 5.2**

Independent of effects on body weight, a healthy dietary pattern rich in plant foods, including fruits, non-starchy vegetables, whole grains, and legumes (e.g., beans), and low in red and processed meats, reduces risk of certain cancers, particularly colorectal cancer.

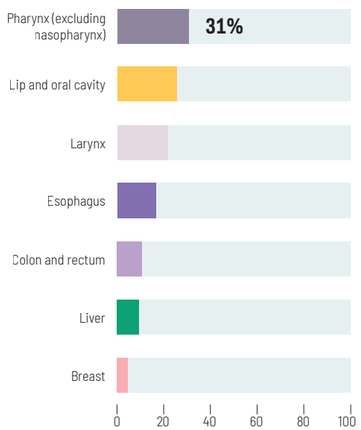
Independent of effects on body weight, physical activity reduces risk of some types of cancer, specifically colon, and among women, breast and endometrial cancer. Globally, 23% of adults did not meet World Health Organization physical activity guidelines in 2010, and more than 80% of adolescents were insufficiently physically active.

Reversing the obesity epidemic, limiting alcohol consumption (among those who drink), and increasing the prevalence of healthy eating and active living hold considerable potential for reducing cancer incidence and mortality, which will require a comprehensive approach involving actions by institutions and individuals at all levels from national to local communities.

> *Movement is a medicine for creating change in a person's physical, emotional, and mental states.*
>
> *— Carol Welch, biosomatics instructor.*

FIGURE 5.2

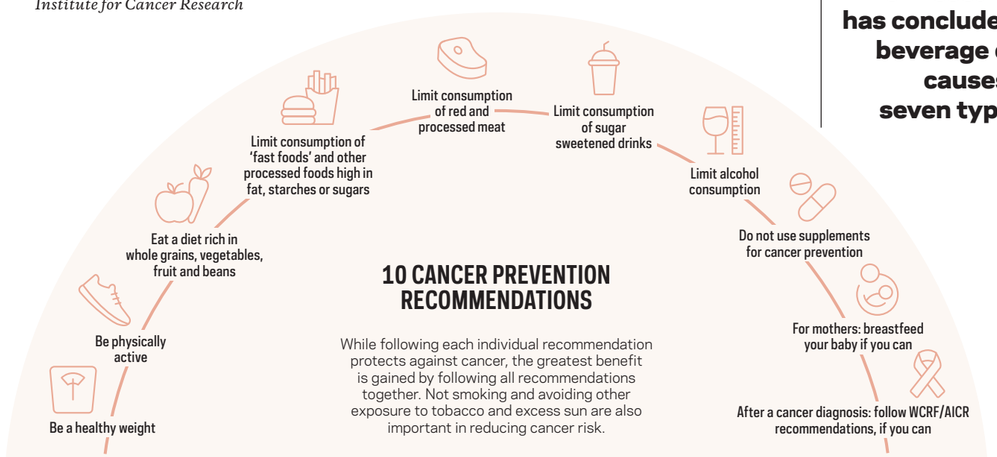
Proportion of cancer deaths attributable to alcohol (%) by site, 2016



The International Agency for Research on Cancer has concluded that alcoholic beverage consumption causes at least seven types of cancer.

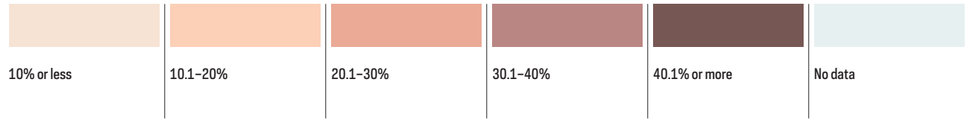
FIGURE 5.1

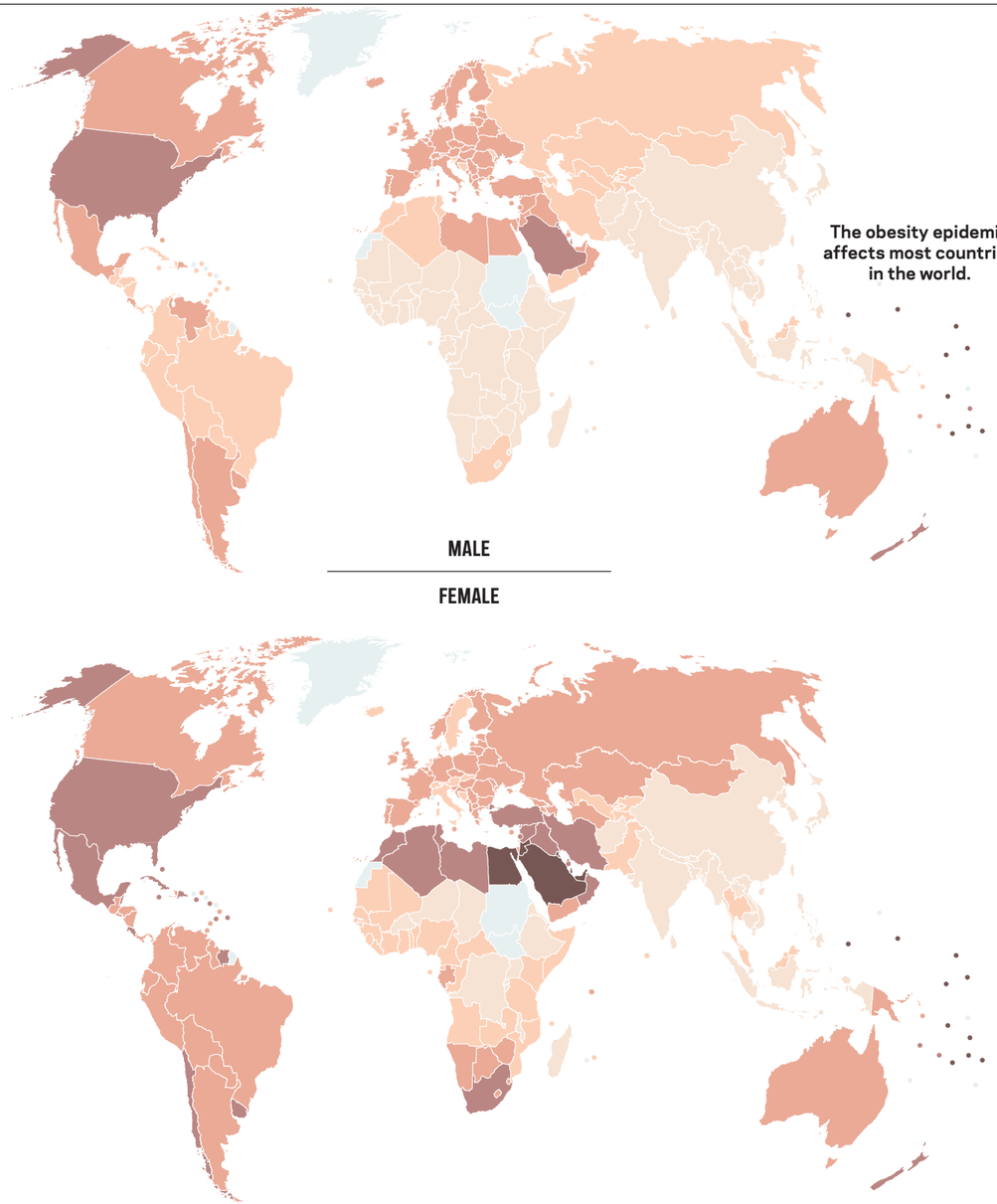
Cancer Prevention Recommendations of the World Cancer Research Fund/American Institute for Cancer Research



MAP 5.1

International variation in the prevalence of obesity by sex, 2016





ULTRAVIOLET RADIATION

Skin cancers are caused by ultraviolet radiation and can be prevented by sun protection and banning sunbeds.

A majority of skin cancers are caused by ultraviolet (UV) radiation. Keratinocyte skin cancers (basal cell and cutaneous squamous cell carcinomas) are the most common human cancers with over 13 million cases estimated each year worldwide. While rarely fatal, keratinocyte cancers cause substantial burdens of morbidity and cosmetic concern (most occur on the face). Melanoma is a more fatal form of skin cancer with about 69,000 deaths and 350,000 cases annually worldwide. In many countries skin cancers pose a significant economic burden due to their sheer numbers and the high cost of treatment for metastatic melanoma. **FIGURE 6.1**

UV radiation comes from the sun, filtered by stratospheric ozone. The UV Index measures the intensity of sunburn-causing UV reaching the Earth's surface on a scale of 1 (low) to 11+ (extreme) and varies with latitude, altitude, time of day and year, cloud cover, and air pollution. In summer, the UV Index averages around 12 in Bangkok, Thailand (14°N); 9 in Sydney, Australia (34°S); 8 in New York, USA (41°N); 7 in Berlin, Germany (52°N) and 5 in St Petersburg, Russia (60° N). Cosmetic tanning devices also emit UV radiation, often stronger than summer sun, and are classified as human carcinogens; however, their use remains high, particularly in Europe and North America. **FIGURE 6.2** Banning these devices brings potentially high savings of lives and costs.

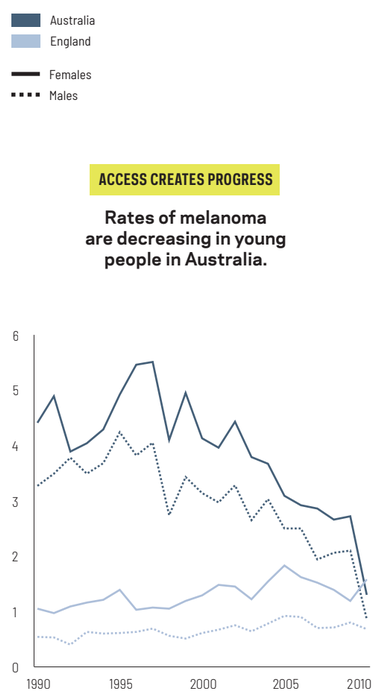
Inherited risk factors for skin cancer, such as light skin and red hair, and having freckles and moles, influence the effects of ambient UV and occupational and recreational sun exposure. Skin cancer is rare in people with innately dark skin. Risk is higher with high UV exposure in childhood.

When the UV Index is 3+, skin can be protected by avoiding outdoor activities in the middle of the day; providing effective shade outdoors; wearing hats, clothing cover and sunglasses; and applying sunscreen of Sun Protection Factor 15+ or higher. In contrast to many European countries, Australia began implementing UV protection campaigns in the 1980s, and rates of melanoma are now decreasing in younger generations. **FIGURE 6.3**

> *There is no such thing as a healthy tan.*
>
> *— World Health Organization*

FIGURE 6.3

Age-standardized incidence rates (world) per 100,000, invasive melanoma, persons aged <25 years by sex in Australia and England, 1990–2010

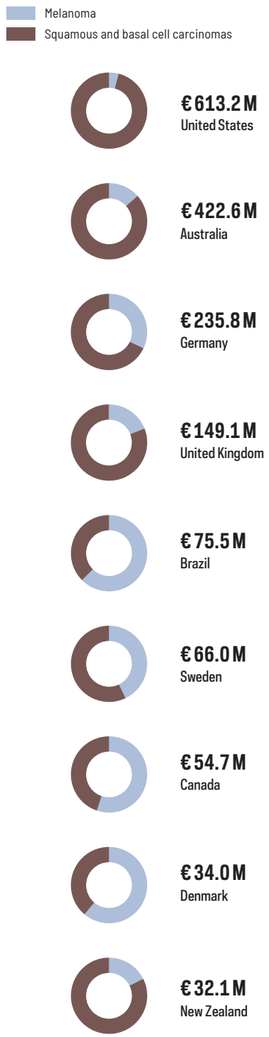


ACCESS CREATES PROGRESS

Rates of melanoma are decreasing in young people in Australia.

FIGURE 6.1

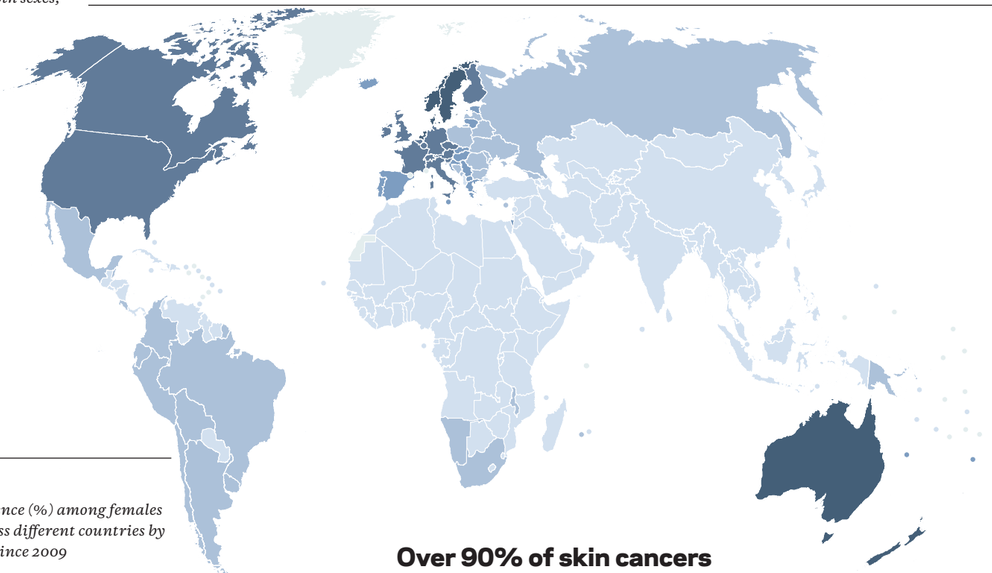
Direct costs of melanoma skin cancers and squamous cell carcinomas and basal cell carcinomas combined, 2013 Euros (millions)



Skin cancers create a substantial economic burden in many countries.

MAP 6.1

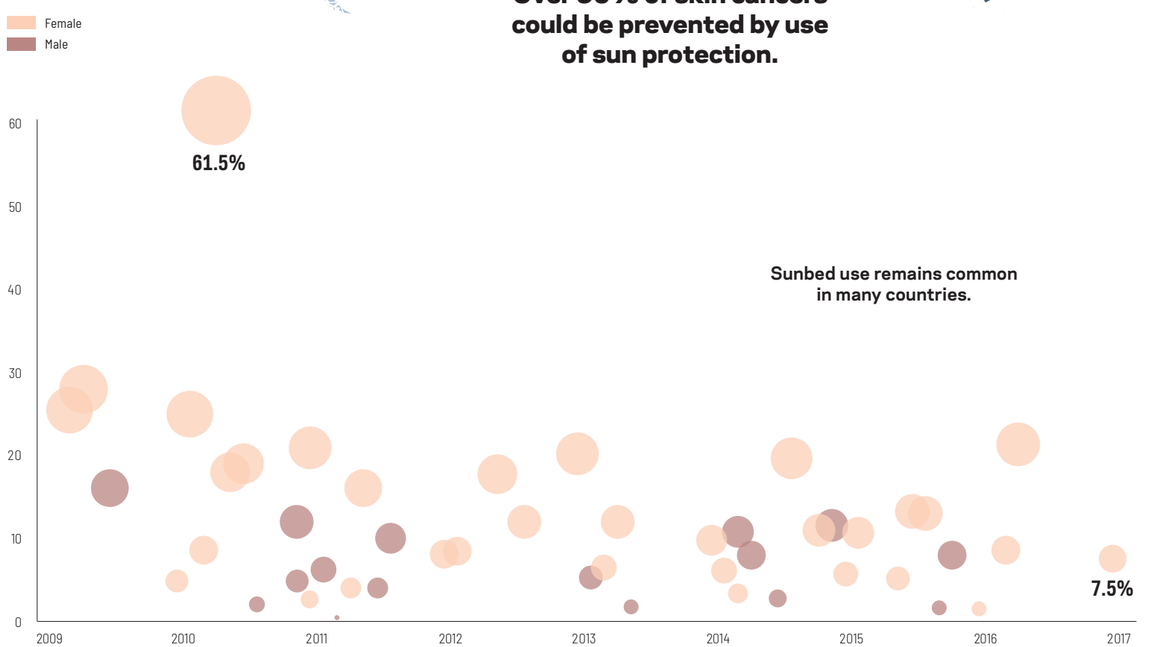
Melanoma skin cancer incidence, age-standardized rate (world) per 100,000, both sexes, 2018



Over 90% of skin cancers could be prevented by use of sun protection.

FIGURE 6.2

Sunbed prevalence (%) among females and males across different countries by year of survey since 2009



Sunbed use remains common in many countries.

REPRODUCTIVE & HORMONAL FACTORS

The magnitude of the associations of reproductive factors with cancer risk is relatively small. However, these factors affect all women. Therefore, they have a large impact at the population level.

Reproductive patterns and exposure to reproductive hormones play a role in the development of some cancers in women. Economic, political and societal shifts in the last century have been marked by profound changes in sexual maturation and reproductive patterns. These changes have led to increased lifetime number of monthly menstrual cycles, which is associated with higher risk of breast, endometrial and ovarian cancers. Although not fully understood, one mechanism that could underlie these relationships is increased exposure to endogenous estrogen and progesterone levels. Other aspects of menses may play a role in the development of some types of ovarian cancers. Longer-term breastfeeding **MAP & FIGURE 7.1** lowers risk of most types of breast cancer, likely through cessation of the menstrual cycle, changes to the hormonal milieu, and profound cellular changes to the breast tissue.

While shifting patterns of reproductive factors, such as decreasing age at menarche, increasing age at first birth, and fewer births per woman, continue in many developing countries—and may have contributed to increases in incidence rates for hormone-related cancers—these trends have plateaued in many developed countries. **MAP 7.2**, **FIGURE 7.2** In addition, many women in higher-income counties are exposed to sustained use of exogenous hormones for contraception, reproductive assistance, and menopausal symptoms. Hormonal contraceptive users have a slight, transient increase in the risk of breast cancer, but a moderate and long-term reduction in the risk of some types of ovarian cancer and endometrial cancer. **FIGURE 7.3** Although use of fertility drugs is a relatively recent exposure, early studies indicate that use of these powerful hormones does not increase cancer risk. Menopausal hormone therapy increases risk of breast and endometrial cancer dependent on formulation, timing of use, and body size, but may be associated with a decreased risk of colorectal cancer.

Increasing breastfeeding duration from present levels to 12 months per child in high-income countries and 2 years per child in low- and middle-income countries could avert 22,000 breast cancer deaths per year.

FIGURE 7.3

Associations of reproductive and hormonal risk factors with the ten most common cancers among women worldwide

	Breast	Endometrium	Ovary	Cervix uteri	Liver	Thyroid	NHL	Colon & rectum	Lung, bronchus & trachea	Stomach
High endogenous estradiol levels (vs. low)	●●●●	○○○○	○					○○○		
Older age at menarche (vs. youngest)	●	●	○		○○○○	×		×	×	
Ever hormonal oral contraceptive use (vs. never)	○	●●	●●●●	●●●	×	×	○	○		×
Parous (vs. nulliparous)	●	●	●●	●●	×	×			×	×
Older age at first birth (vs. younger)	●●●	●●	×	●●	×	○○				×
Breastfeeding for long duration (vs. no breastfeeding)	●	×	●●		×	○			○	×
Late age at menopause (vs. early)	●	○	○○		×	×		○	○	○○
Current use of estrogen alone menopausal hormone therapy (vs. never)	○	●●●●	○		○○○	×	○○	○		
Current use of combination menopausal hormone therapy (vs. never)	●●●	●●	○		○○	×	×	○○○	○	○○
Removal of any reproductive organs (vs. retention)	○		●●●●		○○○○	○○		×		×

Increased Risk Association
●●●●: > 1.95
●●●: 1.57 – 1.95
●●: 1.26 – 1.56
●: 1.05 – 1.25

No Risk Association
× Strong Evidence
× Moderate Evidence

Decreased Risk Association
●: 0.80 – 0.95
●●: 0.64 – 0.81
●●●: 0.51 – 0.63
●●●●: < 0.51

Evidence Strength
● Strong Evidence
○ Moderate Evidence

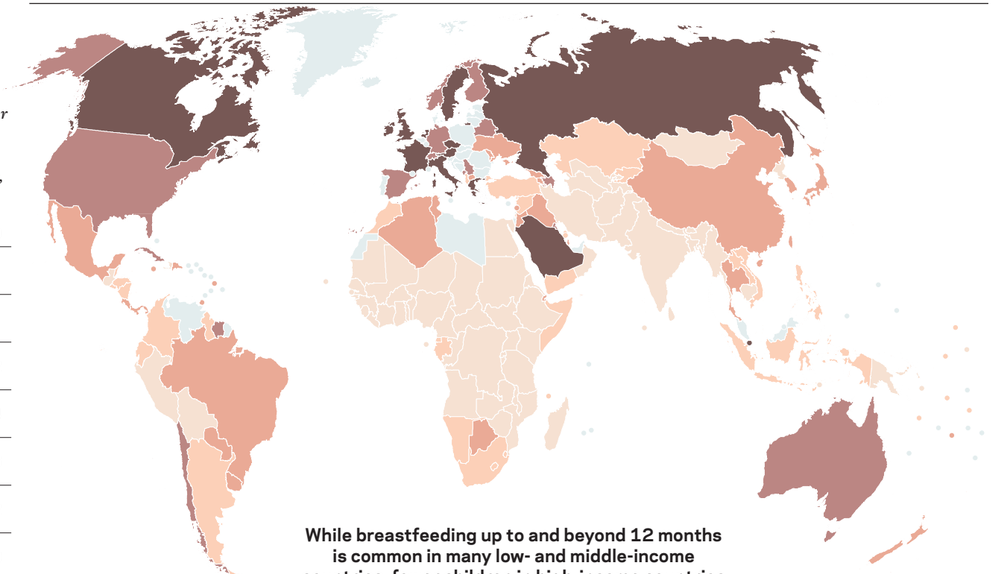
MAP & FIGURE 7.1

Percent (%) of children who receive any breast milk at 12 months of age

20% or less | 20.1–40% | 40.1–60% | 60.1–80% | 80.1% or more | No data

Global breast cancer deaths averted through current breastfeeding rates, by region

ANNUAL DEATHS AVERTED	
Central & Eastern Europe	417
Middle East & North Africa	853
Eastern & Southern Africa	1,452
West & Central Africa	1,264
Latin America & Caribbean	1,266
High-income countries	2,602
East Asia & Pacific	2,990
South Asia	8,651



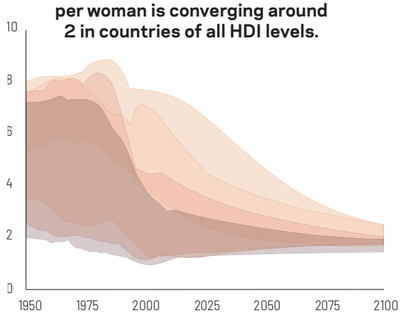
While breastfeeding up to and beyond 12 months is common in many low- and middle-income countries, fewer children in high-income countries are breastfed to this point.

FIGURE 7.2

Mean number of births per woman in representative countries by level of Human Development Index (HDI) from 1950–2100

Low HDI
Medium HDI
High HDI
Very High HDI

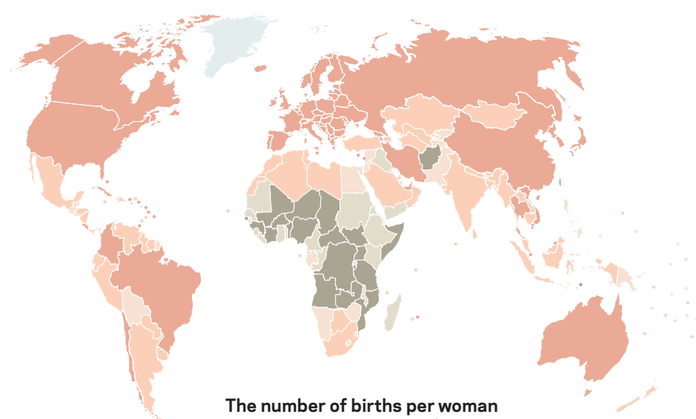
Average number of births per woman is converging around 2 in countries of all HDI levels.



MAP 7.2

Average births per woman, 2010–2015

2.0 or fewer | 2.1–3 | 3.1–4 | 4.1–5 | 5.1 or more | No data



The number of births per woman has decreased to 2 or fewer in most higher-HDI countries.

ENVIRONMENTAL & OCCUPATIONAL EXPOSURES

Limiting carcinogenic exposures in the environment and in the workplace provides an opportunity to reduce the cancer burden, particularly for workers with unacceptably high exposures.

ENVIRONMENTAL POLLUTANTS

Outdoor air pollution causes between 6 and 8 million premature deaths from lung cancer and other diseases each year. The International Agency for Research on Cancer (IARC) has classified outdoor air pollution and the particulate matter in outdoor air pollution as known human carcinogens. Outdoor air pollution levels are particularly high in rapidly-growing cities in low- and middle-income countries. **MAP 8.1** Diesel exhaust, also classified as a lung carcinogen by IARC, contributes to outdoor air pollution and is also an occupational lung carcinogen.

Indoor air pollution from use of solid fuel (e.g. wood, other biomass, and coal) is estimated to cause about 3.8 million deaths, including about 285,000 lung cancer deaths, each year in low- and middle-income countries. Globally, the number of people cooking with solid fuels has declined, but populations in less-developed countries continue to be exposed to high levels of household air pollution. **MAP 8.2**, **FIGURE 8.1** IARC classifies indoor smoke emissions from coal as a known human carcinogen, and from other types of solid fuels as probable carcinogens.

Exposure to radon is probably the second-leading cause of lung cancer in the United States and Europe. Radon gas forms from the radioactive decay of uranium, found at differing concentrations in soil and rock throughout the world. While the general population is exposed primarily from radon gas entering homes from the soil, exposure to high levels of radon can also occur when the gas is trapped in underground mines.

Populations consuming high levels of arsenic in drinking water have excess risks of skin, lung, and bladder cancer. High levels of arsenic in drinking water have been found in parts of China, Bangladesh, and some countries in Central and South America. Some predominantly occupational exposures, such as asbestos and asbestiform fibers, benzene, and polychlorinated biphenyls (PCBs), may also occur in the general population, albeit at lower levels.

OCCUPATIONAL EXPOSURES

Numerous substances are known to cause cancer in workers. **FIGURE 8.2** Due to the intensity and/or duration of these exposures, the cancer burden can be relatively high among those workers exposed. Exposure to occupational carcinogens remains a concern in low- and middle-income countries, where exposures are likely to be higher than in high-income countries, and regulations and enforcement are often less strict.

Asbestos is an important cause of occupational lung cancer and the unique cause of malignant mesothelioma, and remains an occupational and environmental hazard in many countries. However, there are many other causes of occupational cancer, and asbestos accounts for less than one-third of occupational cancers globally.

FIGURE 8.1

Proportion (%) of population using solid fuels, 1990–2017

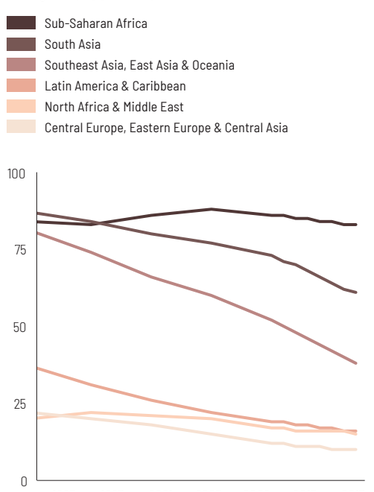
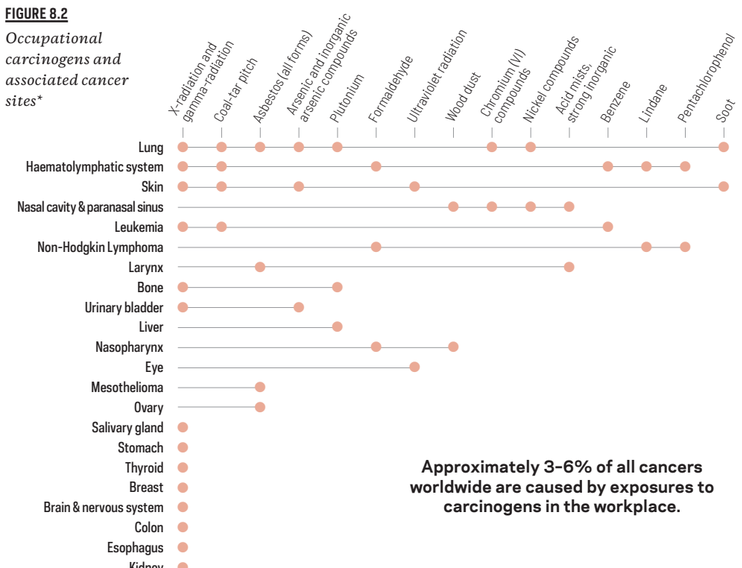


FIGURE 8.2

*Occupational carcinogens and associated cancer sites**

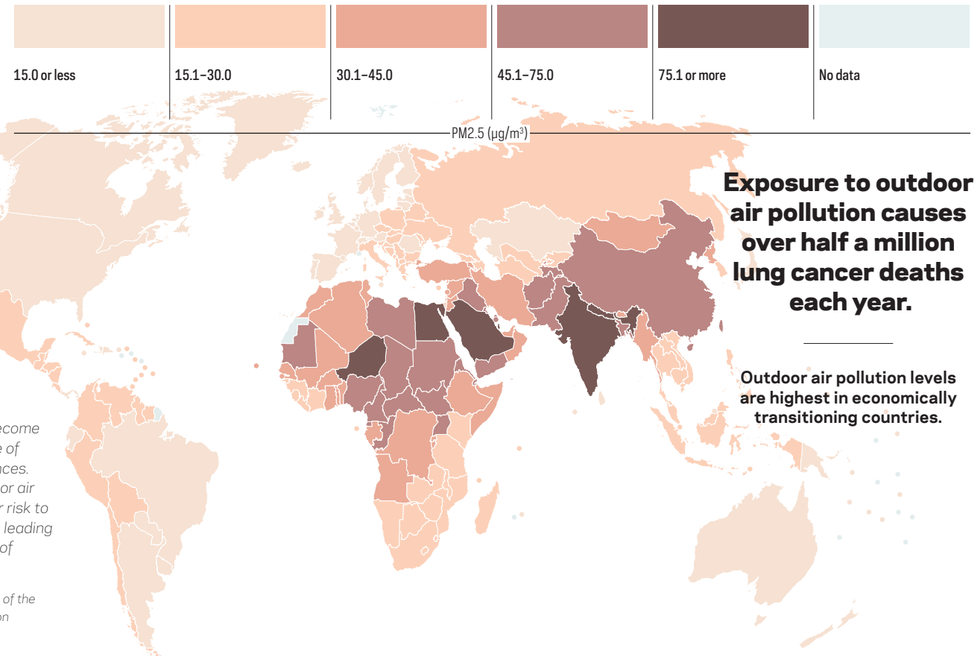


Approximately 3–6% of all cancers worldwide are caused by exposures to carcinogens in the workplace.

*limited to agents with occupational exposure linked to two or more cancer sites

MAP 8.1

OUTDOOR AIR POLLUTION: *Average annual population-weighted concentrations of PM2.5 (particulate matter of 2.5 µm diameter or less), measured in µg/m³, 2017*



Exposure to outdoor air pollution causes over half a million lung cancer deaths each year.

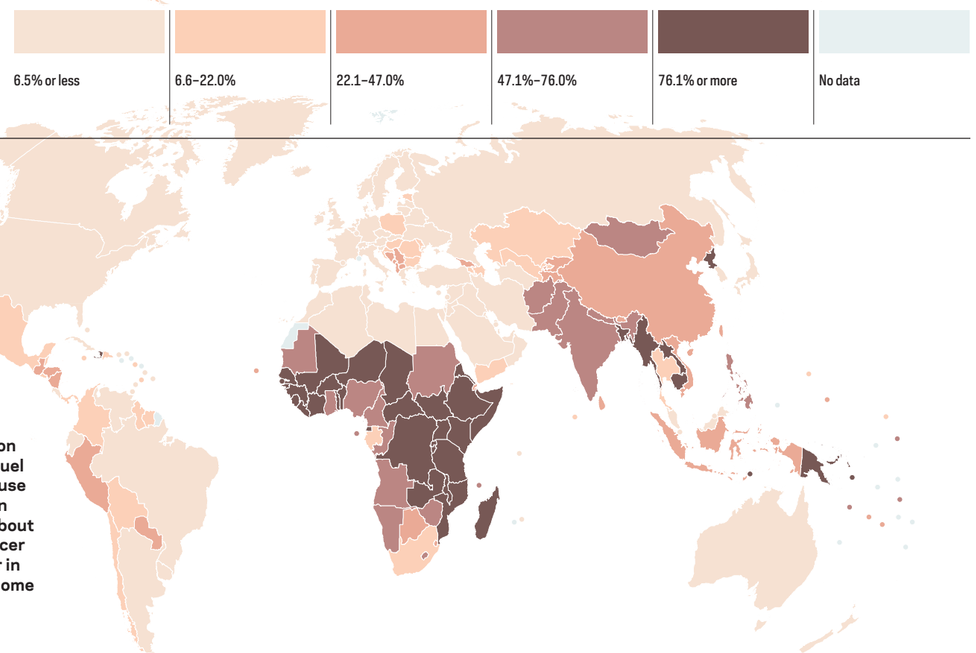
Outdoor air pollution levels are highest in economically transitioning countries.

"The air we breathe has become polluted with a mixture of cancer-causing substances. We now know that outdoor air pollution is not only a major risk to health in general, but also a leading environmental cause of cancer deaths.

— Dr. Kurt Straif, former Head of the IARC Monographs Section

MAP 8.2

INDOOR AIR POLLUTION: *Proportion (%) of population using solid fuels in 2017*



Indoor air pollution from use of solid fuel is estimated to cause about 3.8 million deaths, including about 285,000 lung cancer deaths, each year in low- and middle-income countries.

HUMAN CARCINOGENS

Identified by the IARC Monographs Program

The International Agency for Research on Cancer (IARC) Monographs *(www.monographs.iarc.fr)* identify environmental and occupational causes of human cancer. Sometimes called the WHO "Encyclopedia of Carcinogens," the IARC Monographs are critical reviews and evaluations of the weight of the evidence that an agent can increase the risk of cancer in humans. Since the program's inception in 1971, over 1000 agents have been evaluated, including individual chemicals, complex mixtures, physical agents, biological agents, personal habits, and occupational exposures.

The agents are classified as "carcinogenic to humans" (Group 1), "probably carcinogenic to humans" (Group 2A), "possibly carcinogenic to humans" (Group 2B), "not classifiable as to their carcinogenicity to humans" (Group 3), or as "probably not carcinogenic to humans" (Group 4). This classification, based on all published scientific literature, reflects the strength of the evidence derived from epidemiological studies in humans, cancer bioassays in experimental animals, and in-vivo and in-vitro studies on the mechanisms of carcinogenicity. Evidence from studies in humans and animals is considered to be sufficient, limited, inadequate, or suggesting lack of carcinogenicity. Data from mechanistic studies are considered as providing strong, moderate, or weak evidence for a given mechanism. To date, 120 agents have been classified in Group 1, the vast majority on the basis of sufficient evidence from epidemiological studies that the agent can cause cancer at one or several sites in humans. Some important risk factors known to cause cancer in humans have however not been covered in the IARC Monographs program, notably genetic traits, reproductive status, and some nutritional factors. Other factors, such as weight control or physical activity, have been evaluated by the IARC Handbooks for their preventive effects.

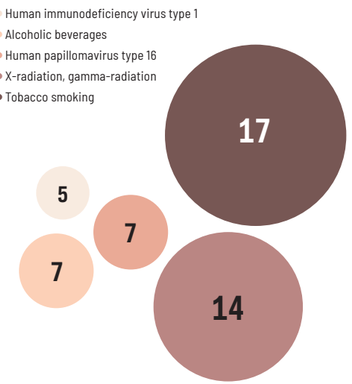
The main figure shows, for each organ or group of organs in the human body, which agent(s) can cause an increased risk of cancer at a given site. **FIGURE 9.1** Over 40 agents have more than one target organ site, with up to 17 sites for tobacco smoking and 14 sites for X-radiation and gamma-radiation. **FIGURE 9.2** Some agents have been classified in Group 1 with less than sufficient evidence from epidemiological studies, often on the basis of sufficient evidence of carcinogenicity in experimental animals and strong evidence in exposed humans that the agent acts through a relevant mechanism of carcinogenicity. It is noteworthy that a few agents have been shown to cause cancer in the offspring of the person exposed.

HAZARD VS. RISK

The classification indicates the strength of the evidence that a substance or agent causes cancer. The Monographs Programme seeks to identify cancer hazards. An agent is considered a cancer hazard if it is capable of causing cancer under some circumstances. However, it does not indicate the level of risk associated with exposure. The cancer risk associated with substances or agents assigned the same classification may be very different, depending on factors such as the type and extent of exposure and the strength of the effect of the agent.

FIGURE 9.2

Carcinogenic agents associated with five or more cancer sites as listed here

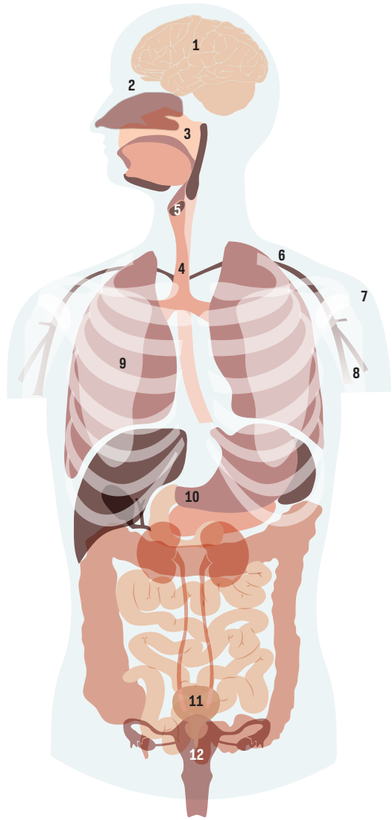


To date, IARC has classified 120 agents as carcinogenic to humans.

FIGURE 9.1

Group 1 carcinogenic agents by target site

[1] **Brain and Central Nervous System**	• X-radiation, gamma-radiation		
[2] **Eye**	Human immunodeficiency virus type 1 (HIV)	Ultraviolet-emitting tanning devices	Welding
[3] **Oral Cavity and Pharynx**	**ORAL CAVITY** Alcoholic beverages Betel quid with tobacco Betel quid without tobacco • Human papillomavirus type 16 Smokeless tobacco • Tobacco smoking	**PHARYNX (ORO-, HYPO- AND/OR NOT OTHERWISE SPECIFIED)** Alcoholic beverages Betel quid with tobacco • Human papillomavirus type 16 • Tobacco smoking **SALIVARY GLAND** • X-radiation, gamma-radiation	**NASOPHARYNX** Epstein-Barr virus Formaldehyde Salted fish, Chinese-style Wood dust **TONSIL** • Human papillomavirus type 16
[4] **Respiratory System**	**NASAL CAVITY AND PARANASAL SINUS** Isopropyl alcohol manufacture using strong acids Leather dust Nickel compounds Radium-226 and its decay products Radium-228 and its decay products • Tobacco smoking Wood dust **LARYNX** Acid mists, strong inorganic Alcoholic beverages Asbestos (all forms) • Tobacco smoking **LUNG** Acheson process (occupational exposures associated with)	Aluminium production Arsenic and inorganic arsenic compounds Asbestos (all forms) Beryllium and beryllium compounds Bis(chloromethyl)ether; chloromethyl methyl ether (technical grade) Cadmium and cadmium compounds Chromium (VI) compounds Coal, indoor emissions from household combustion Coal gasification Coal-tar pitch Coke production Diesel engine exhausts Hematite mining (underground) Iron and steel founding	MOPP (vincristine-prednisone-nitrogen mustard-procarbazine mixture) Nickel compounds Outdoor air pollution Outdoor air pollution, particulate matter in Painter (occupational exposure as) Plutonium Radon-222 and its decay products Rubber production industry Silica dust, crystalline Soot Sulfur mustard Tobacco smoke, secondhand • Tobacco smoking • X-radiation, gamma-radiation Welding fumes
Mesothelium	Asbestos (all forms) Erionite	Fluoro-edenite Painter (occupational exposure as)	
[5] **Thyroid**	Radioiodines, including iodine-131 (exposure during childhood and adolescence)	• X-radiation, gamma-radiation	



Multiple Sites (Partly Unspecified)	Cyclosporine Fission products, including Strontium-90 • X-radiation, gamma-radiation (exposure in utero)		
All Cancers Combined	2,3,7,8-Tetrachlorodibenzo-para-dioxin		
Endothelium (Kaposi Sarcoma)	HIV type 1 Kaposi sarcoma herpes virus		
Less Than Sufficient Evidence in Humans*	Areca nut Aristolochic Acid Benzidine, dyes metabolized to Benzo[a]pyrene Ethanol in alcoholic beverages Ethylene oxide Etoposide Ionizing radiation (all types) 4,4'-Methylenebis (1-chloroaniline) (MOCA) Neutron radiation	N'-Nitrosonornicotine, (NNN) and 4-(N-nitro-methyl-amino-1-(3-pyridyl)-1-but none (NNK) 2,3,4,5,8-Pentachlorodibenzofuran 3,4,5,3',4'-Pentachlorobiphenyl (PCB-126) Polychlorinated biphenyls dioxin like, with a Toxic Equivalent Factor according to WHO (PCBs 77, 81, 105, 114, 118, 123, 126, 156, 167, 169, 189) Radionuclides, alpha-particle emitting, internally deposited Radionuclides, beta-particle emitting, internally deposited Ultraviolet radiation *Mechanistic upgrades to Group 1	

[6] **Hematopoietic System**	Azathioprine Benzene Busulfan 1,3-Butadiene Chlorambucil Cyclophosphamide Cyclosporine Epstein-Barr virus Etoposide with cisplatin and bleomycin Fission products, including Strontium-90	Formaldehyde *Helicobacter pylori* Hepatitis C virus • HIV type 1 Human T-cell lymphotropic virus type 1 Kaposi sarcoma herpes virus Lindane Melphalan MOPP (vincristine-prednisone-nitrogen mustard-procarbazine mixture)	Pentachlorophenol Phosphorus-32, as phosphate Rubber production industry Semustine [1-(2-Chloroeth-yl)-3-(4-methylcyclohexyl)-1-nitrosourea, or methyl-CCNU] Thiotepa Thorium-232 and its decay products • Tobacco smoking Treosulfan • X-radiation, gamma-radiation
[7] **Skin**	**MELANOMA** Solar radiation Polychlorinated biphenyls Ultraviolet-emitting tanning devices	**OTHER MALIGNANT NEOPLASMS** Arsenic and inorganic arsenic compounds Azathioprine Coal-tar distillation Coal-tar pitch Cyclosporine	Methoxsalen plus ultraviolet A Mineral oils, untreated or mildly treated Shale oils Solar radiation Soot • X-radiation, gamma-radiation
[8] **Bone**	Plutonium Radium-224 and its decay products	Radium-226 and its decay products Radium-228 and its decay products	• X-radiation, gamma-radiation
[9] **Breast**	Alcoholic beverages Diethylstilbestrol	Estrogen-progestogen contraceptives Estrogen-progestogen menopausal therapy	• X-radiation, gamma-radiation
[10] **Digestive System**	**ESOPHAGUS** Acetaldehyde associated with consumption of alcoholic beverages Alcoholic beverages Betel quid with tobacco Betel quid without tobacco Smokeless tobacco • Tobacco smoking • X-radiation, gamma-radiation **UPPER AERODIGESTIVE TRACT** Acetaldehyde associated with consumption of alcoholic beverages **STOMACH** *Helicobacter pylori* Rubber production industry • Tobacco smoking • X-radiation, gamma-radiation	**LIVER (ANGIOSARCOMA)** Vinyl chloride **LIVER (HEPATOCELLULAR CARCINOMA)** Aflatoxins Alcoholic beverages Estrogen-progestogen contraceptives Hepatitis B virus Hepatitis C virus Plutonium Thorium-232 and its decay products • Tobacco smoking (in smokers and in smokers' children) **GALLBLADDER** Thorium-232 and its decay products	**BILIARY TRACT** *Chlonorchis sinensis* 1,2-Dichloropropane *Opisthorchis viverrini* **PANCREAS** Smokeless tobacco • Tobacco smoking **COLON AND RECTUM** Alcoholic beverages Processed meat (consumption of) • Tobacco smoking • X-radiation, gamma-radiation **ANUS** HIV type 1 Human papillomavirus type 16
[11] **Urinary System**	**KIDNEY** • Tobacco smoking Trichloroethylene • X-radiation, gamma-radiation **RENAL PELVIS** Aristolochic acid, plants containing Phenacetin Phenacetin, analgesic mixtures containing • Tobacco smoking	**URINARY BLADDER** Aluminum production 4-Aminobiphenyl Arsenic and inorganic arsenic compounds Auramine production Benzidine Chlornaphazine Cyclophosphamide Magenta production 2-Naphthylamine Painter (occupational exposure as)	Rubber production industry *Schistosoma haematobium* • Tobacco smoking *ortho*-Toluidine • X-radiation, gamma-radiation **URETER** Aristolochic acid, plants containing Phenacetin Phenacetin, analgesic mixtures containing • Tobacco smoking
[12] **Genital System**	**UTERINE CERVIX** Diethylstilbestrol (exposure in utero) Estrogen-progestogen contraceptives • HIV type 1 Human papillomavirus type 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59 • Tobacco smoking	**ENDOMETRIUM** Estrogen menopausal therapy Estrogen-progestogen menopausal therapy Tamoxifen **OVARY** Asbestos (all forms) Estrogen menopausal therapy	• Tobacco smoking **VAGINA** Diethylstilbestrol (exposure in utero) • Human papillomavirus type 16 **VULVA** • Human papillomavirus type 16 **PENIS** • Human papillomavirus type 16

THE BURDEN

This section describes the global cancer burden in terms of incidence, mortality, prevalence, and survival for each major world region as well as by Human Development Index.

Each year, about 270,000 cancer cases are diagnosed in children. Today, five-year survival from childhood cancer in high income countries is greater than 80%, but it can be as low as 20% in lower-income countries.

ACCESS CREATES PROGRESS

With interventions to improve **early diagnosis** and adherence to appropriate **treatment,** childhood cancer survival can be increased to 60% in lower-income countries, **saving almost 1 million children's lives over a decade.**

THE BURDEN OF CANCER

Cancer is a major public health and economic issue and its burden is set to spiral. With over 18 million cases in 2018, we can expect 29 million cases by 2040 due to the aging and growth of the population.

Worldwide, there were an estimated 18.1 million cases and 9.6 million cancer deaths in 2018 (including non-melanoma skin cancers), with one in four men and one in five women developing the disease, and one in eight men and one in eleven women dying from it. **FIGURE 10.1** In addition, there were 43.8 million persons living with cancer in 2018 who were diagnosed within the last 5 years.

Half of the new cancer cases and cancer deaths in the world occur in Asia. **FIGURE 10.2** China, with the largest population size in the region and worldwide—1.4 billion inhabitants, representing 19% of the global population in 2018—has the greatest global proportion of new cases (4.3 million cases, 24% of the total) and deaths (2.9 million deaths, 30%). Northern America is second in terms of new cases (2.4 million, 13%), and fourth for cancer deaths (0.7 million, 7%). Close to one fourth of all new cases globally (4.2 million) and one fifth of deaths (1.9 million) occur in Europe, despite the region representing less than one tenth of the global population.

For both sexes combined worldwide, lung cancer continues to be the most commonly diagnosed cancer (2.1 million, 12% of the total) **FIGURE 10.3** and the leading cause of cancer death (1.8 million, 18%) because of its poor prognosis. Female breast cancer is the second most common cancer overall (2.1 million, 12%) but the fifth leading cause of cancer death (627,000, 7%) because of its relatively favorable prognosis. As such, it is the most prevalent cancer worldwide (6.9 million women living within 5 years of their breast cancer diagnosis). Colorectal cancer is the third most frequently-diagnosed cancer globally, but second only to lung cancer in terms of mortality (1.8 million cases and 881,000 deaths). Prostate cancer is the fourth most frequently diagnosed cancer, while stomach and liver cancer remain major causes of cancer death in 2018.

Based on projected population aging and growth, the global burden of cancer is set to increase by more than 60% by 2040, from 18.1 million new cases in 2018 to a predicted 29.4 million cases in the year 2040. **FIGURE 10.4**

More broadly, cancer has become a leading cause of death over the last few decades. In terms of premature mortality (defined as death in ages 30-69 years), in the year 2016, cancer was the leading cause of death in 55 (largely high-income) countries, but second (mainly to cardiovascular disease) in an additional 79 countries. **MAP 10.1** With rates of cardiovascular mortality in decline in many countries due to highly successful prevention and treatment, cancer is set to become the leading barrier to increasing life expectancy in this century.

FIGURE 10.1

*Percentage (%) of males and females developing and dying from cancer worldwide in 2018**

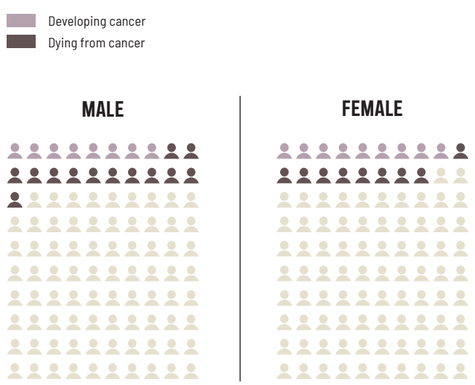
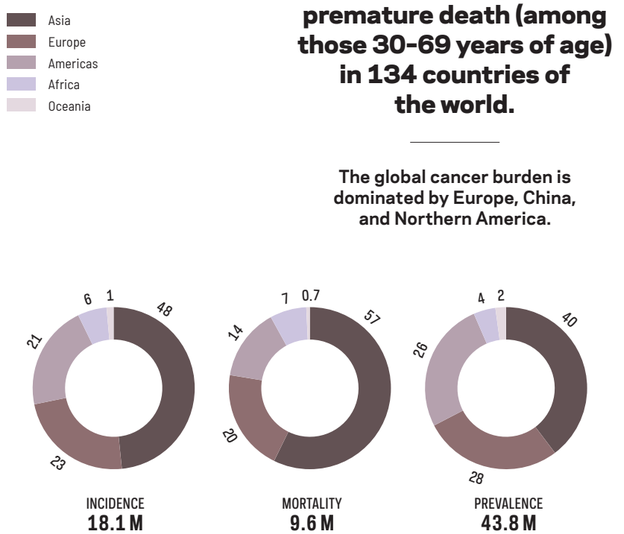


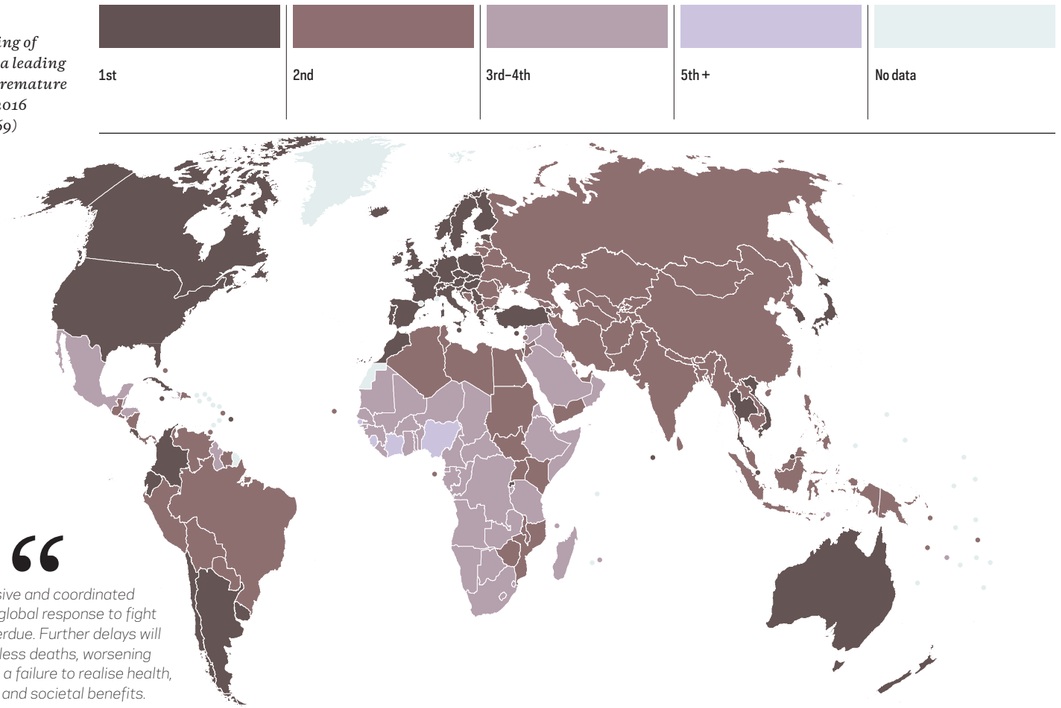
FIGURE 10.2

*Cancer incidence, mortality and survivors diagnosed within the past 5 years worldwide in 2018**



MAP 10.1

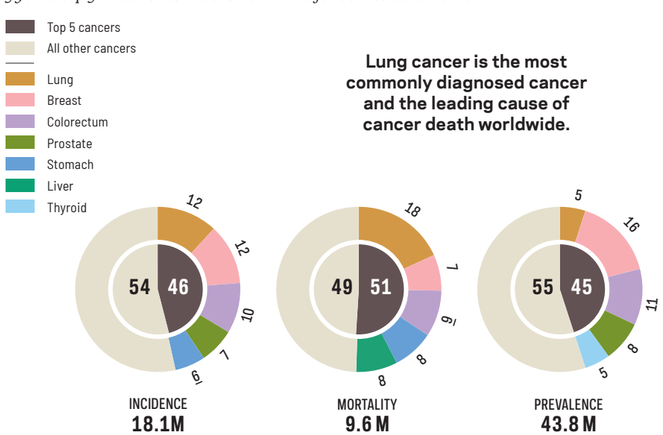
The ranking of cancer as a leading cause of premature death in 2016 (ages 30-69)



> *An inclusive and coordinated large-scale global response to fight cancer is overdue. Further delays will mean needless deaths, worsening inequities, and a failure to realise health, economic, and societal benefits.*
>
> *— Rifat Atun, global health systems expert, and Franco Cavalli, medical oncologist*

FIGURE 10.3

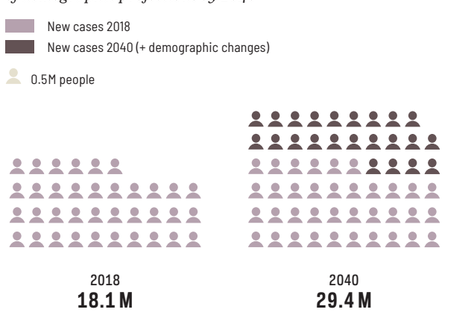
*Cancer incidence, mortality and survivors diagnosed within the past 5 years: top 5 cancer sites in 2018 worldwide for both sexes combined**



*Total includes non-melanoma skin cancers

FIGURE 10.4

Number of new cancer cases in 2018 vs. 2040: impact of demographic projections by 2040



LUNG CANCER

Lung cancer remains the most commonly diagnosed cancer and the leading cause of cancer death worldwide because of inadequate tobacco control policies.

Globally, there were an estimated 2.1 million lung cancer cases and 1.8 million deaths in 2018. Incidence and mortality rates vary 20-fold between regions. **FIGURE 11.1** The variation is similarly large across countries. The highest incidence rates among men are in Europe, particularly in Eastern European countries such as Hungary (77 cases per 100,000 male population) as well as Western Asia (particularly in the former Soviet Union) and in certain countries in Asia such as Turkey and China. **MAP 11.1** Among women, lung cancer incidence rates are highest in Hungary (38 cases per 100,000 female population), followed by other European countries, Northern America, Australia, and New Zealand. In general, the geographic patterns of lung cancer mortality are quite similar to those of incidence due to the relatively poor prognosis of the disease after diagnosis.

Historically, lung cancer mortality rates have been higher among males than females due to an earlier uptake of smoking in large numbers. **FIGURE 11.2** More recently, reports have noted a convergence in incidence and mortality rates between young men and women in Europe, North America, and Australia, due to a larger decrease in rates in men and a substantial rise (or slower decline) in women who acquired the smoking habit later than men. **FIGURE 11.3** In Asia, Latin America, and Africa, however, the lung cancer burden among men still largely exceeds that of women at all ages. **FIGURE 11.4** In the last few decades, mortality rates among men in these regions have started to decline, however, with rates among women often remaining low.

In most parts of the world, tobacco use is the main cause of lung cancer, although other causes can be particularly important in selected countries. **FIGURE 11.5** Other established risk factors include secondhand smoke, air pollution, radon, and several occupational agents (see *08, Environmental Pollutants and Occupational Exposures*). However, reducing tobacco smoking alone could prevent the majority of lung cancers. Screening for detection of the disease at an earlier stage for long-term heavy current and former smokers is available, but wide dissemination of the procedure is unlikely in the short term, even in high-income countries, because of the need for a more advanced and coordinated healthcare system.

FIGURE 11.1

Lung cancer incidence and mortality rates, 2018

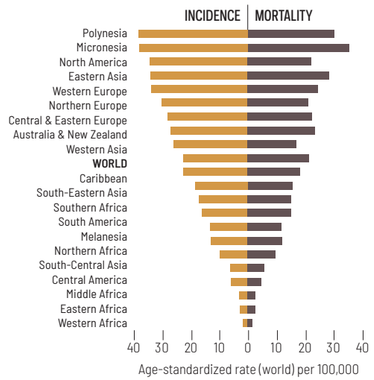


FIGURE 11.2

Smoking and lung cancer mortality rate trends in men and women, United States

The tobacco epidemic is characterized by an increase in uptake of smoking followed by an increase in lung cancer mortality rates a few decades later.

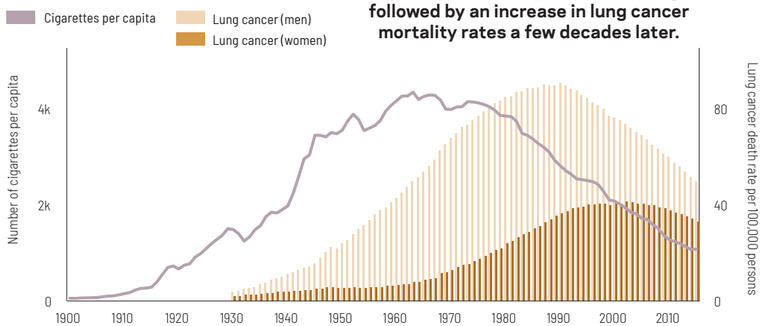


FIGURE 11.3

Converging lung cancer mortality rates among males and females, select high-income countries, 1952–2013, age-standardized rate (world) per 100,000, all ages

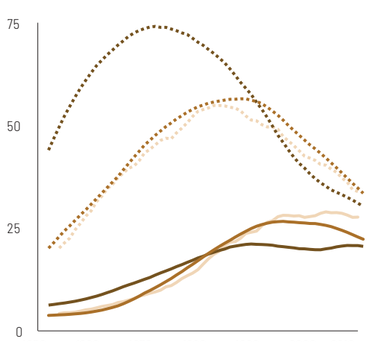
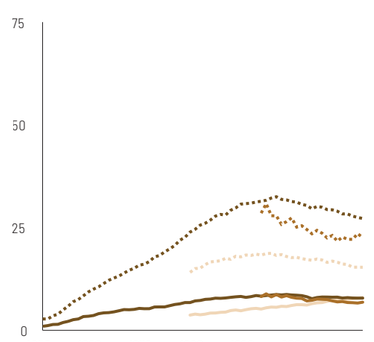


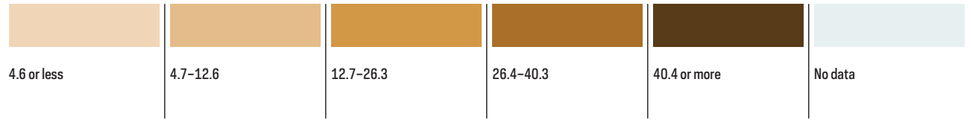
FIGURE 11.4

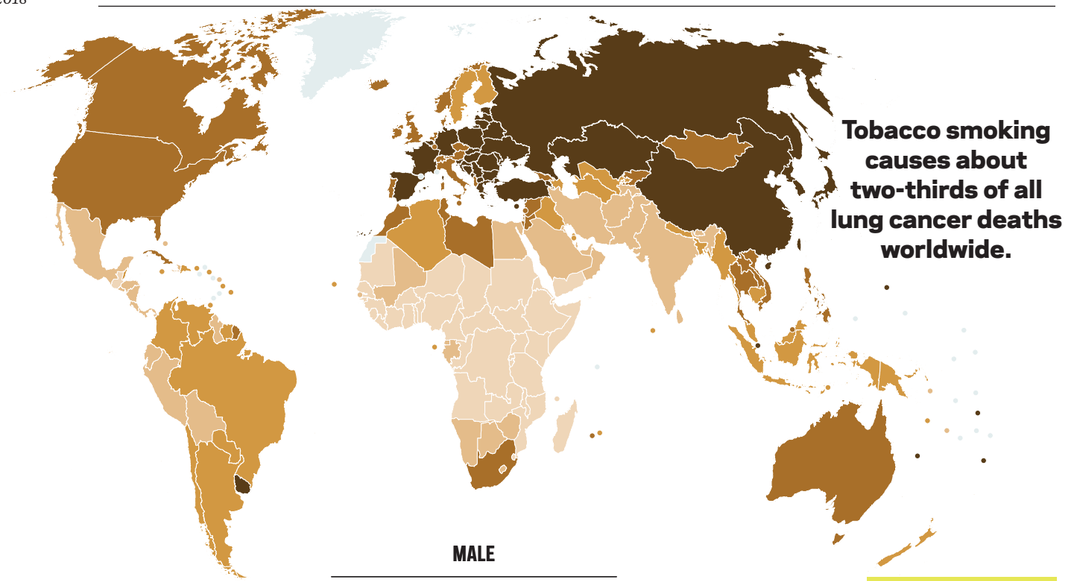
Lung cancer mortality rates among males and females, select countries in Asia, Africa, and Latin America, 1950–2013, age-standardized rate (world) per 100,000, all ages



MAP 11.1

Lung cancer incidence by sex, age-standardized rate (world) per 100,000, 2018





Tobacco smoking causes about two-thirds of all lung cancer deaths worldwide.

MALE

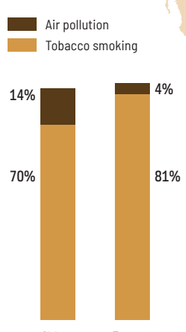
FEMALE

ACCESS CREATES PROGRESS

Since the United States Surgeon General's Report on Smoking and Health in 1964, smoking prevalence among adults in the United States has decreased by half.

FIGURE 11.5

Lung cancers related to tobacco smoking and air pollution in China and France



Although tobacco remains the most important risk factor for lung cancer, other factors such as air pollution are significant in some countries.

BREAST CANCER

Breast cancer accounts for almost a quarter of new cancer cases among women.

Breast cancer is the leading cancer type in females in most countries in the world in 2018. MAP 12.1 About one in twenty females will be diagnosed with breast cancer over the course of their lifetime, although this number varies significantly by country. FIGURE 12.1 There are large variations in estimated incidence rates worldwide, with an almost fourfold difference between the highest- and lowest-ranked regions. FIGURE 12.2 Incidence rates are elevated in Australia/New Zealand, Europe and North America, notably in Belgium (113 cases per 100,000 female population) and Luxembourg (109) in Europe, and in Australia (94). In contrast, incidence rates in sub-Saharan African regions, particularly in Eastern (30 cases per 100,000 female population) and Middle Africa (28), as well as South Central Asia (26), were considerably lower. Geographic variation is less pronounced for mortality rates, with the highest rates seen in Melanesia (26 deaths per 100,000 female population) and Polynesia (22), as well as in Northern and Western Africa (18). Notably, some countries in Europe, North America, and Oceania have among the lowest mortality rates despite their high incidence rates.

The variations observed in breast cancer incidence across countries can likely be at least partly attributed to differences in the prevalence and distribution of the major risk factors (e.g. reproductive factors, obesity) and partly to the degree of early detection and screening activities in operation. Breast cancer screening detects breast cancer at earlier stages, but also captures cases that would have never been diagnosed otherwise. As such, incidence rates are often higher in countries that implement breast cancer screening programs. In countries where the incidence of breast cancer is high, there has been a decline or stabilization of rates, while in countries where rates have historically been low, rates have been markedly increasing, probably related to improved diagnosis (i.e., detection of asymptomatic cancers) in combination with socio-cultural changes linked to an increase in westernized lifestyle. FIGURE 12.3 Declines in breast cancer mortality rates have been reported in many high-income countries, with large decreases in European and North American countries and in Australia and New Zealand, whereas countries in transition continue to show a slight increase in mortality from breast cancer, though this appears to be slowing. FIGURE 12.4 The favorable trends in mortality may result from the combined effects of earlier detection (screening and increased breast cancer awareness) and a range of improvements in treatment.

> *In lower-resource settings, breast and cervical cancer disproportionately affect women in the prime of life, resulting in significant economic and societal impact. A woman's country… should not be allowed to influence the likelihood of dying from these cancers.*
>
> — Dr. Ophira Ginsburg, medical oncologist

Lifetime risk of breast cancer among females in high-income countries can be up to three times that in low-income countries.

FIGURE 12.1

Cumulative risk of being diagnosed with female breast cancer by age 75 years, globally and in select countries

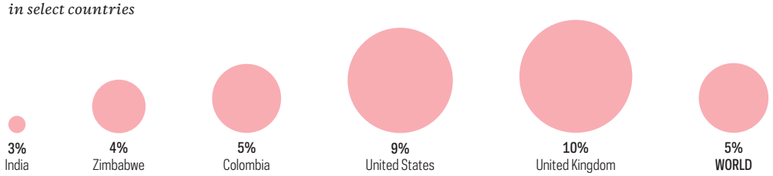
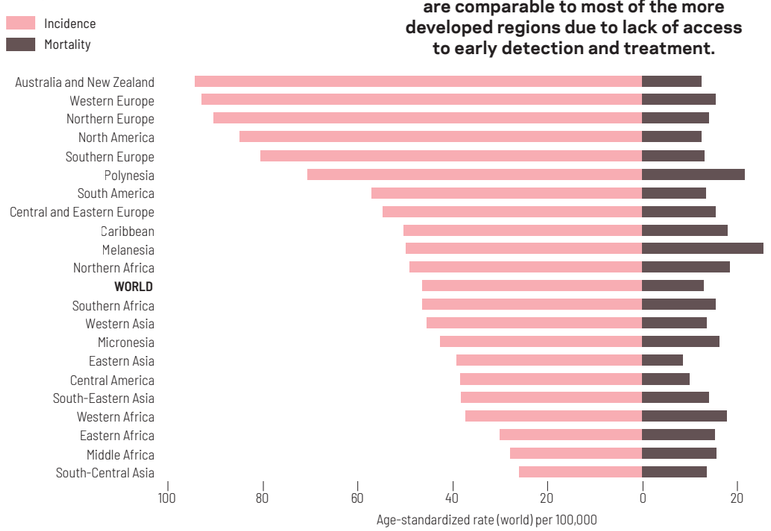


FIGURE 12.2

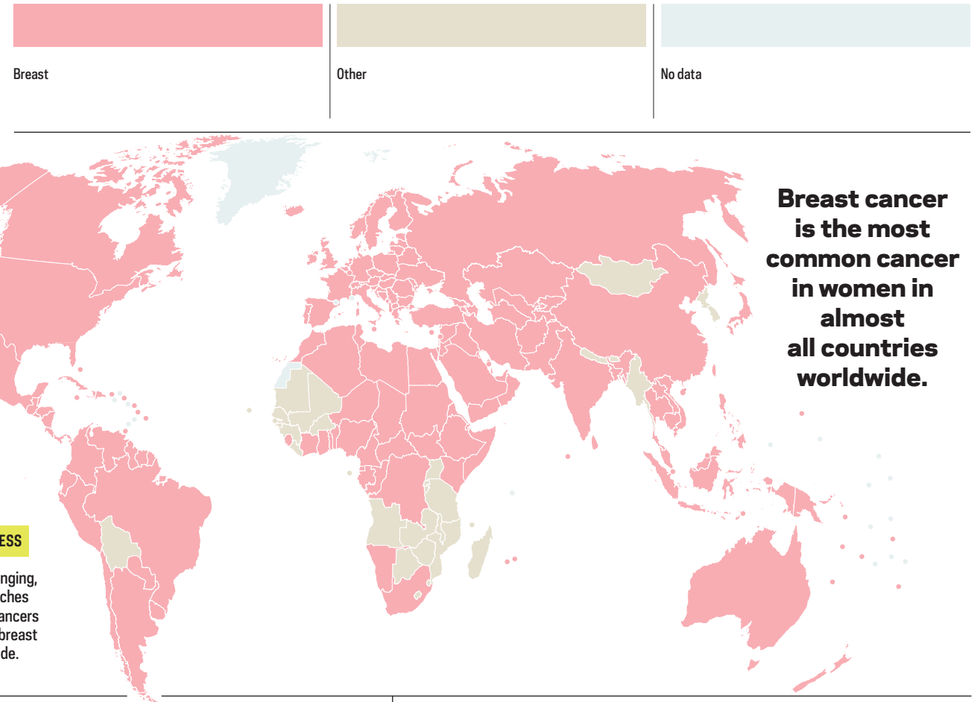
Female breast cancer incidence and mortality rates, 2018

Although female breast cancer incidence rates are lowest in less developed regions, mortality rates in these areas are comparable to most of the more developed regions due to lack of access to early detection and treatment.



MAP 12.1

Countries where breast cancer is the most frequently diagnosed cancer in women, 2018



ACCESS CREATES PROGRESS

Although enormously challenging, resource stratified approaches to detect and treat breast cancers can substantially decrease breast cancer mortality worldwide.

FIGURE 12.3

Female breast cancer incidence rates, all ages, 1978–2012, age-standardized rate (world) per 100,000

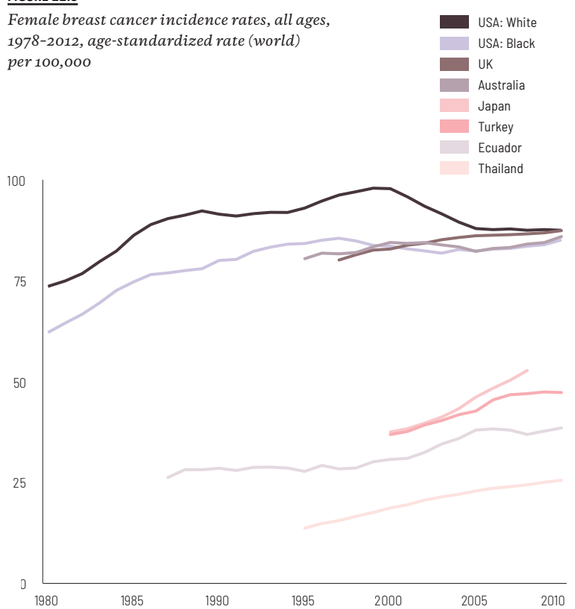
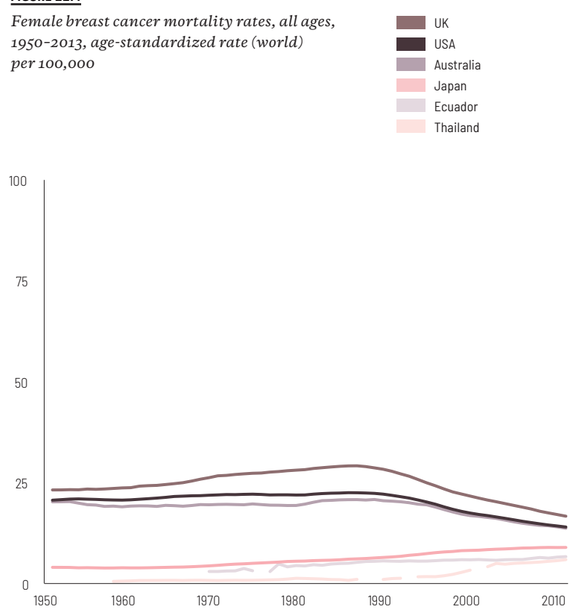


FIGURE 12.4

Female breast cancer mortality rates, all ages, 1950–2013, age-standardized rate (world) per 100,000

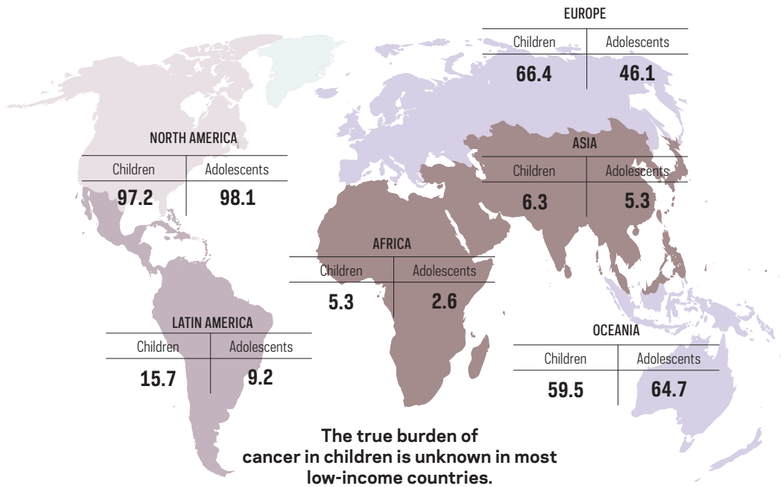


CANCER IN CHILDREN

The childhood cancer burden is strongly related to level of development, with high incidence in high-income countries but higher mortality in low-income countries.

FIGURE 13.1

Percentage (%) of the population in which frequency of cancer is measured on each continent in children (age 0–14 years) and adolescents (age 15–19 years)



The true burden of cancer in children is unknown in most low-income countries.

Cancers occurring in childhood and adolescence differ markedly from cancers in adults in their incidence and tumor characteristics. Worldwide, the average annual incidence in children aged less than 15 years is 140 new cases per million children, although there are threefold variations between world regions and ethnic groups. FIGURE 13.2 The low rates recorded by population-based cancer registries in some low-income countries are thought to result from under-diagnosis. FIGURE 13.1 The most common cancers in children are leukemia and lymphoma, while the major cancers among adults, such as carcinoma of the lung, breast or colon, are rare in children. The incidence of carcinomas increases progressively with age, and together with lymphomas or germ cell tumors they become the most common cancers in adolescents aged 15–19 years, with the overall incidence rate rising to 185 per million. In contrast, the incidence of embryonal tumors, such as neuroblastoma, retinoblastoma, and nephroblastoma is very low in adolescents. FIGURE 13.3

More than half of long-term survivors of childhood cancer experience chronic health conditions.

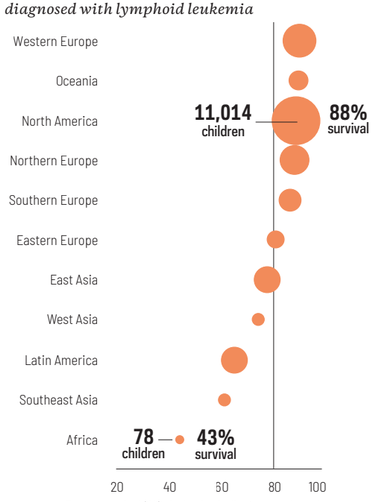
The incidence of cancer in children and adolescents has been increasing by 0.5 to 1 percent per year in the high-income countries with established cancer registries over the past few decades. Although the increase may in part reflect more frequent diagnosis facilitated by advanced imaging techniques, other factors may have also contributed. Exposures to high doses of ionizing radiation, high birth weight and certain genetic syndromes have been consistently associated with increased risk of cancer in children. The role of other risk factors, such as air pollutants, tobacco or pesticide use, older parental age, or fewer children per family is debated. Potentially protective effects of breastfeeding and folate supplementation are being investigated.

More than 80% of childhood cancer patients in high-income countries survive 5 years after their diagnosis. In many low-income countries, in contrast, the outlook is much less favorable because of suboptimal access to care, late diagnosis, treatment abandonment, inadequacy of therapy, and the financial burden. Survival of childhood cancer patients has been assessed in only a few low-income countries. FIGURE 13.4

As survival of cancer patients improves over time FIGURE 13.5, many survivors experience chronic health conditions later in life as a consequence of their cancer or the anti-cancer therapy.

FIGURE 13.4

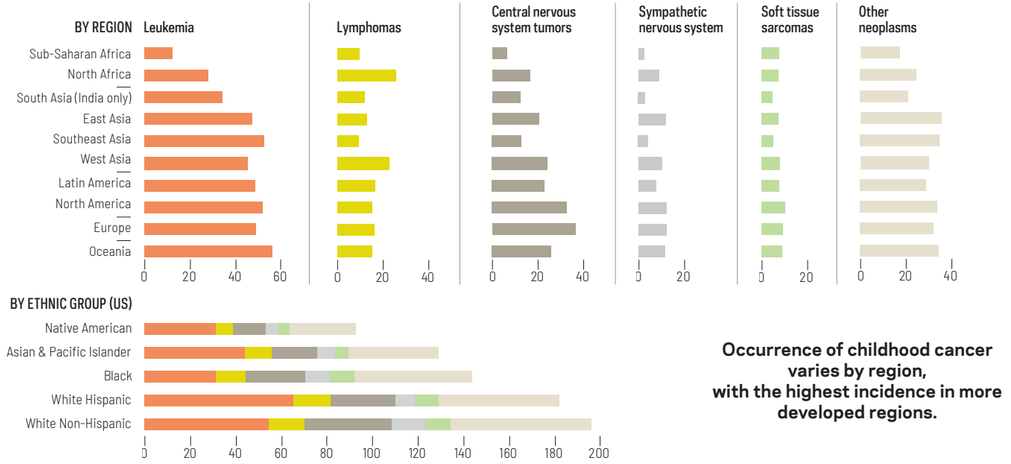
Five-year age-standardized net survival (%) observed in the available cohorts of cases diagnosed with lymphoid leukemia



Survival from lymphoid leukemia is over 80% in more developed regions.

FIGURE 13.2

Age-standardized cancer incidence rates (world) per million population, 2001–2010



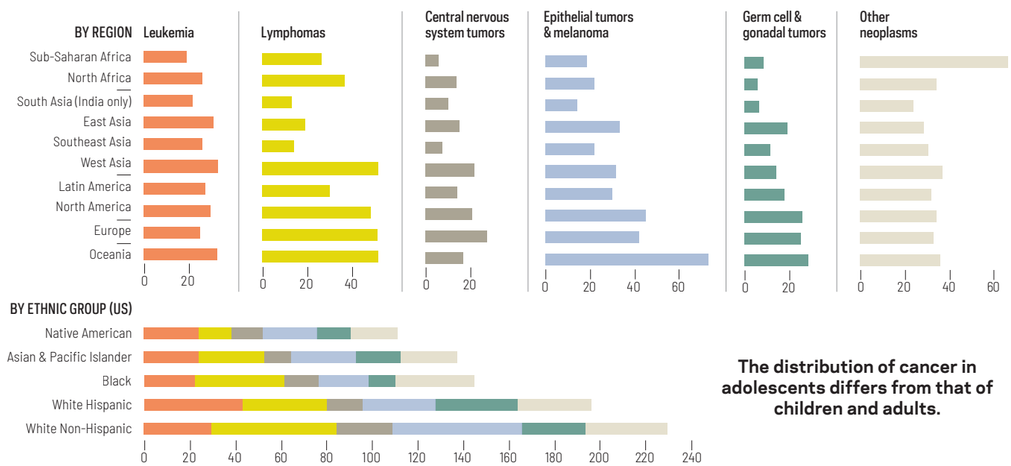
CHILDREN AGE 0–14 YEARS

Occurrence of childhood cancer varies by region, with the highest incidence in more developed regions.

15–19 YEARS

FIGURE 13.3

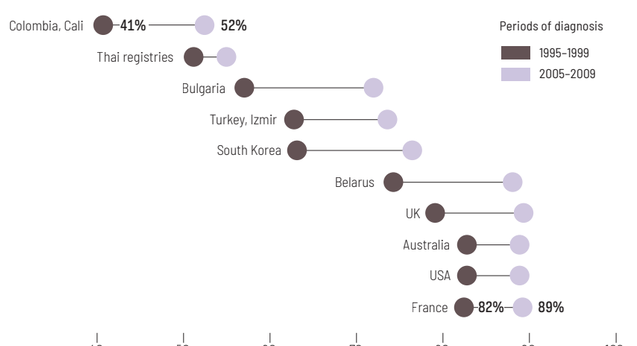
Age-standardized cancer incidence rates (world) per million population, 2001–2010



The distribution of cancer in adolescents differs from that of children and adults.

FIGURE 13.5

Changes in 5-year age-standardized net survival (%) for children aged 0–14 years diagnosed with acute lymphoid leukemia, select countries 1995–2009



ACCESS CREATES PROGRESS

Burkitt lymphoma is the most common pediatric cancer in many parts of sub-Saharan Africa. While about 90% of children with Burkitt lymphoma in high-income countries can be cured with timely treatment including high-intensity chemotherapy and supportive care infrastructure, about 50% of children with the disease in resource-constrained settings where such treatment is not feasible can be cured with a simplified protocol.

HUMAN DEVELOPMENT INDEX TRANSITIONS

Understanding the transition from infection-related cancers to lifestyle-related cancers in many low- and middle-income countries is vital for planning tailored cancer control programs to reduce the future deaths and suffering from the disease.

Over the last century, reductions in mortality from infectious disease, childhood and maternal conditions, and changes in fertility have led to rapid population growth and aging, and consequently an increasing burden of noncommunicable diseases, including cancer. The unsurpassed scale of the cancer problem worldwide continues to evolve as countries undergo major transitions, as measured by human development index (HDI). **MAP & FIGURE 14.1**

Cancer is a major cause of premature death (at ages <70) linked to socioeconomic transitions. **MAP 14.2** It is the leading cause of premature death in 48 (predominantly very high-HDI) countries, where cancer has surpassed the first position from cardiovascular disease. In Japan, cancer now represents 45% of all premature deaths, compared with 21% due to cardiovascular disease. **FIGURE 14.2** In a further 43 countries, cancer is the second-leading cause of premature death following cardiovascular disease, while both diseases rank lower in most low- and medium-HDI countries.

In South Africa, for example, infectious and parasitic diseases account for 45% of premature deaths, while cancer and cardiovascular disease each account for only 10%.

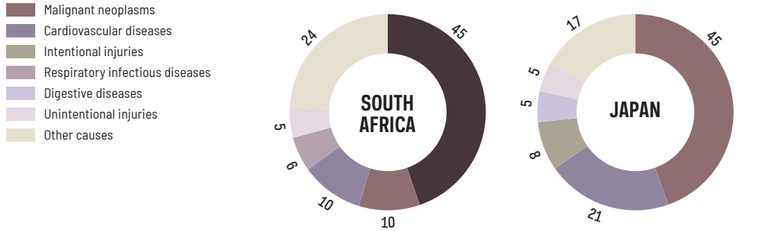
The profiles of cancer substantially vary by HDI, reflecting differences in lifestyle factors, entrenchment of tobacco marketing, the built environment, and the availability of detection and diagnostic services that are associated with social and economic development. Among the top 5 most commonly diagnosed cancers and 5 leading causes of cancer death by HDI, and separately for India and China, there are 16 different cancer types that rank within the top five even within these six broad "regions." **FIGURE 14.3**

The rising cancer burden will hit the lower HDI countries the hardest. Low- and medium-HDI countries, many of which are ill-equipped to deal with the present situation, are projected to have the greatest percentage increase in the burden of cancer in the coming decades. **FIGURE 14.4**

FIGURE 14.2

Leading causes of premature mortality (%) (ages <70 years) in South Africa and Japan

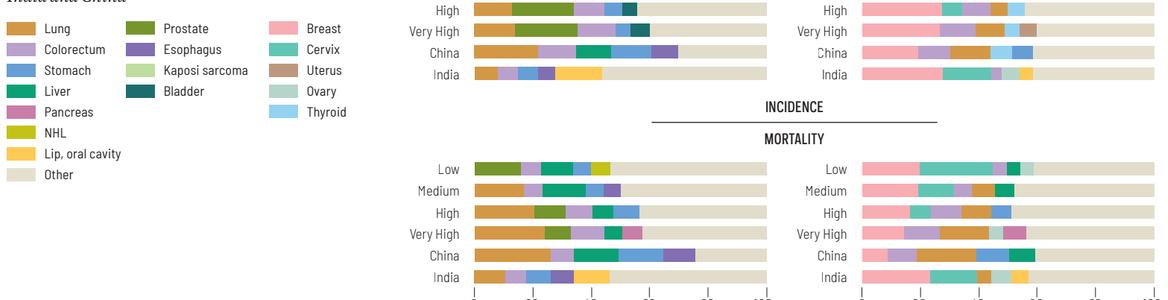
While infectious causes of death dominate in South Africa, cancer is the most common cause of death in Japan.



Numbers may not sum to 100 due to rounding.

FIGURE 14.3

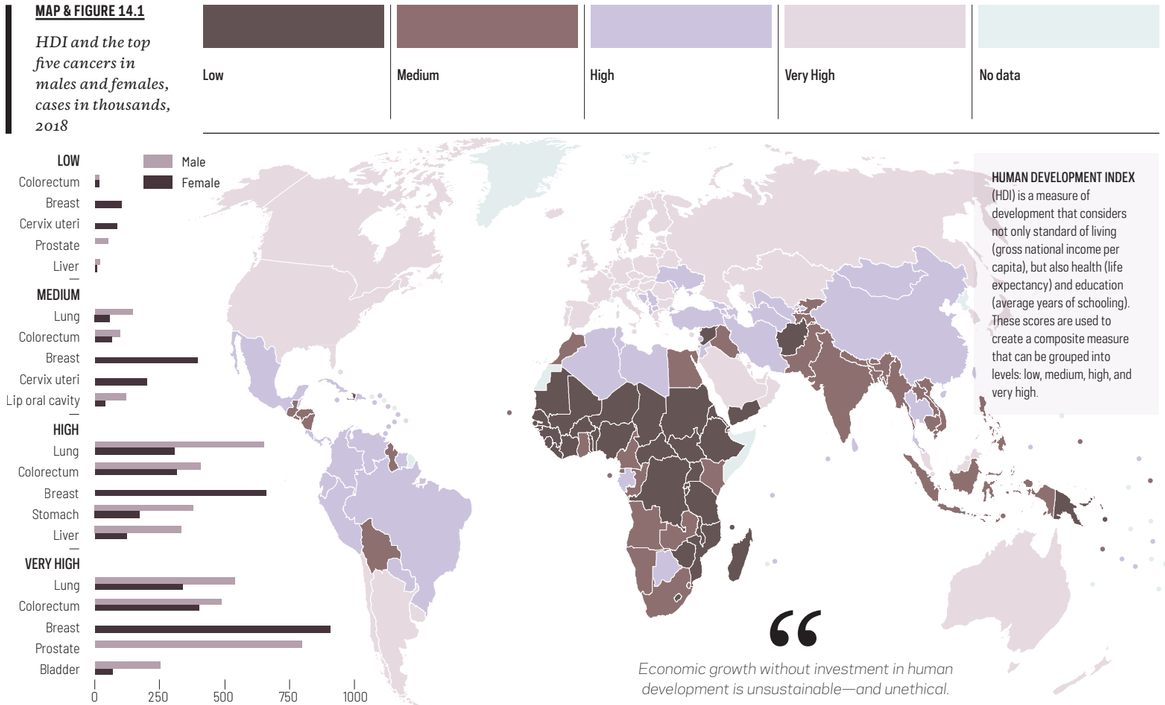
*Most commonly diagnosed cancers and leading causes of cancer death (%) by four-tier HDI plus India and China**



*India and China are not included in HDI categories

MAP & FIGURE 14.1

HDI and the top five cancers in males and females, cases in thousands, 2018



HUMAN DEVELOPMENT INDEX (HDI) is a measure of development that considers not only standard of living (gross national income per capita), but also health (life expectancy) and education (average years of schooling). These scores are used to create a composite measure that can be grouped into levels: low, medium, high, and very high.

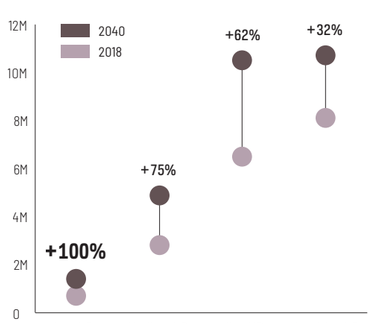
By 2040, the cancer burden will double in low-HDI countries, which are least equipped to deal with the pending cancer epidemic.

Economic growth without investment in human development is unsustainable—and unethical.

— Amartya Sen, awarded the Nobel Prize in Economics.

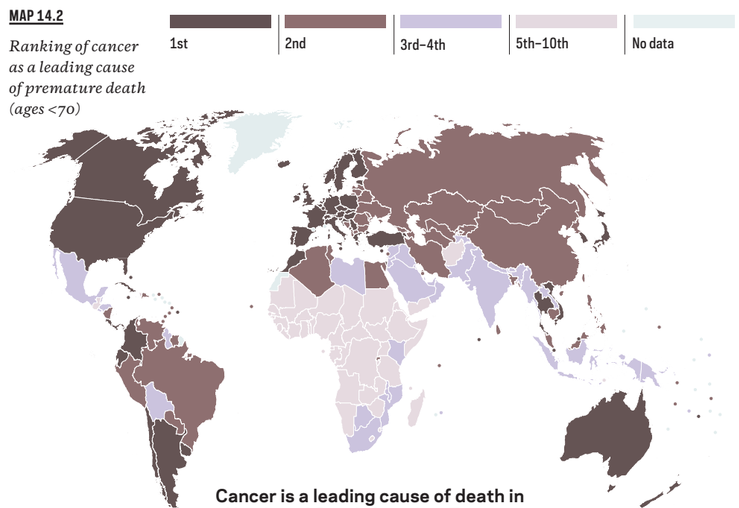
FIGURE 14.4

Estimated millions of new cancer cases in 2018 and the projected increase by 2040 by four-tier HDI level, assuming only a demographic effect



MAP 14.2

Ranking of cancer as a leading cause of premature death (ages <70)



Cancer is a leading cause of death in North and South America, Europe, Australia, North Africa, and parts of Asia.

CANCER IN INDIGENOUS POPULATIONS

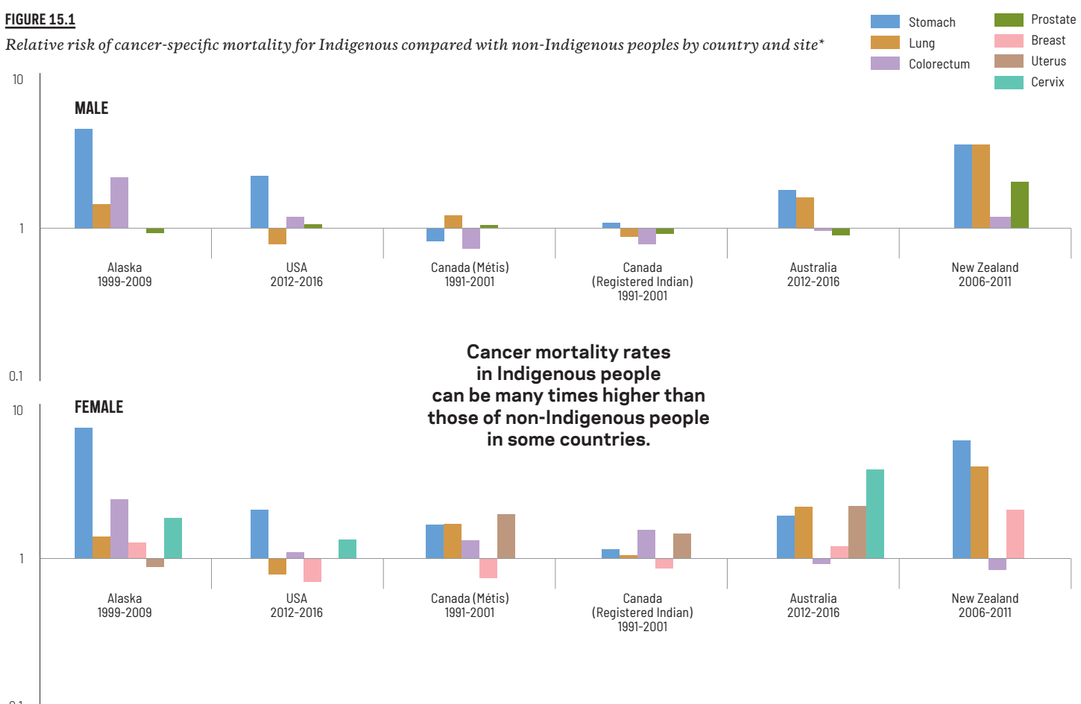
Higher prevalence of risk factors, poor outcomes, and under-reporting are among the cancer control challenges for Indigenous peoples.

There are more than 370 million Indigenous people spanning at least 70 countries worldwide. Indigenous peoples generally face disadvantage and have worse health than non-Indigenous people. Data related to cancer in these populations tend to be absent or of poor quality making many Indigenous peoples statistically invisible, with the majority of data that exist coming from a few high-income countries. There is under-reporting of cancer incidence and mortality in many jurisdictions. Indigenous peoples often have higher incidence and mortality rates of cancers related to exposure to tobacco, alcohol, poor diet, physical inactivity, high BMI, and diabetes mellitus than non-Indigenous people living in the same countries, although cancer patterns vary from country to country. **FIGURE 15.1** Cancer-causing infections such as *Helicobacter pylori* and hepatitis B virus, which are related to poverty and overcrowding, tend to be higher in Indigenous populations, particularly in regions where vaccination for hepatitis B is not occurring. **FIGURE 15.2** Further, survival after diagnosis is lower, and its improvement is slower in Indigenous populations, suggesting Indigenous populations have not benefited equally from advances in early detection and treatment. Comprehensive, sustained efforts centered around indigenous leadership and participation are needed to improve cancer outcomes for Indigenous peoples. Cancer control planning by and for Indigenous peoples is progressing in some jurisdictions.

THE WORLD HEALTH ORGANIZATION HAS CALLED FOR THE ELIMINATION OF CERVICAL CANCER.
While disease burden is highest in lower- and middle-income countries, significant disparities exist in high-income countries. In Australia, cervical cancer incidence in Indigenous women is double that of non-Indigenous women, with mortality rates over three times higher. Strategies and actions needed to accelerate cervical cancer elimination for Indigenous women globally must be led by Indigenous women and form part of the draft global strategy tabled at the 2020 World Health Assembly.

FIGURE 15.1

*Relative risk of cancer-specific mortality for Indigenous compared with non-Indigenous peoples by country and site**

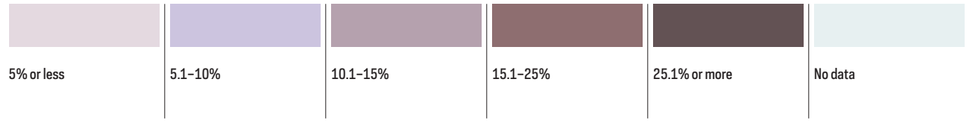


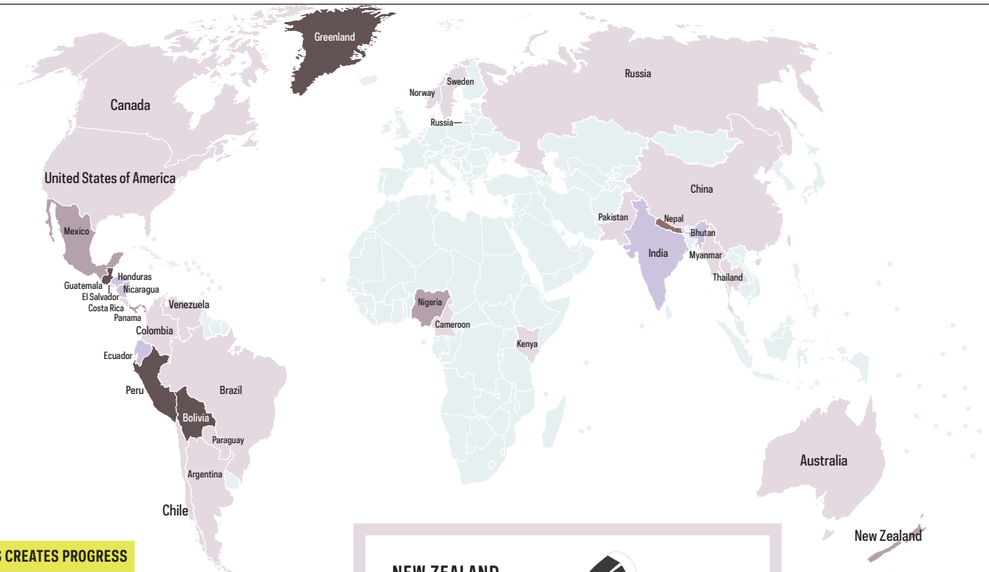
Cancer mortality rates in Indigenous people can be many times higher than those of non-Indigenous people in some countries.

*Source varies by country. See Sources and Methods, page 116

MAP 15.1

Indigenous peoples as percent of total population, 2010 or most recent data year





ACCESS CREATES PROGRESS

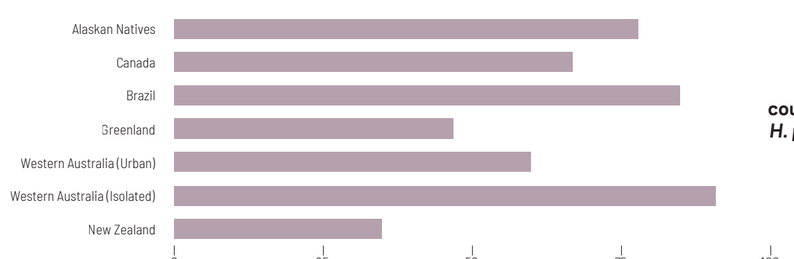
New Zealand is the only country in the world that routinely records and reports national-level cancer statistics for its Indigenous population.

NEW ZEALAND
INDIGENOUS MĀORI PEOPLE

Hei Ahuru Mowai, Aotearoa/New Zealand's Indigenous Māori cancer leadership group, aims to influence national cancer policy by ensuring participation and engagement with Māori from policy development to implementation across the cancer control continuum. The group has representatives on most of the country's cancer groups and also partnered with the Ministry of Health on a Cancer and Racism seminar which will inform a new national cancer strategy. Hei Ahuru Mowai is currently working with the National Bowel Screening Programme to ensure equity is addressed in its national roll-out.

FIGURE 15.2

Prevalence (%) of H. pylori *among Indigenous peoples, select studies**



Indigenous peoples in many countries have a high prevalence of *H. pylori*, an infection which causes stomach cancer.

OVERVIEW OF GEOGRAPHIC DIVERSITY

The diversity in cancer profiles in different world areas signifies that both regional cooperation and local, evidence-based interventions are needed in the fight against cancer.

There are striking geographic differences in the incidence and mortality of different cancer types in different world regions. This global diversity reflects both the presence of local risk factors for specific cancers, and the extent to which effective cancer control measures have been implemented. Much of the observed variation in recorded incidence rates of different cancer types in different registry populations can be ascribed to lifestyle and environmental factors. **FIGURE 16.1** Such marked international variability supports the critical role of cancer prevention as a means to reduce the future cancer burden. Although specific causes remain unknown for many cancers, where measured, about two-fifths of cancers diagnosed today are potentially avoidable. Prevention measures include eliminating exposure to known lifestyle and environmental risk factors, including tobacco and alcohol, dietary factors, excess body weight, and UV radiation, and increasing resistance to infection by vaccination. However, the proportion of cancer cases avoidable—overall and for specific risk factors—substantially varies by region. For example, infection accounts for 30–50% of all cases in sub-Saharan Africa, whereas this proportion is only 3–5% in Europe and North America.

The most frequently diagnosed cancers and leading causes of cancer death at the national level reflect the major risk factors in the population and the average prognosis of the major cancers observed. **MAP 16.1**, **16.2** Certain cancers dominate the global landscape, particularly in women: female breast cancer is the most frequent cancer in four-fifths of the world's nations, with cervical cancer ranking most frequent in the majority of remaining countries, particularly in sub-Saharan Africa. The mortality profile among women is slightly more heterogeneous, with lung cancer also a leading cause of death.

Among men, there is considerable international diversity in the leading cancer types, with around 10 different cancers as the most commonly diagnosed cancer or leading cause of cancer death. Prostate, lung, and liver cancer are major cancers in men, although other cancers dominate in some regions (lip and oral cavity in South Asia and Kaposi sarcoma in Eastern Africa). Nevertheless, lung cancer is the leading cause of cancer death among men in over half of the world's countries.

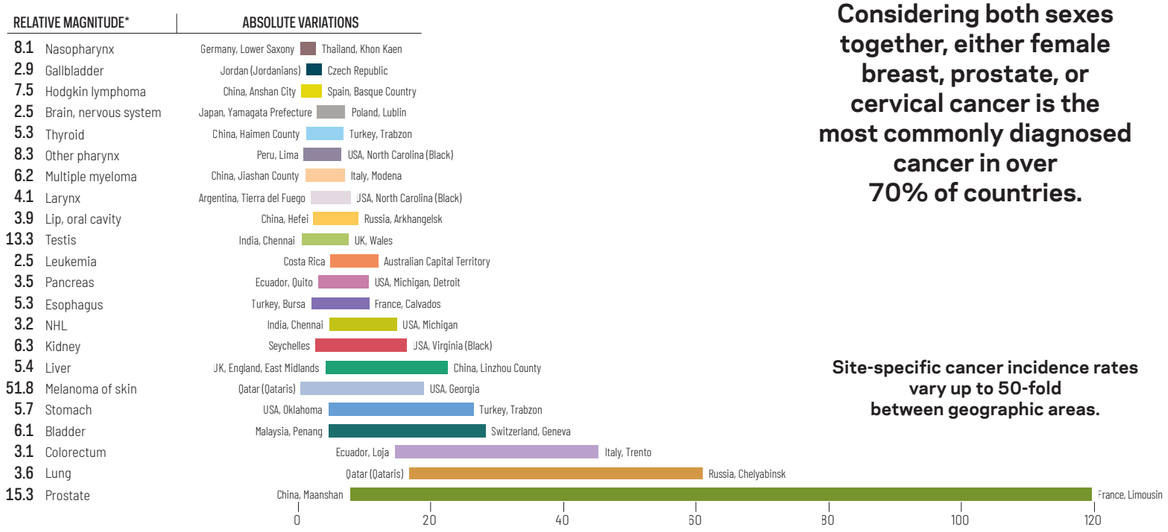
> *Cancer varies between different populations, and every type is rare in some part of the world. Many specific causes are now known (to explain these differences), but a large proportion of global variation for common cancers remains unexplained.*
>
> *— Prof. Julian Peto, Nature, 2001*

Considering both sexes together, either female breast, prostate, or cervical cancer is the most commonly diagnosed cancer in over 70% of countries.

Site-specific cancer incidence rates vary up to 50-fold between geographic areas.

FIGURE 16.1

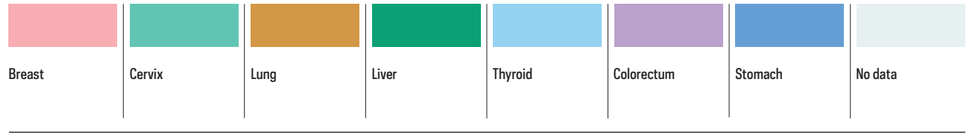
Relative and absolute global variations in incidence rates of registry populations included in CI5 Volume XI (circa 2008–12); rates shown are those within the 10th and 90th percentiles in males

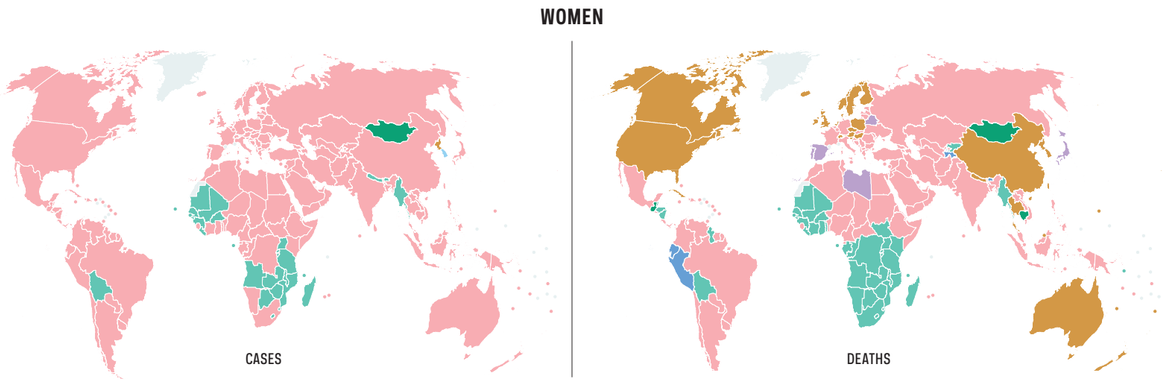


*Relative magnitude is the rate in the 90th percentile divided by the rate in the 10th percentile.

MAP 16.1

The most common cancer cases and deaths in women in 185 countries in 2018

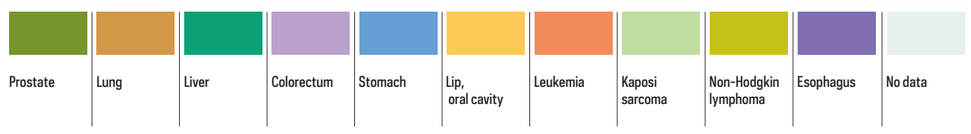


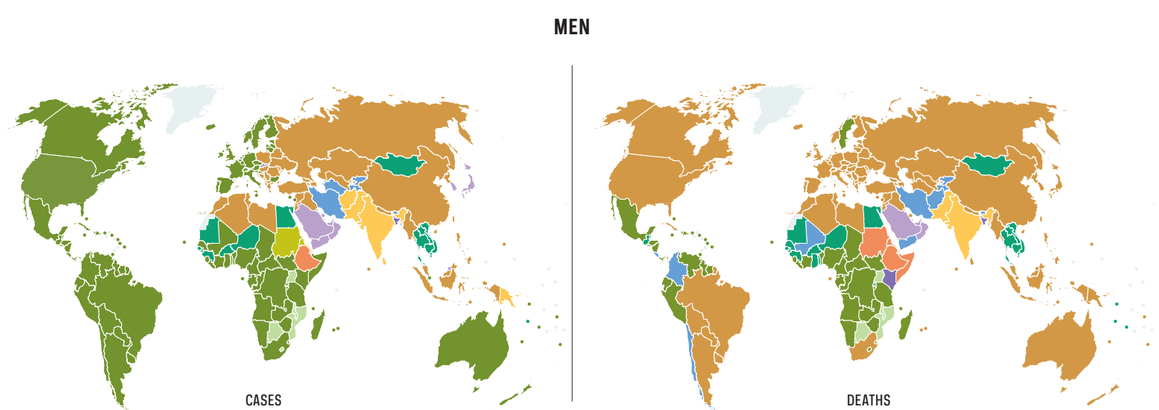


Breast and cervical cancer are the most frequently diagnosed cancers and leading causes of cancer death in many countries in women. Lung cancer is also a leading cause of cancer death in many countries.

MAP 16.2

The most common cancer cases and deaths in men in 185 countries in 2018





While prostate cancer is the most commonly diagnosed cancer among men in 106 countries worldwide, lung cancer dominates as the leading cause of cancer death in 93 countries.

Regional Diversity

SUB-SAHARAN AFRICA

Up to 50% of the cancers diagnosed in some countries in Eastern Africa are still related to infection, and these are largely preventable.

An estimated 752,000 new cancer cases (4% of the global total) and 506,000 cancer deaths occurred in sub-Saharan Africa in 2018. Although the overall cancer burden in the region is dominated by breast, cervical, and prostate cancers, the cancer profile in sub-Saharan Africa is quite diverse. **MAP 17.1**

The most common cancers in men are prostate (69,000 cases, or 23% of all cancers) and liver cancers (24,000 cases, or 8% of all cancers) as well as Kaposi sarcoma (20,000 cancers, 7%). Breast (115,000 cases, 25% of all cancers) and cervical cancers (112,000 cases, 24%) are the most frequently diagnosed cancers in women. **FIGURE 17.1**, **17.2**

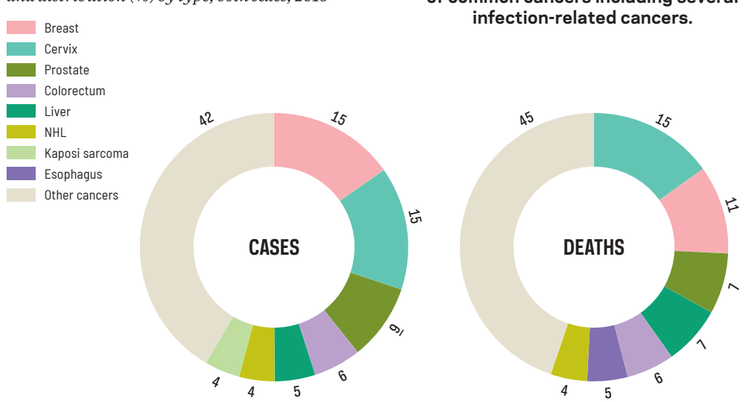
Incidence rates have been increasing for several major cancer sites. For example, cervical cancer rates increased by 80% in Zimbabwe and 36% in South Africa, although they have risen and declined recently in Uganda. **FIGURE 17.3** Major increases have been seen for breast as well as for prostate cancers where they have been measured, doubling in Zimbabwe (breast) and South Africa (both cancers) over the last 15 years. While the cause of elevated rates for certain cancers such as esophagus is still largely unknown, a westernization of lifestyle (e.g. dietary habits, fertility, excess body weight, and physical inactivity) has been related to observed increases in breast cancer, and is expected to give rise to increases in rates of other cancers such as colorectum. An improved awareness and increased capacity to perform prostatectomies on older men has been suggested to be linked to the increase in prostate cancer rates.

There is a large opportunity for cancer prevention and control programs to improve health outcomes in the region. Comparing incidence and mortality rates of all cancers combined across countries, large disparities in terms of incidence-to-mortality ratios are apparent. **FIGURE 17.4** Large differences between incidence and mortality suggest poor outcomes and substantial case-fatality from cancers. Yet primary prevention remains key in sub-Saharan Africa, where there is a need to prioritize the most cost-effective means of reducing the cancer burden. Improved access to diagnosis and treatment, including palliative care, is also essential to improve survival and limit suffering from the disease in the region.

FIGURE 17.1

Estimated number of new cancer cases vs. deaths and distribution (%) by type, both sexes, 2018*

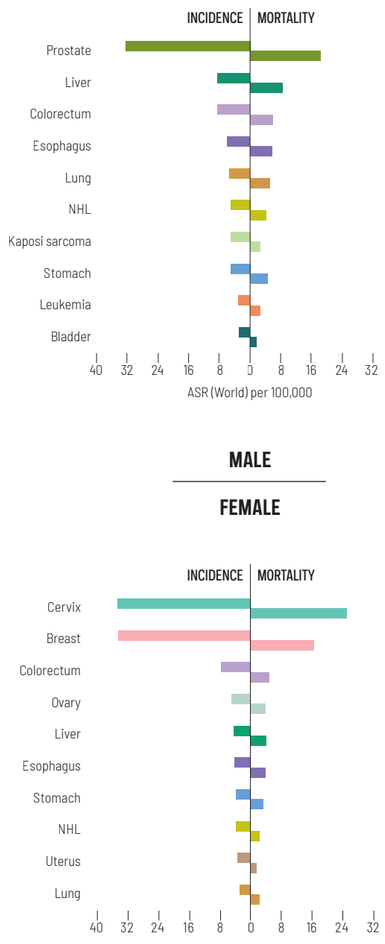
Sub-Saharan Africa has a unique mix of common cancers including several infection-related cancers.



*Excludes non-melanoma skin cancer.

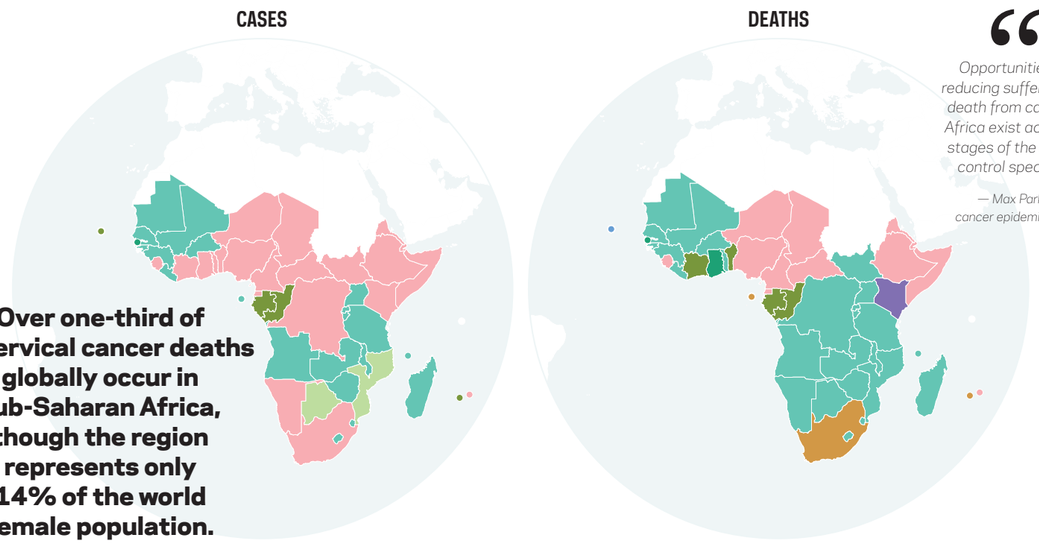
FIGURE 17.2

Incidence and mortality rates of the most common cancers in sub-Saharan Africa in males and females, 2018



MAP 17.1

The most common cancer cases and deaths in sub-Saharan Africa, both sexes combined, 2018



> *Opportunities for reducing suffering and death from cancer in Africa exist across all stages of the cancer control spectrum.*
>
> *— Max Parkin, cancer epidemiologist*

FIGURE 17.3

Trends in incidence rates in selected countries in sub-Saharan Africa

Rates for several major cancers are increasing.

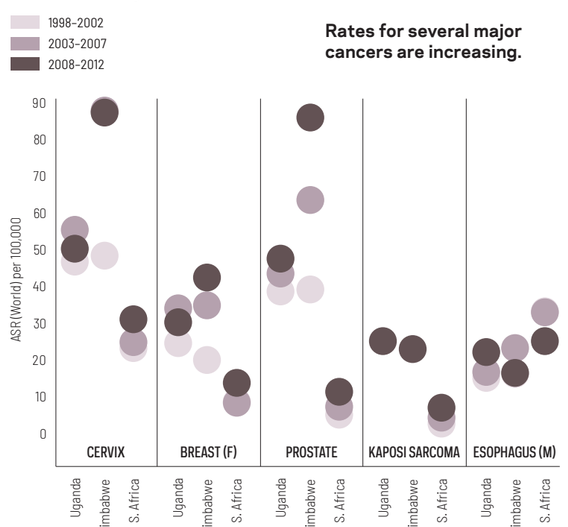
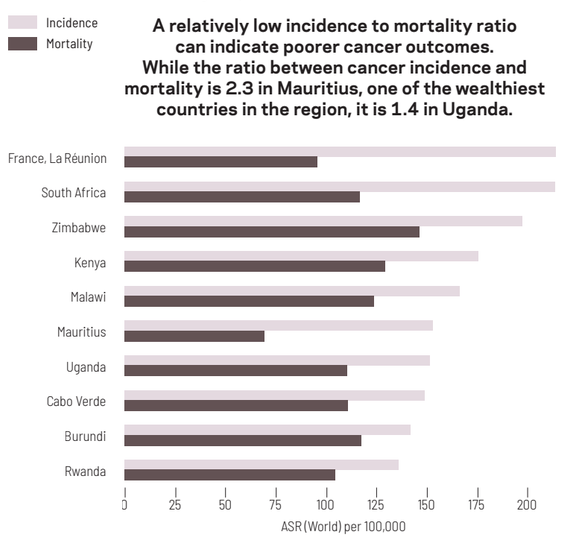


FIGURE 17.4

Incidence and mortality rates in selected countries in sub-Saharan Africa, 2018

A relatively low incidence to mortality ratio can indicate poorer cancer outcomes. While the ratio between cancer incidence and mortality is 2.3 in Mauritius, one of the wealthiest countries in the region, it is 1.4 in Uganda.



Regional Diversity

LATIN AMERICA & THE CARIBBEAN

Prostate, breast and colorectal cancer are the main cancers in the region.

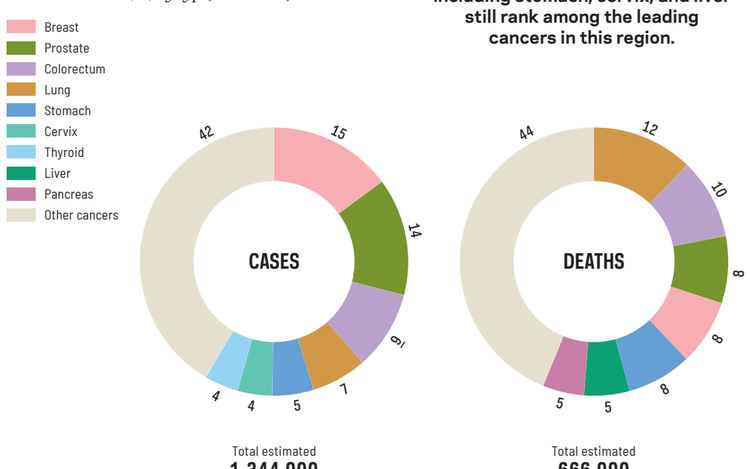
About 1.3 million new cancer cases and 666,000 cancer deaths were estimated to have occurred in 2018 in Latin America and the Caribbean. The five most common cancers in 2018 were female breast (200,000 new cases, 15% of all cancer cases), prostate (190,000, 14%), colorectal (128,000, 9%), lung (90,000, 7%) and stomach cancer (67,000, 5%). Lung cancer is the leading cause of death (81,000, 12%), followed by colorectal (65,000 10%), prostate (54,000, 8%), female breast (53,000, 8%) and stomach (52,000, 8%). **FIGURE 18.1**

Incidence and mortality rates for all cancers combined (except non-melanoma skin) reveal the extent of variation between countries, with incidence rates varying (in both sexes) from 263 (per 100,000) in Uruguay to 105 in Guyana, and mortality from 130 in Uruguay to 61 in Mexico. **FIGURE 18.2** The lifetime risk of being diagnosed with cancer ranges from 26% (1 in 4 persons) in Uruguay to 11% (1 in 10 persons) in Guyana. The corresponding cancer mortality risk ranges from 14% (1 in 7 persons) in Uruguay to 7% (1 in 15 persons) in Mexico. There are marked variations in the incidence and mortality rates of specific cancers across countries: for example, cervical cancer varies six-fold for incidence, from 39 per 100,000 in Bolivia to 7 in Guadeloupe, and a striking 15-fold for mortality, from 19 in Jamaica to 1 in Martinique. While the highest prostate cancer incidence rates are seen in the Caribbean, with 189 per 100,000 in Guadeloupe, the lowest are estimated in Honduras (25). In Bolivia, the most common cause of cancer death is gallbladder cancer. **MAP 18.1**

In some countries with longstanding cancer registries, there is evidence of moderate increases in all-cancer incidence rates; this is mainly due to an upwards trend in incidence rates of the most common cancer types, including female breast, colorectal and prostate cancer—coinciding with marked declines in stomach and cervical cancer. **FIGURE 18.3**, **18.4** In contrast, overall cancer mortality rates are stabilizing or in decline in most countries during the most recent decade, driven by favorable mortality trends for major cancers in the region, except colorectal cancer, for which rates are rising in many countries. While lung cancer mortality rates in men are decreasing in many countries, they are still increasing in women. Bolivia and Chile exhibit the highest incidence rates of gallbladder cancer worldwide (14 and 9 per 100,000, respectively), possibly related to specific types of indigenous ancestry.

FIGURE 18.1

Estimated number of new cancer cases vs. deaths and distribution (%) by type, both sexes, 2018*

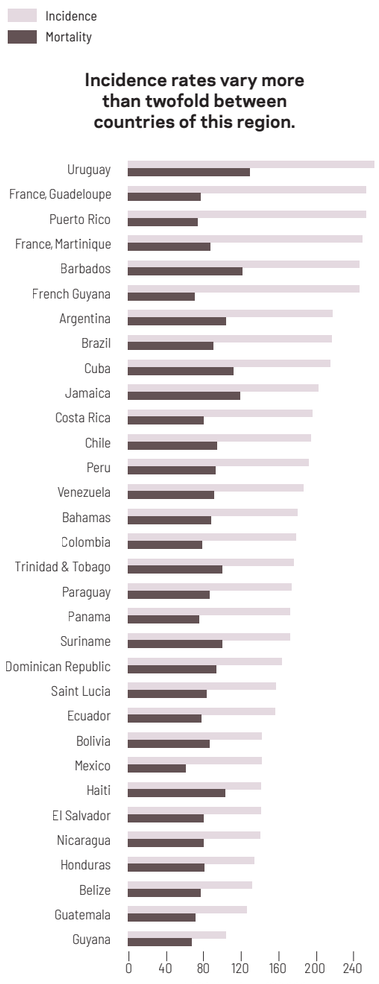


Infection-related cancers including stomach, cervix, and liver still rank among the leading cancers in this region.

*Excludes non-melanoma skin cancer.

FIGURE 18.2

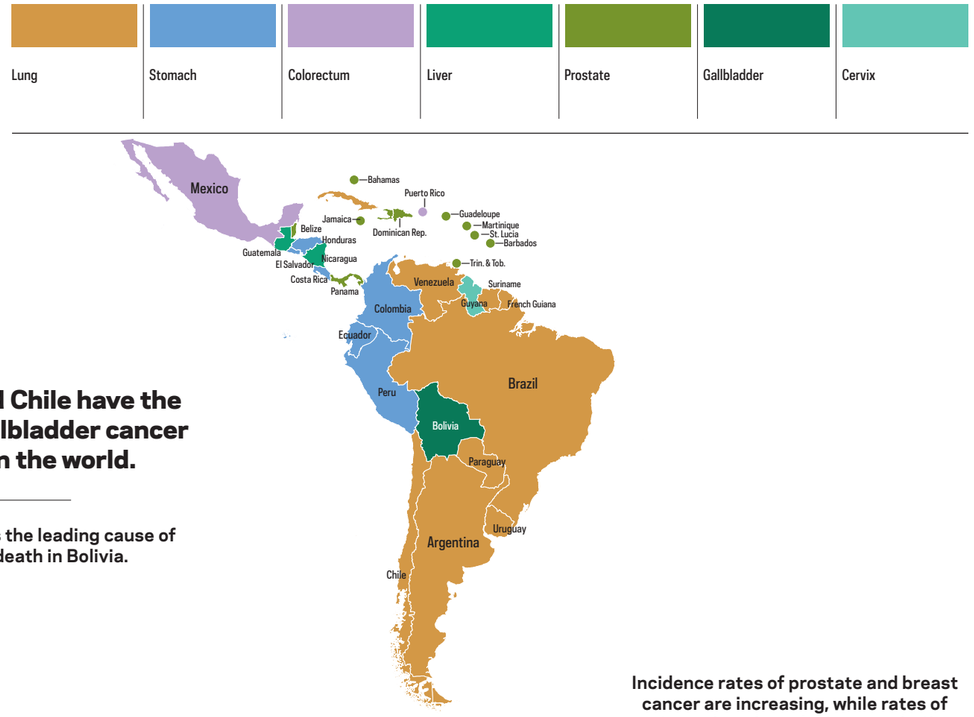
All cancer sites combined incidence and mortality rates in Latin America and the Caribbean, both sexes, all ages, 2018



Incidence rates vary more than twofold between countries of this region.

MAP 18.1

Leading cause of cancer death in Latin America and the Caribbean, both sexes, 2018



Bolivia and Chile have the highest gallbladder cancer rates in the world.

Gallbladder is the leading cause of cancer death in Bolivia.

Incidence rates of prostate and breast cancer are increasing, while rates of stomach and cervical cancer, both related to infection, are decreasing.

FIGURE 18.3

Incidence trends in selected countries in Latin America, prostate and breast cancer, all ages, 1982-2012

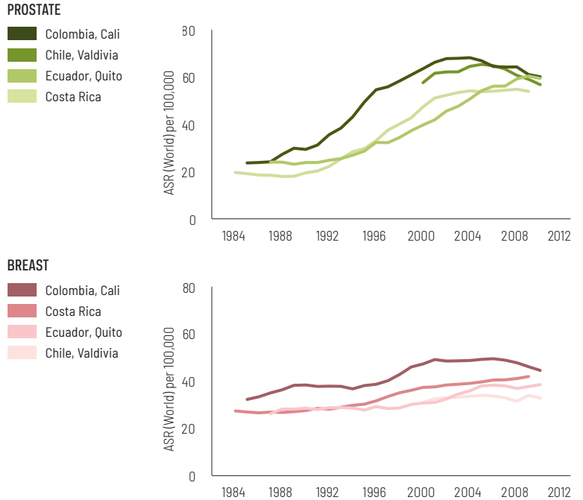
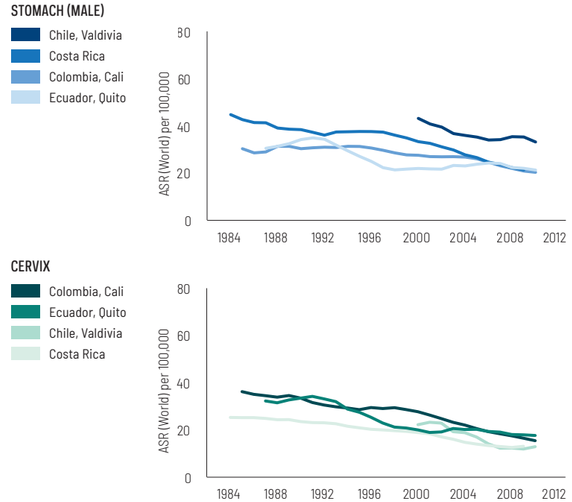


FIGURE 18.4

Incidence trends in selected countries in Latin America, stomach and cervical cancer, all ages, 1982-2012



Regional Diversity

NORTHERN AMERICA

Lung cancer remains the leading cause of cancer death in Northern America, despite decades of declines in smoking prevalence.

Cancer is the leading cause of death in Canada and the second-leading cause, after heart disease, in the USA. About 1.9 million new cancer cases and 693,000 cancer deaths were estimated to have occurred in Northern America in 2018. The most commonly diagnosed cancers are prostate in males and breast in females, while lung cancer remains the most common cause of cancer death in both sexes. **FIGURE 19.2**

Patterns in cancer occurrence are similar in the USA and Canada, reflecting the shared prevalence of behaviors associated with disease risk. Incidence is relatively low for infection-related cancers, and high for cancers associated with lifestyle "westernization". For example, Northern America has among the highest incidence of colorectal cancer worldwide. However, because this cancer is amenable to primary prevention and treatment, there is substantial socioeconomic and geographic variation in incidence and mortality within the region. **MAP & FIGURE 19.1** For instance, incidence rates of colorectal cancer are two-fold higher among residents of the North and Atlantic regions of Canada than among residents in the Western US, largely because of differences in risk factor exposures and access to screening.

Cancer trends in the two countries are likewise comparable, with mortality rates declining continuously for more than two decades because of improvements in prevention, early detection, and treatment. Progress against tobacco-related diseases as a result of reductions in smoking is reflected in declines for lung cancer, which are slower and more prolonged among women than men because of later uptake of smoking and slower cessation. **FIGURE 19.3** Colorectal cancer incidence rates have decreased by almost 40% since 2000 in adults 50 and older, largely because of increased screening, which allows for removal of precancerous polyps. **FIGURE 19.4** In contrast, rates are rising in young adults for cancers associated with excess body weight, such as colorectal and endometrial cancers, foreshadowing the health effects of the obesity epidemic. **FIGURE 19.5**

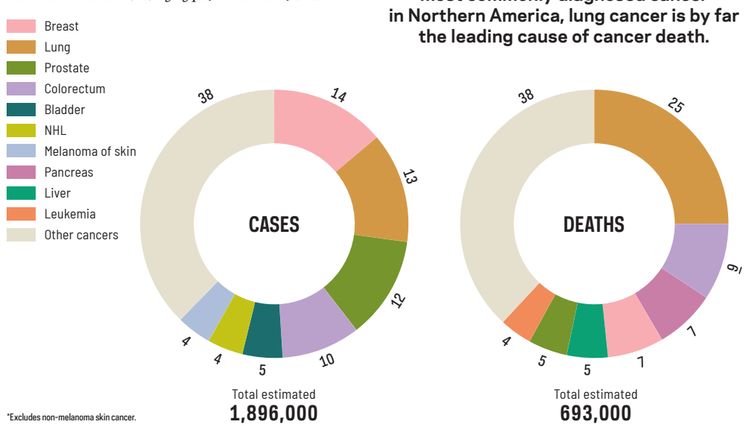
> *The crisis is obesity. It's the fastest-growing cause of disease and death in America. And it's completely preventable.*
>
> *— Dr. Richard H. Carmona, US Surgeon General*

Three in five endometrial cancers in the USA are caused by excess body weight.

FIGURE 19.2

Estimated number of new cancer cases vs. deaths and distribution (%) by type, both sexes, 2018*

While breast cancer is the most commonly diagnosed cancer in Northern America, lung cancer is by far the leading cause of cancer death.

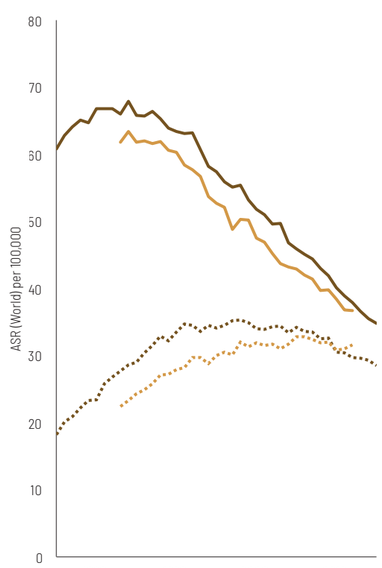


*Excludes non-melanoma skin cancer.

FIGURE 19.3

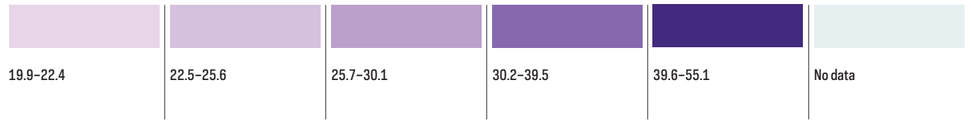
Lung cancer incidence trends by sex in the United States and Canada, 1975-2015

Progress in lung cancer incidence in Northern America is the result of declines in smoking that began decades earlier.

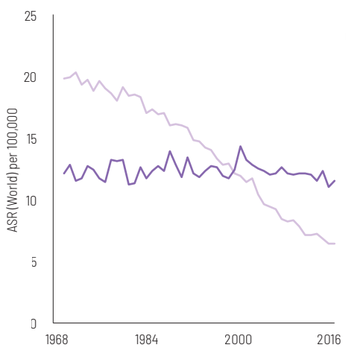


MAP & FIGURE 19.1

Colorectal cancer incidence in Northern America, age-standardized rate (world) per 100,000, both sexes, 2011-2015



Trends in colorectal cancer mortality in Massachusetts and Mississippi, 1970-2016



There are wide differences in progress against colorectal cancer incidence and mortality in Northern America.

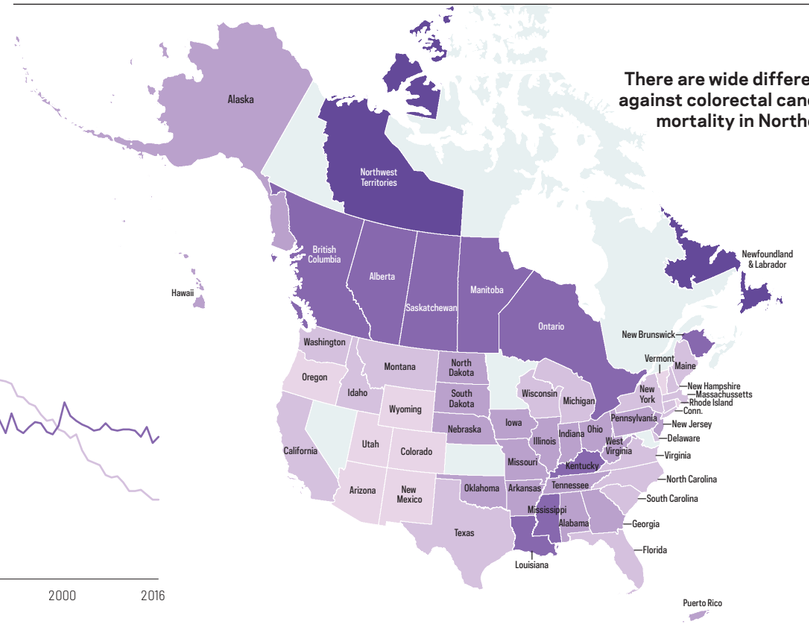
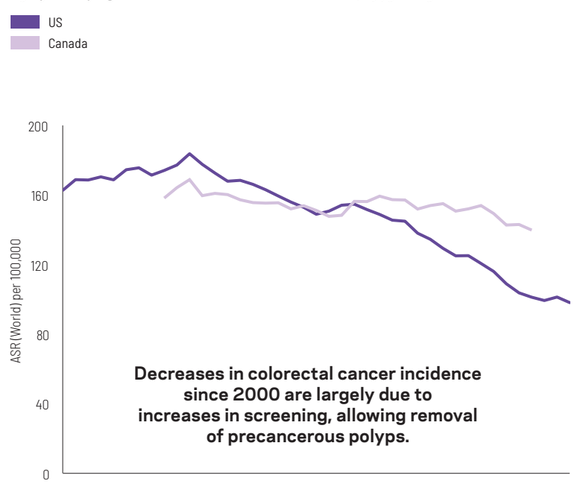


FIGURE 19.4

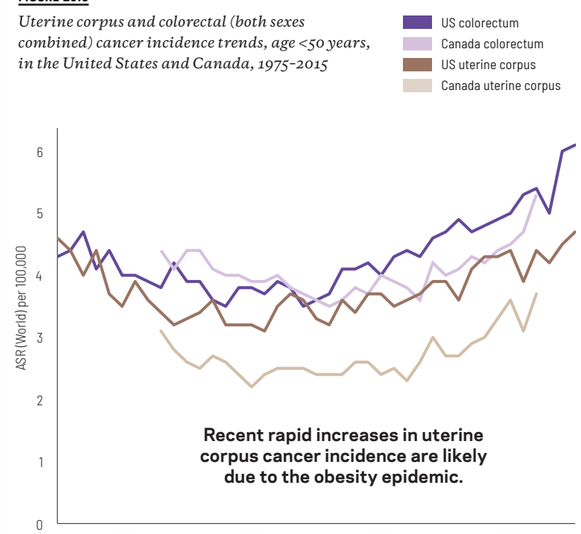
Colorectal cancer incidence trends among adults ≥50 years of age in the United States and Canada, 1975-2015



Decreases in colorectal cancer incidence since 2000 are largely due to increases in screening, allowing removal of precancerous polyps.

FIGURE 19.5

Uterine corpus and colorectal (both sexes combined) cancer incidence trends, age <50 years, in the United States and Canada, 1975-2015



Recent rapid increases in uterine corpus cancer incidence are likely due to the obesity epidemic.

Regional Diversity

SOUTHERN, EASTERN & SOUTH-EASTERN ASIA

Lung, breast, and colorectal cancers are common in this region, in addition to liver and stomach cancers, which are associated with infection.

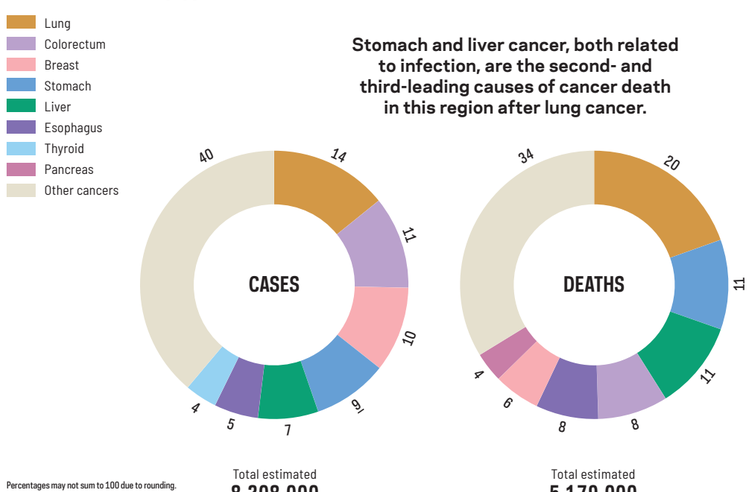
Southern, Eastern, and South-Eastern Asia is a diverse, densely populated region with 4.2 billion inhabitants, making up 55% of the world population. In 2018, 8.2 million new cancer cases and 5.2 million cancer deaths were estimated in the region, corresponding to around half of the cancer burden worldwide. China alone accounts for 52% of new cancer cases (4.3 million) and 55% of cancer deaths (2.9 million) in the region. Overall, cancers of the lung (1,166,200 new cases, 15% of all cases), colorectum (914,200, 11%) and female breast (845,400, 10%) are the most common cancers. **FIGURE 20.1** Lung cancer remains the leading cause of death (1,013,100 deaths, 21% of all deaths), followed by stomach (560,500, 11%) and liver cancer (554,000, 11%).

Cancer rates in the region vary widely, with nearly a fourfold difference across countries. **MAP 20.1** Incidence rates are higher in South-Eastern Asia, and highest in the overall region in the Republic of Korea (314 cases per 100,000 population). In contrast, lower rates are seen in many countries in South Asia, including Bhutan, Sri Lanka, and India (fewer than 90 cases per 100,000). Mortality rates followed a similar pattern by subregion: Mongolia (170 per 100,000) and China (130) had the highest mortality rates, whereas Sri Lanka (51) and India (61) had the lowest rates.

While female breast cancer is the most commonly diagnosed cancer in nearly all countries among women in Asia, marked differences in the cancer profiles are observed among males according to subregion. For example, cancer of the oral cavity is a common cancer in much of South and South-East Asia, and a number of countries in this region (India, Sri Lanka) exhibit among the highest rates in the world, **FIGURE 20.2** largely as a result of the high usage of smokeless tobacco products. In South-Eastern and Eastern Asia, two infection-related cancers (liver and stomach cancers) continue to be among the most commonly diagnosed cancers and leading causes of cancer death among males. **FIGURE 20.3**

FIGURE 20.1

Estimated number of new cancer cases vs. deaths and distribution (%) by type, both sexes, 2018*

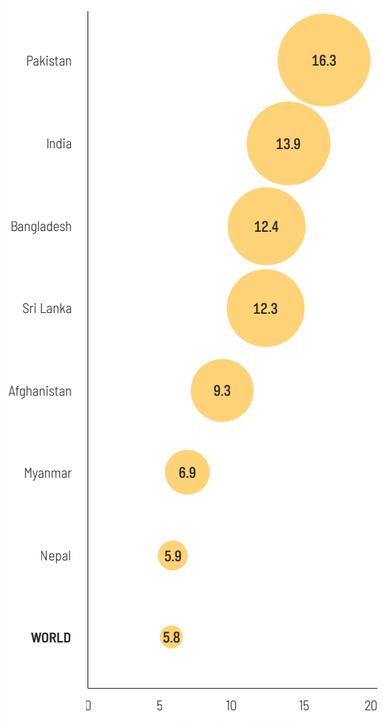


Percentages may not sum to 100 due to rounding.
*Excludes non-melanoma skin cancer.

FIGURE 20.2

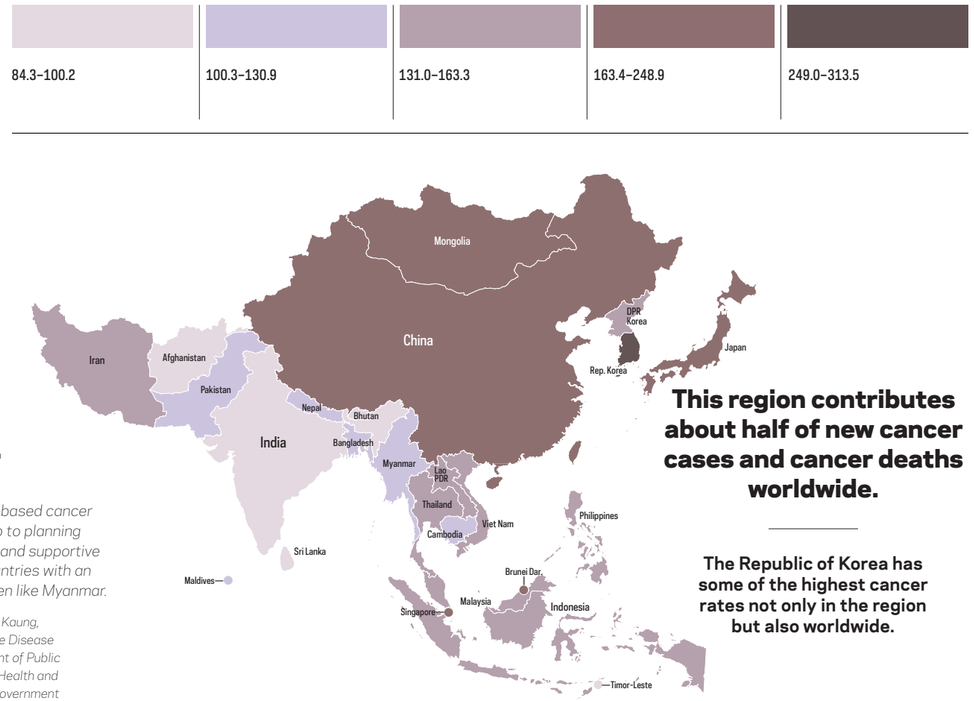
Highest lip and oral cavity cancer incidence rates in Southern, Eastern, and South-Eastern Asia, males, 2018

Due to the high use of smokeless tobacco products, rates of lip and oral cavity cancers in some countries in this region are up to three times higher than the global average.



MAP 20.1

All cancer sites combined incidence rates in Southern, Eastern, and South-Eastern Asia, age-standardized rate (world) per 100,000, both sexes combined, 2018



> *Accurate population-based cancer data are a first step to planning prevention, treatment and supportive care programs in countries with an increasing cancer burden like Myanmar.*
>
> *— Dr. Kyaw Kan Kaung, Non-communicable Disease Director, Department of Public Health, Ministry of Health and Sports, Myanmar Government*

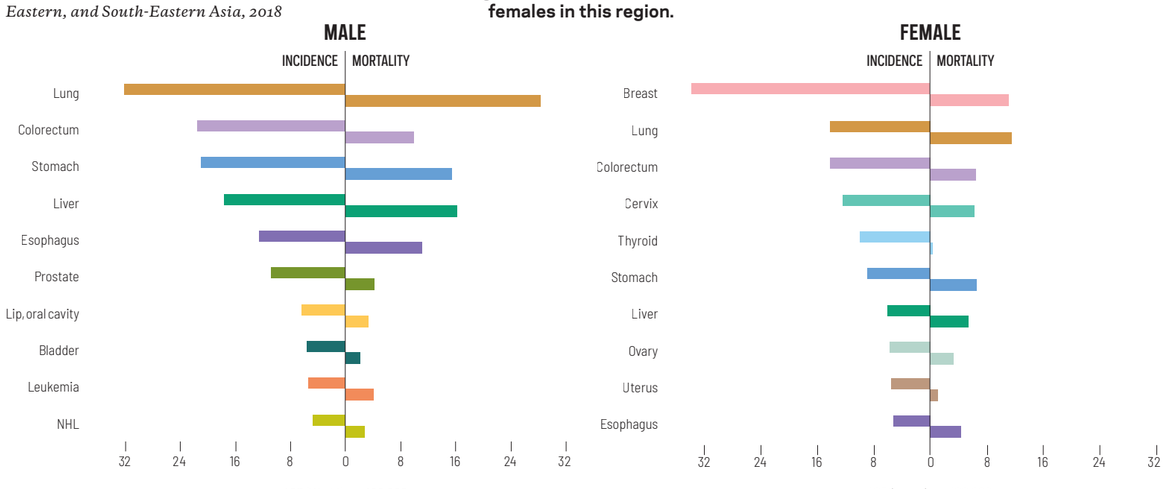
This region contributes about half of new cancer cases and cancer deaths worldwide.

The Republic of Korea has some of the highest cancer rates not only in the region but also worldwide.

FIGURE 20.3

Incidence and mortality rates for the most common cancers in Southern, Eastern, and South-Eastern Asia, 2018

Mortality rates are highest for lung cancer in both males and females in this region.



Regional Diversity

EUROPE

Breast, prostate, lung, and colorectal cancers represent over half of all cancer diagnoses in Europe.

> *The diverging health trends (including cancer) in Europe are a testimony to both the successes and failures of health policy in Europe.*
>
> *— Johan Mackenbach, Professor of Public Health at Erasmus MC, and Martin McKee, Professor of European Public Health at the London School of Hygiene and Tropical Medicine*

There were an estimated 3.9 million new cancer cases and 1.9 million cancer deaths in Europe in 2018. Cancers of the female breast (523,000 new cases, 13% of all cancer cases), colorectum (500,000, 13%), lung (470,000, 12%), and prostate (450,000, 12%) were the most common cancers on the continent, and combined they represented almost half of the overall cancer burden. **FIGURE 21.1** For men, prostate cancer was the most commonly diagnosed cancer in almost all northern and western European countries, and lung cancer was the most commonly diagnosed in most Eastern European countries. For women, breast cancer is the most commonly diagnosed cancer in all European countries. **MAP 21.1** These cancers were also the leading causes of cancer death in Europe: lung (388,000 deaths, 20%), colorectum (242,000, 13%), female breast (138,000, 7%), and pancreas (128,000, 7%).

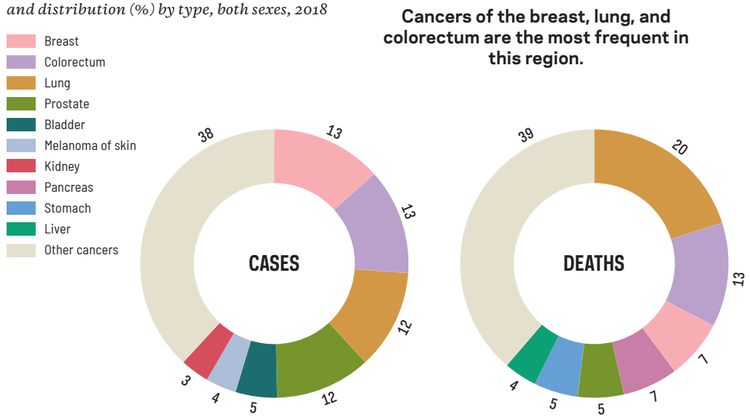
Substantial variation in incidence and mortality rates are observed at the national level, where cancer incidence rates in males vary from 430 per 100,000 in Ireland to 239 in Montenegro. The lifetime risk of a cancer diagnosis ranges from 35% in Ireland—indicating that 1 in 3 persons in Ireland will be diagnosed with cancer over the course of their lifetime—to 25%, or 1 in 4 persons, in Montenegro. **FIGURE 21.2** Similarly, a twofold difference in rates is seen for mortality, with the highest and lowest mortality rates observed in Hungary and Sweden, respectively. The risk of dying from cancer in men varied from 22% in the Republic of Moldova to 10% in Iceland, and in women from 13% in Hungary to 7% in Spain.

Incidence trends for all cancer sites combined have continued to rise in many countries, although at a slower pace in recent years. This slower increase partly results from a stabilization or decline in breast and prostate cancers, countered by an increase in colorectal cancer. **FIGURE 21.3** On the other hand, overall cancer death rates are steadily decreasing in Europe, mainly due to decreasing death rates from breast and prostate cancers as well as lung (male only, particularly in Northern and Western Europe). In Central and Eastern European men, lung cancer incidence and mortality rates are beginning to stabilize or decline. But in women across Europe, who for the most part acquired the smoking habit several decades after men, lung cancer rates are still rising, though there are early signs of stabilization in recent years in some countries, notably in the highest-risk countries of Northern Europe.

FIGURE 21.1

Estimated number of new cancer cases vs. deaths and distribution (%) by type, both sexes, 2018*

Cancers of the breast, lung, and colorectum are the most frequent in this region.



Total estimated **3,911,000**

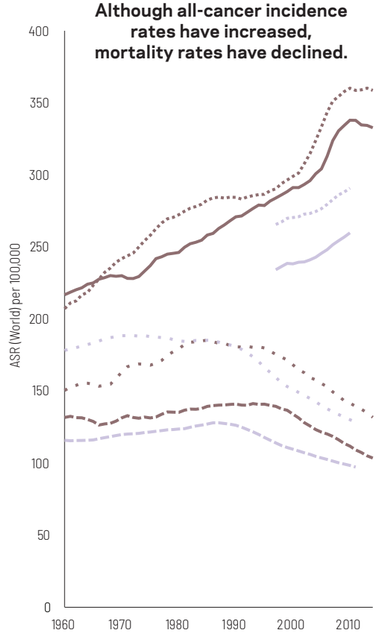
Total estimated **1,930,000**

*Excludes non-melanoma skin cancer.

FIGURE 21.3

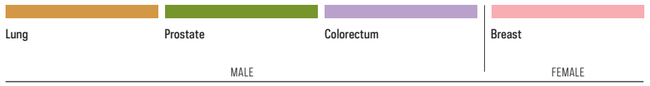
Trends in all cancer sites combined in Denmark and the United Kingdom**, 1960–2014*

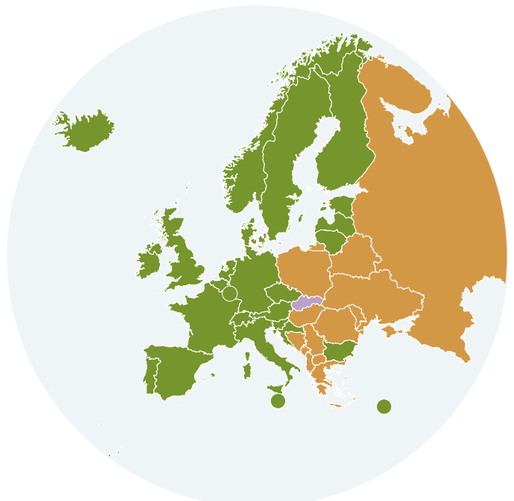
Although all-cancer incidence rates have increased, mortality rates have declined.



**Incidence is UK, England only

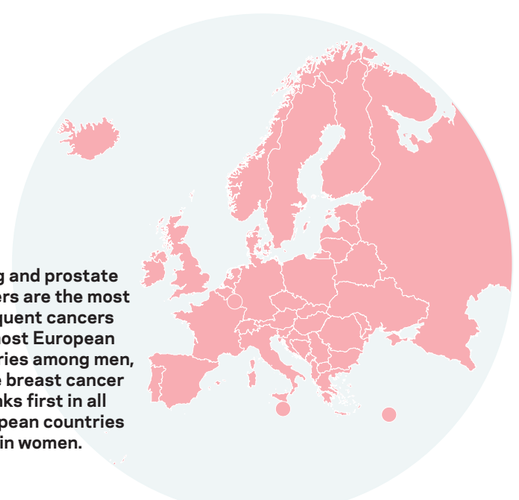
MAP 21.1 *Most commonly diagnosed cancers in Europe among males and females, 2018*





MALE

FEMALE



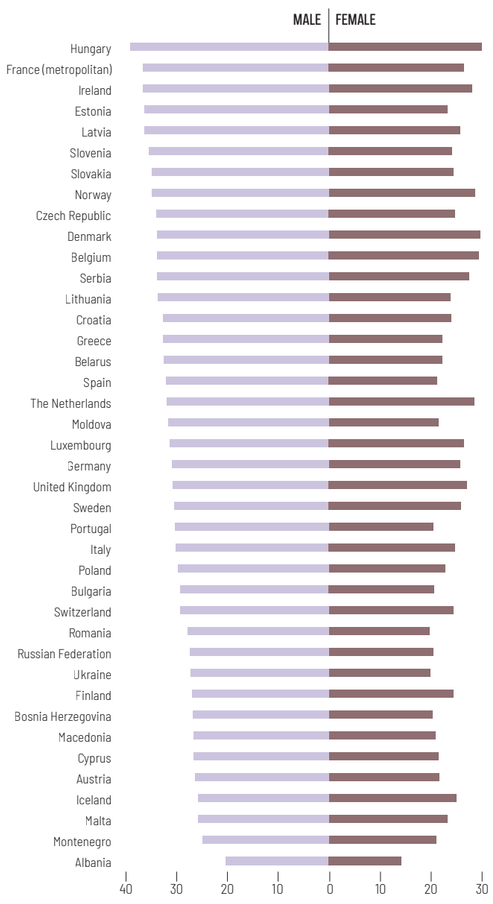
Lung and prostate cancers are the most frequent cancers in most European countries among men, while breast cancer ranks first in all European countries in women.

Europeans represent about one-tenth of the global population, yet one in four of all cancer diagnoses occur in this region.

In many European countries, one in three people will be diagnosed with cancer by the age of 75.

FIGURE 21.2

Lifetime risk (%) of a cancer diagnosis in European countries, by sex



Regional Diversity

NORTHERN AFRICA, WEST & CENTRAL ASIA

In this diverse region with countries at differing stages of the cancer transition, cancers associated with infection, smoking, and excess body weight are all common.

Northern Africa and Central and Western Asia is a large and diverse region characterised by low but increasing cancer incidence rates. The overall number of cases estimated for 2018 in the region was around 745,000, with this number predicted to increase to 1.4 million cases annually by 2040. However, each of the three sub-regions have distinct cancer profiles. **MAP 22.1**

NORTHERN AFRICA

In Northern Africa, cancer incidence rates are typically about one-third to half of the corresponding rates in Western countries, with incidence rates for all cancer sites combined ranging from less than 90 cases per 100,000 population in Sudan to more than 160 in Egypt in men, and less than 100 in Libya and Sudan to more than 140 in Algeria and Morocco in women. **FIGURE 22.1** Liver cancer is the second most common cancer in both sexes combined, with incidence rates in Egypt estimated to be the second-highest worldwide in both men and women. **FIGURE 22.2**

WESTERN ASIA

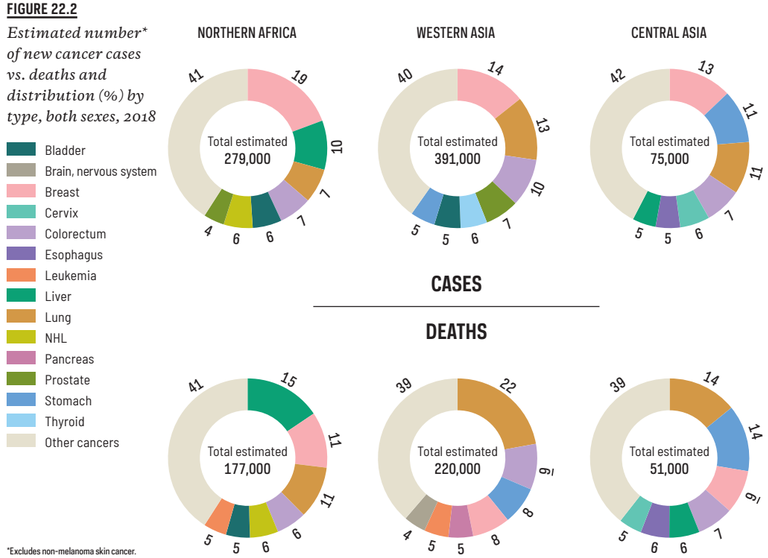
Western Asia is a large region, with close to 400,000 estimated cancer cases annually, but high-quality cancer registry data are available for only few countries, partly due to large numbers of displaced persons and ongoing conflicts. Some of the countries in the region have very high bladder cancer incidence rates; Lebanon notably has the highest estimated incidence rate in the world (40 cases per 100,000 in men), while rates in Israel, Syria, and Turkey also exceed 20 per 100,000 in men. Western Asia also includes the Gulf countries, with specific cancer profiles corresponding to their high national levels of HDI, high prevalence of obesity, and varying levels of smoking uptake, but low alcohol consumption. **MAP 22.2**

CENTRAL ASIA

Cancer incidence rates in Central Asia are relatively low but increasing. Cancer profiles are consistent with low- to medium-HDI countries, with a high incidence of infection-related cancers such as stomach (11% of all cancer cases) and cervical cancer (6% of all cancer cases). The region forms part of the so-called esophageal cancer belt, which includes Turkmenistan, Tajikistan, Uzbekistan, Kazakhstan, Afghanistan and the eastern part of Turkey, with some of the highest incidence rates worldwide, particularly in men.

FIGURE 22.2

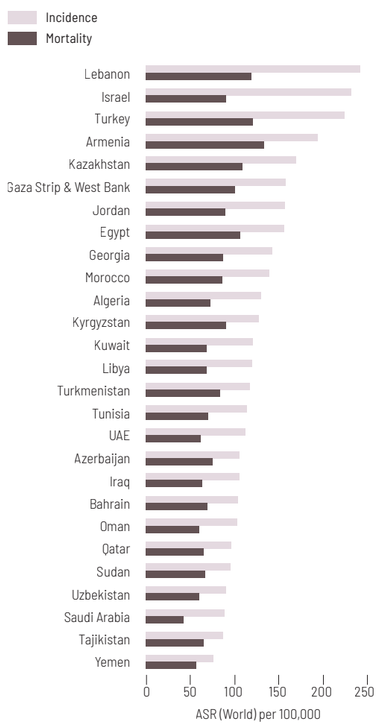
Estimated number of new cancer cases vs. deaths and distribution (%) by type, both sexes, 2018*



*Excludes non-melanoma skin cancer.

FIGURE 22.1

All-sites cancer incidence and mortality rates in Northern Africa and West and Central Asia, both sexes combined, 2018*



MAP 22.1

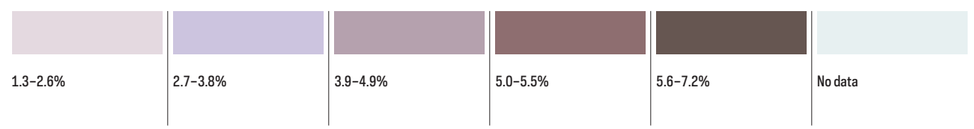
Most commonly diagnosed cancer in Northern Africa and West and Central Asia, both sexes, 2018

Cancer cases are predicted to double in this region by 2040—the largest increase of any world region.

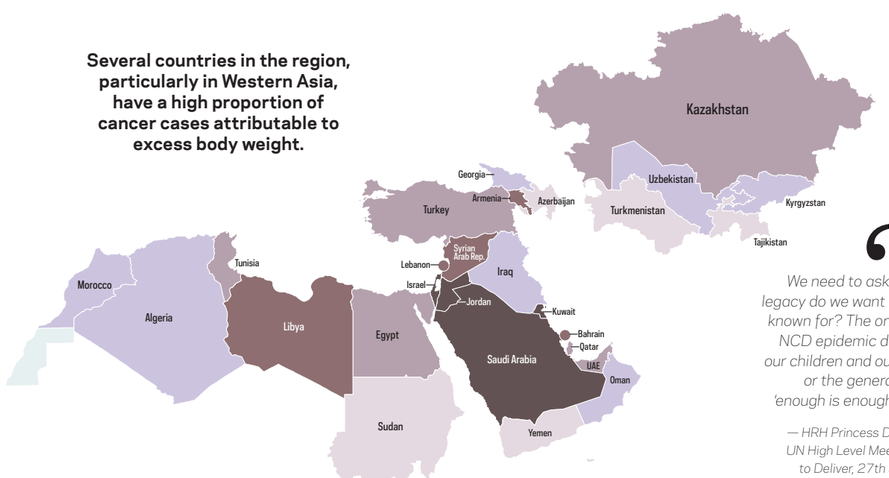
Breast cancer is the most commonly diagnosed cancer in many countries of this region.

MAP 22.2

Proportion (%) of cancer cases attributable to excess body weight in Northern Africa and West and Central Asia, 2012



Several countries in the region, particularly in Western Asia, have a high proportion of cancer cases attributable to excess body weight.



> *We need to ask ourselves: What legacy do we want our generation to be known for? The one that watched the NCD epidemic destroy the lives of our children and our children's children, or the generation that said 'enough is enough' and took action?*
>
> *— HRH Princess Dina Mired, The Third UN High Level Meeting on NCDs: Time to Deliver, 27th September 2018*

Regional Diversity

OCEANIA

Geographic dispersion, long distances, the impact of climate change, and a double burden of infection- and lifestyle-related cancers confront the nations of this vast region.

An estimated 181,000 new cancer diagnoses and 69,000 cancer deaths occurred in 2018 in the subregions of Oceania, namely Australasia, Melanesia, Micronesia, and Polynesia. **FIGURE 23.1** Cancers of the female breast (24,600 new cases, 14% of all cancers), prostate (23,500, 13%), and colorectum (22,300, 12%) are also commonly diagnosed in the region. Lung cancer accounts for the greatest number of cancer deaths (11,800, 17%), followed by colorectal (8,100, 12%) and female breast cancer (4,800, 7%). Skin cancers (melanoma and non-melanoma) are the most common cancers and represent a significant public health issue, particularly in Australia and New Zealand. **FIGURE 23.2** Given the relatively large proportion of the region's inhabitants in Australia and New Zealand, the vast majority of the region's cancer cases and deaths (93% and 85%, respectively) occur in these two countries. Papua New Guinea is unique among the other nations in terms of its relatively large population and burden (8.4 million, 11,200 new cases, 7,100 deaths); most of the Pacific Island countries and territories feature small populations that are often spread across many remote islands.

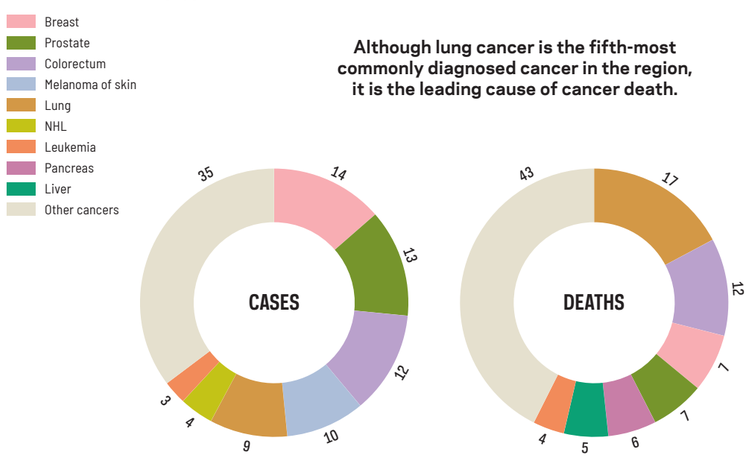
Cancer profiles vary considerably across subregions. In Australasia and Polynesia, the cancers with the highest incidence rates include female breast, prostate, lung, and colorectum. **FIGURE 23.3** In contrast, in Melanesia and Micronesia, breast cancer incidence rates are almost half those of the above regions, and cervical cancer is the second-leading cancer, with rates two to three times higher than the average rate in the region. **MAP 23.1**

> *Delivering cancer services in our small island nations is a challenge. Regional solutions built collaboratively with local leaders have been shown to provide sustainable benefits.*
>
> *— Dr. Paula Vivili, Director, Public Health Division at the Pacific Community, New Caledonia*

FIGURE 23.1

Estimated number of new cancer cases vs. deaths and distribution (%) by type, both sexes, 2018*

Although lung cancer is the fifth-most commonly diagnosed cancer in the region, it is the leading cause of cancer death.

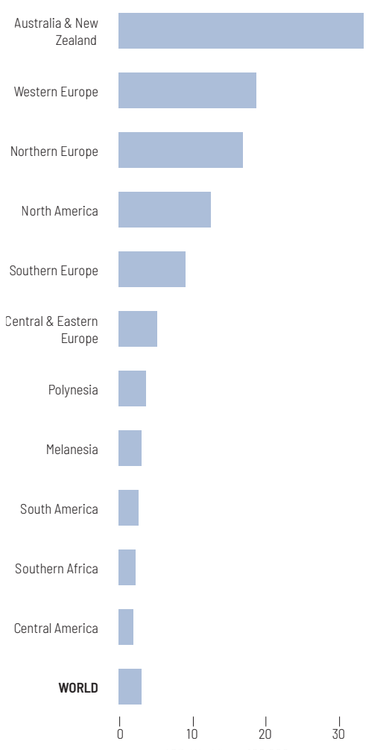


*Excludes non-melanoma skin cancer.

FIGURE 23.2

Incidence rates of melanoma of the skin in selected regions, both sexes combined, 2018

Australia and New Zealand have the highest skin melanoma incidence rates in the world.



MAP 23.1

Cervical cancer incidence in Oceania, age-standardized rate (world) per 100,000, 2018

Australia has achieved high HPV vaccine and cervical cancer screening coverage, which is predicted to reduce cervical cancer rates to fewer than four new cases per 100,000 women by around 2028.

Cervical cancer incidence rates in the region range from 6 cases per 100,000 female population in Australia and New Zealand to 25 or more in Fiji and Papua New Guinea.

FIGURE 23.3

Incidence and mortality rates in Oceania by sub-regions, top 10 cancers, 2018

CANCER SURVIVAL

Access to effective early detection and cancer treatment can substantially improve survival for cancer patients and reduce the survival gap worldwide.

Overall improvements in early detection and treatment have greatly improved average survival of cancer patients worldwide over the past several decades, yet prognosis still varies markedly depending on where a patient lives. **FIGURE 24.1** Survival differences are also marked within regions. Within sub-Saharan Africa for example, overall (observed) survival of women diagnosed with breast cancer is about 50% higher in patients residing in high Human Development Index (HDI) countries than in those residing in low-HDI countries. **FIGURE 24.2** This is in part because breast cancer patients in the low-HDI countries are more likely to be diagnosed at a later stage and less likely to receive the appropriate treatment. In addition to variation between countries, within-country differences have also been reported. For example, in the United States, black cancer patients have lower survival than non-Hispanic white patients. **FIGURE 24.3** In order to close this survival gap, improved population awareness about cancer symptoms, better access to diagnostic services, and adequate care are key. Universal Health Coverage is one strategy to achieving this. (see *40, Universal Health Coverage*) The implementation of universal health coverage in Thailand in 2002 may at least partly account for the increase in the 5-year breast cancer survival proportion, from 44% for patients diagnosed from 1995 to 1999 to 62% for those diagnosed from 2010 to 2014. **FIGURE 24.4**

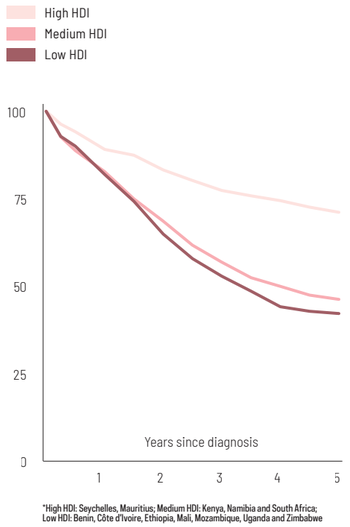
Cancer patient survival benchmarking is an important tool for advocacy to ensure equitable cancer care. Global initiatives assessing international cancer survival include EUROCARE, a cross European project since 1989; the International Cancer Benchmarking Partnership, involving high-income countries with similar health systems; CONCORD, which collects and reports data from all countries worldwide; and SURVCAN, which aims to improve data and capacity for survival estimation in Africa, Asia, and South America, including an initiative with the African Cancer Registry Network to expand population-based survival estimates in sub-Saharan Africa. Unfortunately, high-quality data remains scarce. **MAP 24.1** Improving the quality and availability of population-based survival data is essential to ensuring effective monitoring of progress in cancer control.

NET SURVIVAL is a measure of the probability of surviving the cancer diagnosed that is comparable between countries, as it corrects for differences between countries in death from other diseases (non-cancer mortality). Net survival is often age-standardized for comparability between countries with different age distributions.

OBSERVED SURVIVAL is a measure of the probability of a person with cancer surviving from all causes of death (cancer and other causes).

FIGURE 24.2

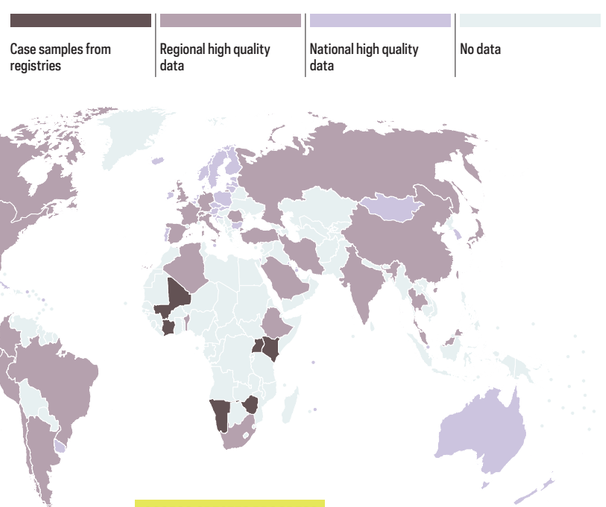
Observed survival (%) in patients with breast cancer since time of diagnosis in countries with high, medium and low human development index in sub-Saharan Africa in 2009-2014*



*High HDI: Seychelles, Mauritius; Medium HDI: Kenya, Namibia and South Africa; Low HDI: Benin, Côte d'Ivoire, Ethiopia, Mali, Mozambique, Uganda and Zimbabwe

MAP 24.1

Availability of high-quality cancer data for survival statistics, 2008–2014



ACCESS CREATES PROGRESS

The number of population-based cancer registries that are able to provide high-quality survival statistics is lacking but has grown over the last decades, providing national and global evidence to improve effectiveness of health care systems.

FIGURE 24.3

Five-year net survival (%) for women diagnosed with advanced breast cancer in the USA in 2009-2015 by race/ethnicity

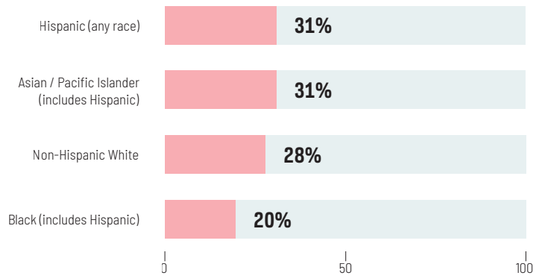


FIGURE 24.4

Trends in five-year net survival (%) from breast cancer in Asia

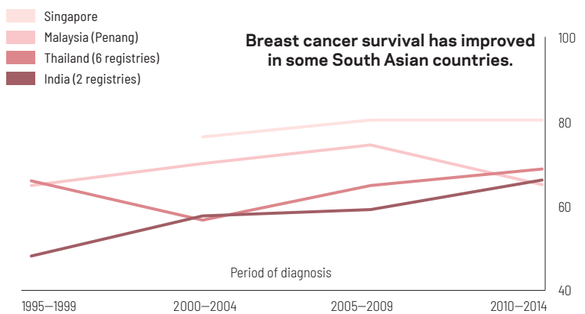
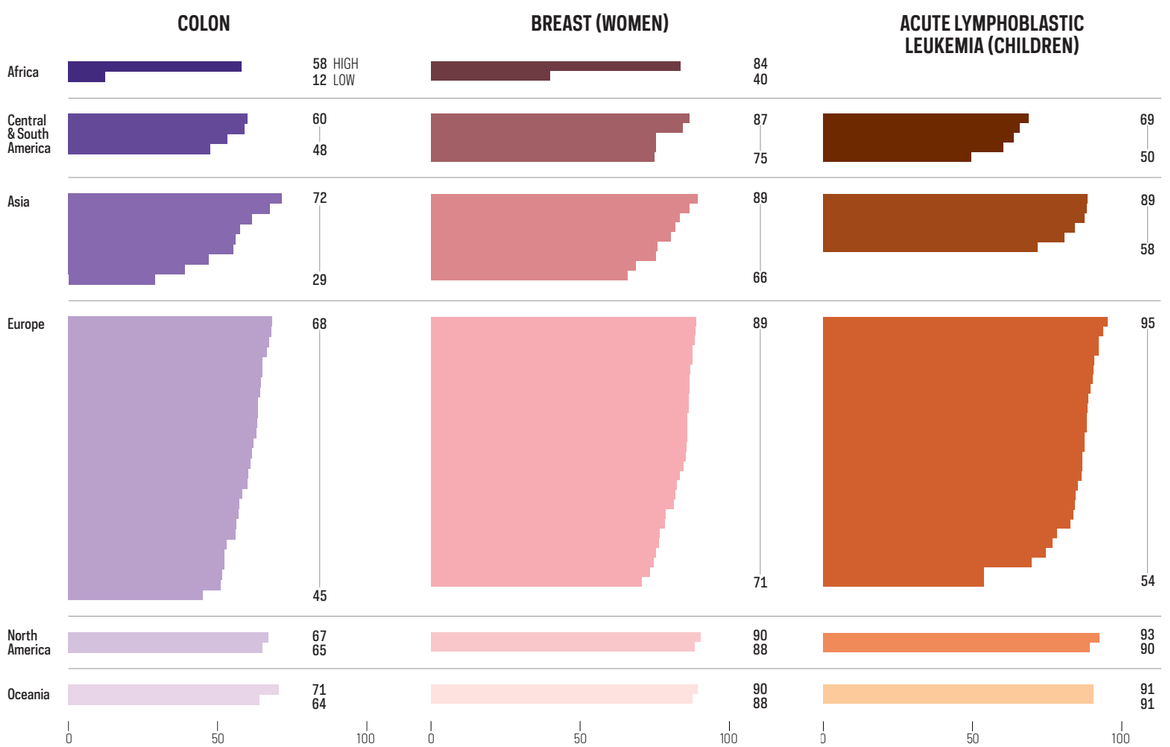


FIGURE 24.1 *Five-year net survival (%) in patients diagnosed with colon cancer, female breast cancer, and acute lymphoblastic leukemia (children) in 2010-2014 CONCORD-3 study worldwide*

Survival from childhood acute lymphoblastic leukemia varies almost twofold across European countries.



CANCER SURVIVORSHIP

The growing population of cancer survivors represents a global challenge for survivors and their families, employers, healthcare systems and governments.

The number of cancer survivors is rising worldwide, propelled by advances in early detection and treatment and the aging of the world's population. In 2018, there were approximately 43.8 million cancer survivors diagnosed within the previous 5 years. **MAP 25.1**

Their growing visibility makes it increasingly clear that while some cancer survivors thrive, for many, life after cancer presents lasting challenges. Fear of recurrence, depression, pain, memory problems, sexual dysfunction, relationship issues and school worries are common. Late effects (occurring months or years after treatment ends) may include cardiac problems, lymphedema, impaired functional status, and second cancers. **MAP 25.2** Combined, long-term and late effects of cancer may double survivors' risk of poor mental and physical health-related quality of life. **FIGURE 25.1**

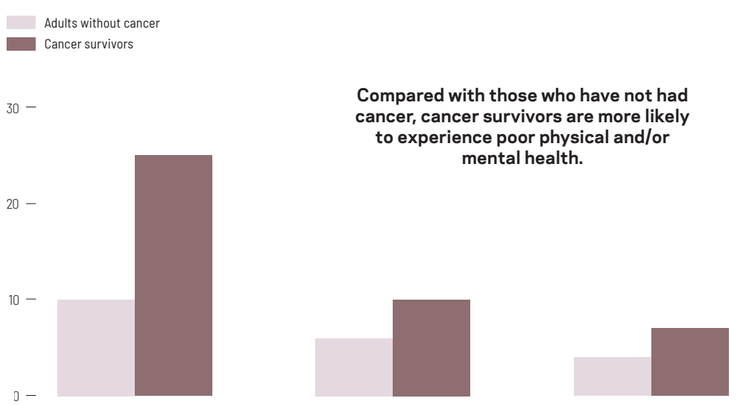
Working-age cancer survivors often face challenges in maintaining employment. They increasingly experience medical financial hardship, including problems paying medical bills, financial distress, and delaying or forgoing care because of cost. In the USA, as many as 60% of working-age cancer survivors report at least one type of financial hardship.

Among older adults, most of those diagnosed with cancer present with one or more co-morbid health conditions. As the proportion of survivors who are older increases, rates of cancer-related morbidity can be expected to rise as well. To reduce the human cost of cancer, finding ways to screen those at risk for and mitigating adverse effects of treatment will be increasingly important, as will tailored follow-up care.

National guidelines for coordinated survivorship care are in place in some high-income countries, such as Australia, Canada, and the UK. **FIGURE 25.2** In the US, guidelines are not always consistent. Survivorship care guidelines are less common in low- and middle-income countries. Developing and delivering care that addresses the long-term and late occurring effects of cancer and its treatment represent key challenges of survivorship worldwide.

FIGURE 25.1

Prevalence (%) of poor health-related quality of life among cancer survivors and adults without cancer, US, 2010



Compared with those who have not had cancer, cancer survivors are more likely to experience poor physical and/or mental health.

> *The challenge in overcoming cancer is not only to find therapies that will prevent or arrest the disease quickly but also to map the middle ground of survivorship and minimize its medical and social hazards.*
>
> *— Fitzhugh Mullan, founding member, National Coalition for Cancer Survivorship*

FIGURE 25.2

Suggested site-specific surveillance recommendations for cancer survivors, United Kingdom

BREAST CANCER (EARLY AND LOCAL STAGES)

- People who have had treatment for breast cancer should have an agreed, written care plan, which should be recorded by a named healthcare professional.
- Offer annual mammography to all people with breast cancer for 5 years.

COLORECTAL CANCER

- Offer patients regular surveillance with a minimum of two CTs of the chest, abdomen, and pelvis in the first 3 years and regular serum carcinoembryonic antigen tests (at least every 6 months in the first 3 years).
- Offer a surveillance colonoscopy at 1 year after initial treatment. If this investigation is normal consider further colonoscopic follow-up after 5 years.

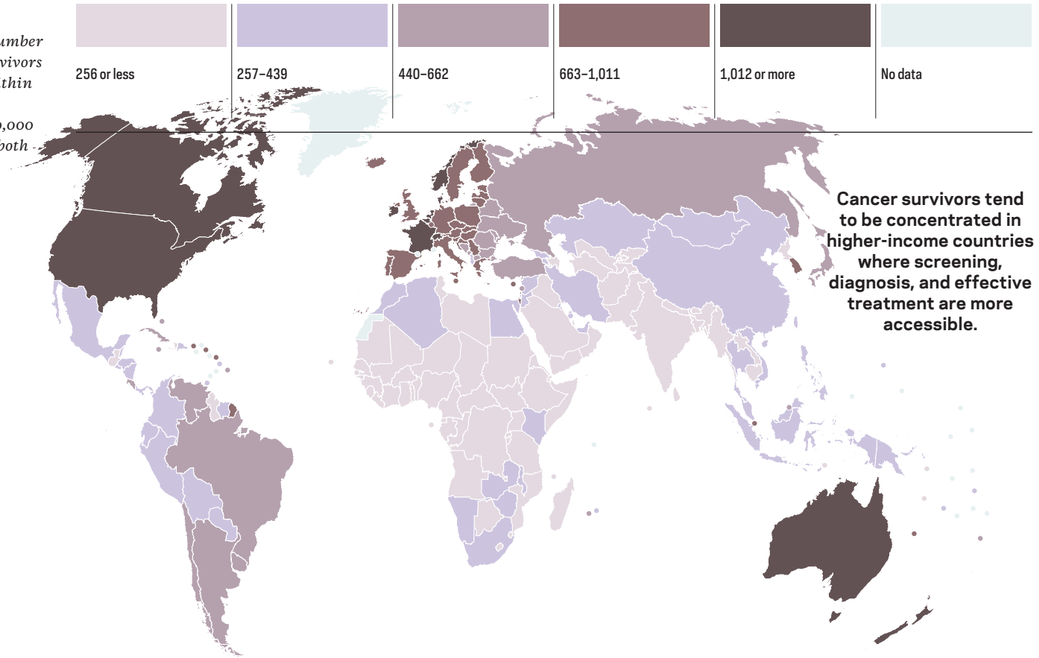
LUNG CANCER

- Offer all patients an initial specialist follow-up appointment within 6 weeks of completing treatment to discuss ongoing care. Offer regular appointments thereafter, rather than relying on patients requesting appointments when they experience symptoms.
- Offer protocol-driven follow-up led by a lung cancer clinical nurse specialist as an option for patients with a life expectancy of more than 3 months.

Guidelines for follow-up care exist in some high-income countries, but are uncommon in low- and middle-income countries.

MAP 25.1

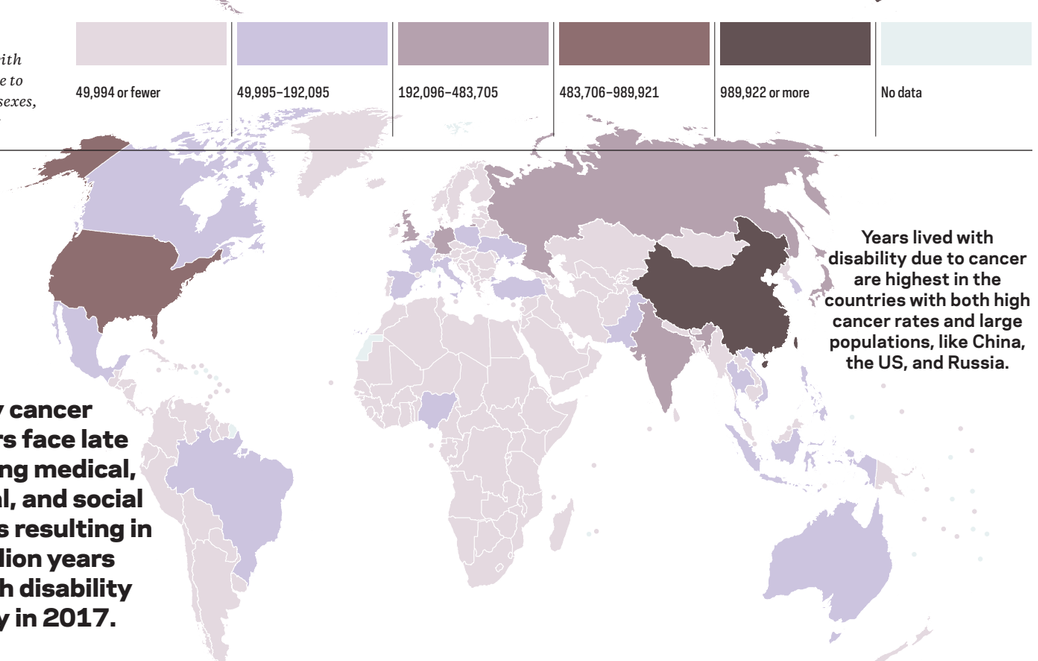
Estimated number of cancer survivors diagnosed within the past five years per 100,000 population, both sexes, 2018



Cancer survivors tend to be concentrated in higher-income countries where screening, diagnosis, and effective treatment are more accessible.

MAP 25.2

Years lived with disability due to cancer, both sexes, all ages, 2017



Years lived with disability due to cancer are highest in the countries with both high cancer rates and large populations, like China, the US, and Russia.

Many cancer survivors face late and lasting medical, emotional, and social challenges resulting in 7.8 million years lived with disability globally in 2017.

TAKING ACTION

This section describes effective interventions across the cancer continuum, from prevention to early detection, treatment, and palliative care. Many organizations work in the fight against cancer through research, health promotion, and policy.

Over the next half century, an estimated 44 million cervical cancer cases will occur if current trends continue worldwide.

ACCESS CREATES PROGRESS

Effective delivery of combined high coverage **screening** and **vaccination** could avert over 13 million cervical cancer cases by 2069,and **eventually lead to cervical cancer being eliminated as a major public health problem.**

THE CANCER CONTINUUM

An Overview of Interventions and Potential for Impact

Resource-appropriate, broad application of known interventions in each country can substantially reduce the morbidity and mortality associated with cancer.

Evidence-based, resource appropriate interventions for cancer prevention and control exist across the cancer continuum in each country, from prevention of risk factors to early detection, treatment, survivorship, and end-of-life care. **FIGURE 26.1** Tobacco use, the cause of the largest number of preventable cancers worldwide, can be substantially reduced through raising excise tax on tobacco products, smoke-free air laws, health warnings on tobacco packaging, and restrictions on promotion and advertising of tobacco products. **FIGURE 26.2** (see *28, Tobacco Control*) Unhealthy diet and physical inactivity can be reduced through increased public awareness about their health hazards and through public policies (e.g., excise tax on sweetened beverages) and structural and environmental interventions (e.g., pedestrian and bike lanes) (see *27, Health Promotion*). The hepatitis B virus (HBV) and human papillomavirus (HPV), infections that cause liver cancer (HBV) and cervical and other urogenital and oropharyngeal cancers (HPV), can be prevented through vaccination (see *29, Vaccination*). Indoor and outdoor air pollution can be reduced through use of clean stoves, cleaner fuels, and proper ventilation, and air quality guidelines and policies. Protection from harmful sun exposure could reduce the risk of skin cancer. Cancer-causing occupational exposures could be prevented through improved work place safety. Addressing cancer risk factors can also have a shared impact on other non-communicable diseases.

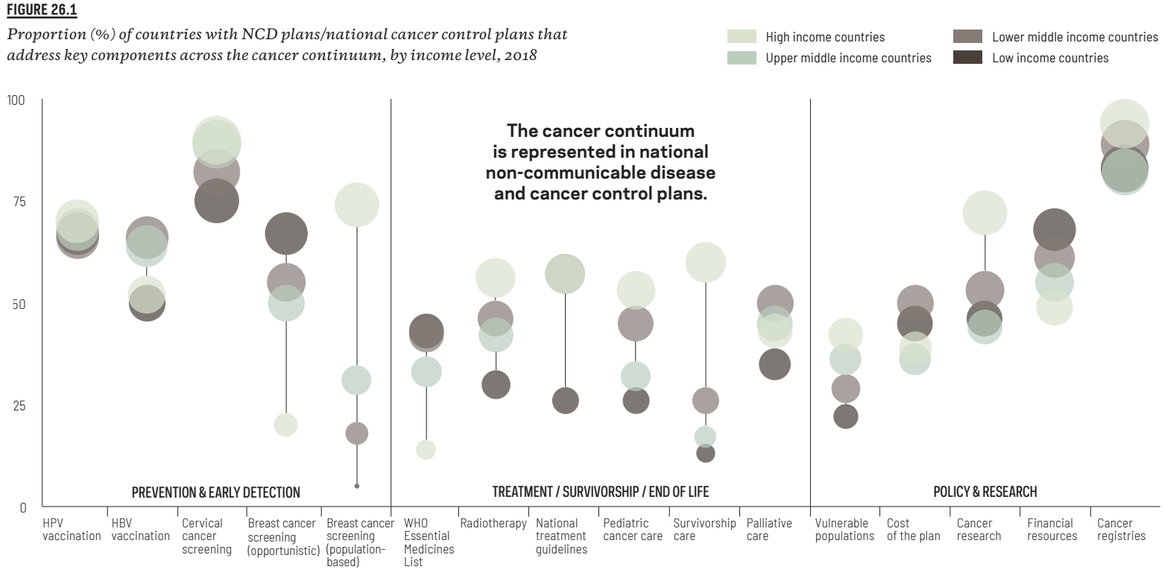
Regular screening for cervical, colorectal, breast, and lung cancers allows detection of these diseases at an early stage, when treatments are more successful and the chance for survival and cure is high. **MAP 26.1** Screening for colorectal and cervical cancers also prevents cancer by detecting precancerous lessions for removal by surgery or other forms of treatment. A heightened awareness of warning signs for cancer of the oral cavity, skin, and some other cancers may also lead to detection of cancers at early stage (see *30, Early Detection*).

Effective treatment modes (surgery, radiation, chemotherapy, hormonal therapy, immunotherapy) have been developed for several cancers, including for cancers of the breast, colon and rectum, and testis and for many childhood cancers. **FIGURE 26.3** (see *31, Management and Treatment*) For certain cancers such as testis, treatment could lead to cure, even for advanced-stage disease. Awareness and availability of services to meet the needs of cancer survivors are increasing worldwide **FIGURE 26.4**, and pain associated with cancer can be controlled by administration of analgesic drugs. **FIGURE 26.5** (see *32, Pain Control*)

Resource-appropriate application of known interventions in each country could prevent a substantial proportion of cancer deaths. However, such broad interventions have not materialized in most parts of the world largely because of lack of political commitment.

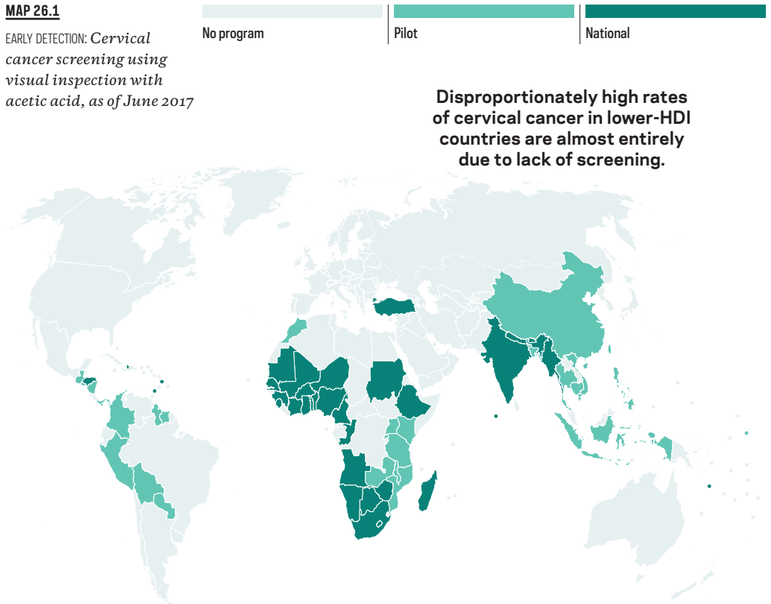
FIGURE 26.1

Proportion (%) of countries with NCD plans/national cancer control plans that address key components across the cancer continuum, by income level, 2018



MAP 26.1

EARLY DETECTION: *Cervical cancer screening using visual inspection with acetic acid, as of June 2017*



If 70% of all eligible girls were vaccinated, an estimated 178,000 cervical cancer deaths could be avoided annually worldwide.

FIGURE 26.2

PREVENTION: *Cumulative probability (%) of death from lung cancer by attained age and smoking status*

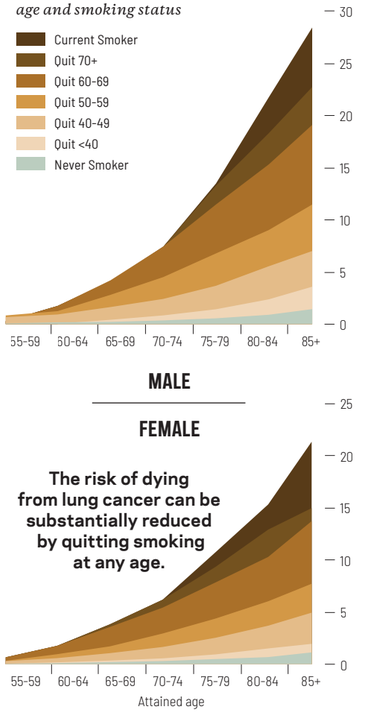


FIGURE 26.3

TREATMENT: *Childhood cancer mortality trends, all cancer sites combined, males 0-19 years, 1975-2013*

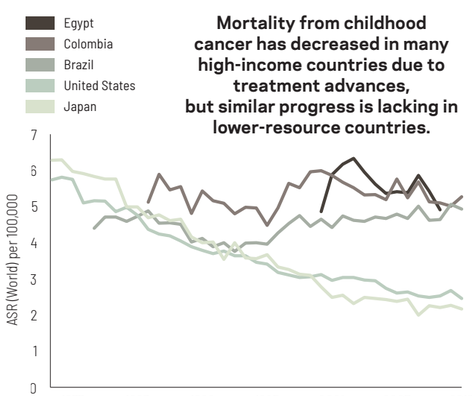


FIGURE 26.4

SURVIVORSHIP: *Breast Health Global Initiative resource allocations for monitoring breast cancer survivorship care*

BASIC

- Monitor for breast cancer recurrence, second primary cancers
- Monitor for long-term complications

LIMITED

- Monitor for endocrine medication adherence

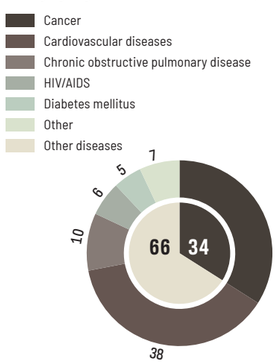
MAXIMAL

- Genetic testing and counseling
- Screening for high-risk cancers

Monitoring practices for breast cancer survivorship care can vary by resource availability.

FIGURE 26.5

END-OF-LIFE CARE: *Adult palliative care needs at the end of life by disease (%) worldwide, 2011*



Cancer forms a large portion of end-of-life palliative care needs worldwide.

HEALTH PROMOTION

A Population and Systems Approach

Health promotion must address the environmental, economic, and social factors that influence health behaviors.

The scale of the global cancer burden and its associated economic costs indicate that adoption of healthy behaviors to reduce the risk of cancer is critical. However, behavior change initiatives directed at individuals are not likely to be successful without addressing the many external factors that influence behavior. In addition to educating and building skills that encourage healthier behaviors, health promotion must also include efforts to address the environmental, economic, and social factors that influence an individual's ability to engage in those behaviors. For instance, the availability of sidewalks and biking infrastructure affects the degree of physical activity in a community, and the availability of affordable fresh fruits and vegetables affects healthy eating habits. This is especially important in the context of health equity, as vulnerable populations are most affected by environments that are not conducive to healthy behaviors.

A comprehensive policy framework to create environments that support following cancer prevention recommendations includes actions at the environmental, system, and individual levels. FIGURE 27.1 While this framework was developed to address diet, physical activity, breastfeeding, and alcohol consumption (all factors associated with cancer risk and/or body weight), the broad policy levers are applicable to other health behaviors, such as tobacco use and vaccination. Examples of initiatives include taxation, FIGURE 27.2 information and community mobilization, FIGURE 27.3 and counseling in healthcare. FIGURE 27.4

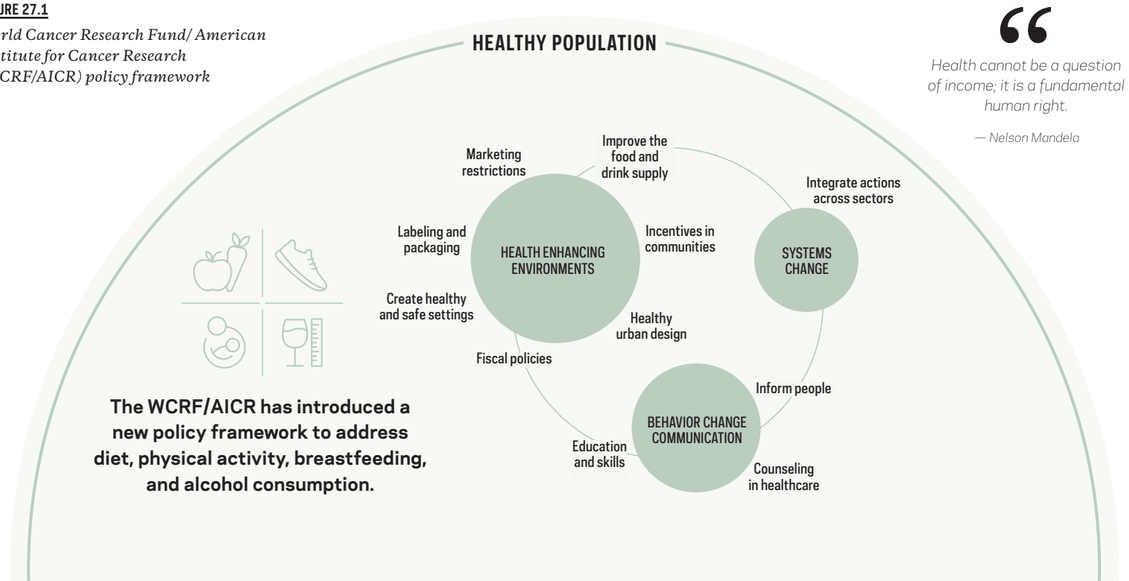
Taxes on sugar-sweetened beverages intended to reduce consumption are an emerging public health strategy.

FIGURE 27.3

Education and Information: The Healthy Caribbean Coalition #toomuchjunk Campaign

FIGURE 27.1

World Cancer Research Fund/ American Institute for Cancer Research (WCRF/AICR) policy framework



The WCRF/AICR has introduced a new policy framework to address diet, physical activity, breastfeeding, and alcohol consumption.

> "Health cannot be a question of income; it is a fundamental human right."
>
> — Nelson Mandela

FIGURE 27.4

Counseling in healthcare: Green Prescriptions (New Zealand)

ACCESS CREATES PROGRESS

In the Netherlands, substantial investments have been made in cycling-promoting infrastructure and policies, resulting in 27% of trips being made by bicycle. This physical activity is estimated to avert 6,500 deaths annually and contribute an additional half-year to the life expectancy of Dutch people.

GRx

A Green Prescription (GRx) is the written advice from a health care professional to a patient to be physically active. The program is administered by District Health Boards, with support from the New Zealand Ministry of Health.

Patients receiving a GRx from their health care provider are eligible for ongoing support, delivered as monthly telephone calls, face to face meetings, or group support in a community setting. The patient's progress is reported back to the referring health professional.

A retrospective study of individuals who had participated in the GRx program two to three years earlier found that those who had completed the program reported an additional 64 min of total physical activity per week and were less likely to be sedentary and more likely to meet the current physical activity guidelines of at least 150 min of physical activity per week.

The Healthy Caribbean Coalition's #toomuchjunk campaign educates citizens about the harmful effects of poor diet and lack of physical activity and asks them to call on their governments to enact policies and legislation that effectively combat childhood overweight and obesity.

FIGURE 27.2

Fiscal policy: Sugar-sweetened beverage taxes

	MEXICO	USA, PHILADELPHIA	UNITED KINGDOM
Action	A 10% excise tax increase on sugar-sweetened beverages on January 1, 2014.	The city of Philadelphia implemented a tax on sugar-sweetened beverages (US $0.015 per ounce) on January 1, 2017.	The 2018 United Kingdom (UK) sugar-sweetened beverage tax utilized a different strategy than other localities by introducing a tiered tax based on the amount of sugar in the beverage—a high tax for drinks with >8g of sugar per 100ml; a moderate tax for drinks with 5–8g/100ml; and no tax for drinks with <5g/100ml.
Result	A 6% decline in purchases of these beverages and a 4% increase in purchases of unsweetened beverages (mainly water) in the first year of the tax.	Two months after the tax went into effect, Philadelphia residents were 40 percent less likely to drink sugary soda and 60 percent less likely to drink an energy drink each day compared with residents of nearby cities. – In addition, Philadelphians were 58 percent more likely to drink bottled water every day.	The tax has already incentivized some manufacturers to markedly reduce the amount of sugar in their recipes, positively affecting all those who consume these beverages. – A 2017 modelling study examining the potential impact of product reformulation estimated that, with reduced sugar content by 15–30%, the number of adults and children with obesity would fall by 144,000, and there would be 19,000 fewer cases of diabetes per year in the UK.

A handful of communities worldwide, including Mexico, the United Kingdom, and various cities in the US, have begun implementing excise taxes on sugar-sweetened beverages and evaluating the impact on consumption and/or product formulation.

TOBACCO CONTROL

There are many effective measures to reduce tobacco use that can lower smoking prevalence and prevent premature deaths.

Tobacco use is the largest preventable cancer risk factor. While global cigarette consumption and overall prevalence have been declining recently, success has been uneven. In countries with vigorous tobacco control policies, tobacco use has typically declined more.

In recent years, tobacco control proponents have developed a proven set of tools to address the challenges of tobacco use. These measures comprise the World Health Organization's Framework Convention on Tobacco Control, which boasts more than 180 Parties. **MAP 28.1** The treaty's provisions include increasing tobacco excise taxes, creating smoke-free environments, and putting strict restrictions on tobacco product marketing and graphic warning labels on tobacco packaging.

Taxing tobacco aggressively has proven to be the most effective tobacco control measure. The mechanism is simple: governments put high excise taxes on tobacco products, tobacco companies raise prices to protect profits, and consumers react to higher prices by quitting, not initiating or reducing tobacco consumption. Importantly, young and/or lower-income people are more likely to be affected. **FIGURE 28.1** Through tobacco taxes, countries enjoy the benefits of lower consumption through higher productivity and lower healthcare costs, and tax revenues increase. Reinvesting these revenues in health can further enhance the effects. **FIGURE 28.2**

In 2012, Australia moved beyond the gold standard of large, graphic warning labels on tobacco packaging by legislating plain standardized packages. Gone are the logos and color themes that even young children can identify around the world. **MAP 28.2**

Tobacco firms' success relies on their ability to present tobacco use as cool and glamorous. Most recently, firms have re-doubled their efforts to sell to young women and girls. To combat this, the health community must constantly remind people that smokers lose on average 11 years of life, and more than half of long-term smokers die prematurely from tobacco-attributable disease.

Finally, it is in countries where broad communities seeking improved social welfare—including health, human rights, and environment, among others—are speaking out loudly against tobacco that tobacco use is waning most.

FIGURE 28.2

The benefits of tobacco taxes in the Philippines

ACCESS CREATES PROGRESS

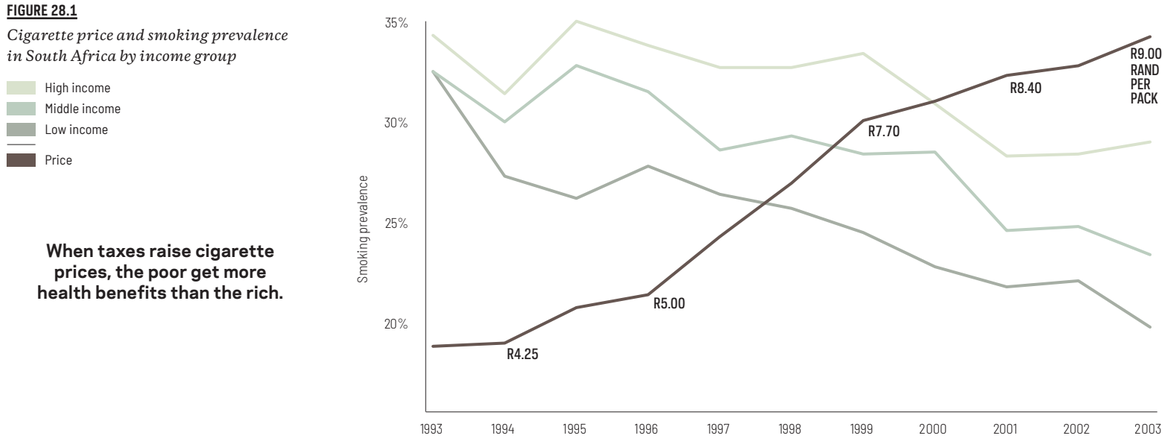
Not only are they saving hundreds of thousands of lives, but the government is spending its new tobacco tax revenue on…

- Universal healthcare for low-income persons
- Improving health infrastructure
- Helping tobacco farming communities

Graphic warning labels and plain packaging on tobacco products can counteract tobacco marketing efforts.

FIGURE 28.1

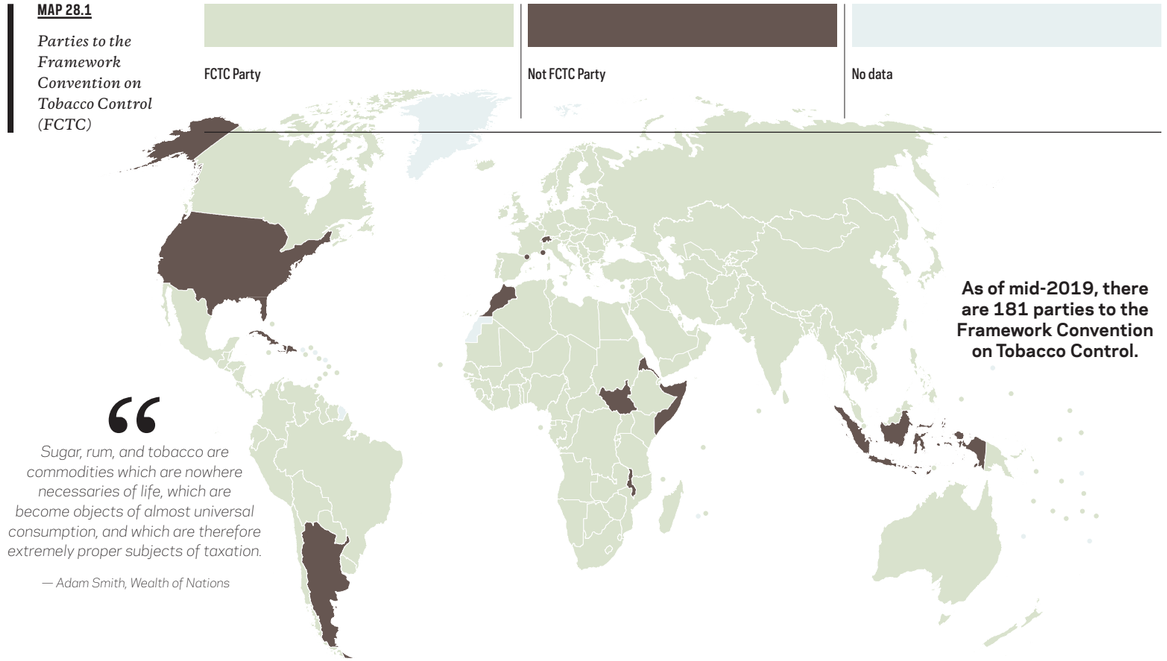
Cigarette price and smoking prevalence in South Africa by income group



When taxes raise cigarette prices, the poor get more health benefits than the rich.

MAP 28.1

Parties to the Framework Convention on Tobacco Control (FCTC)



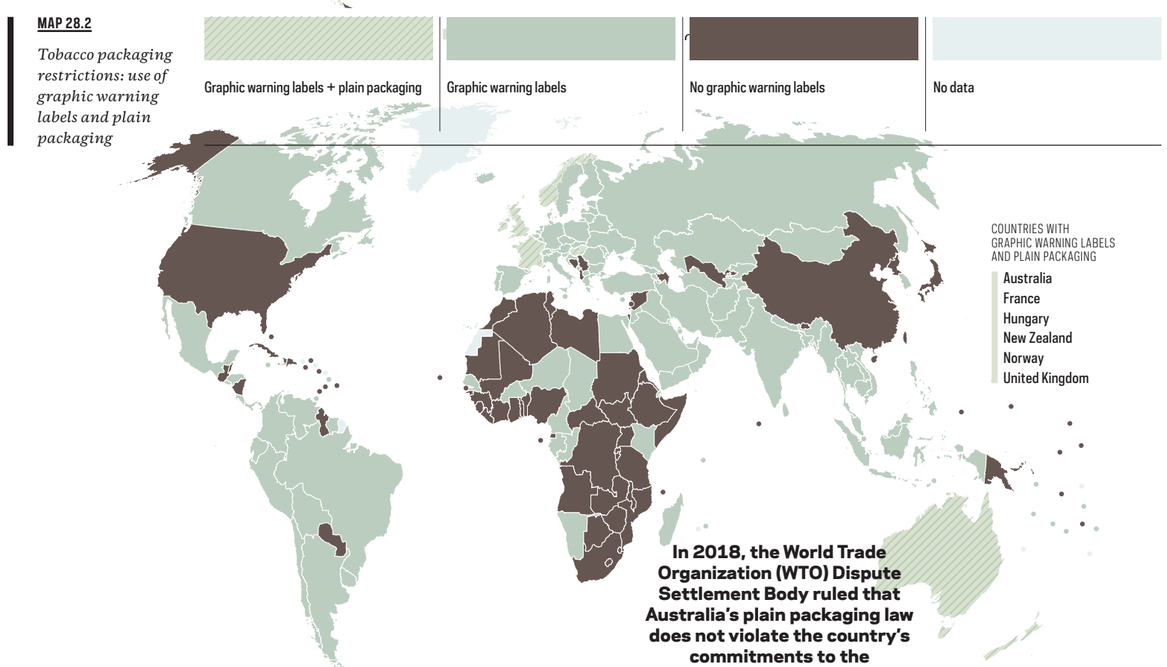
As of mid-2019, there are 181 parties to the Framework Convention on Tobacco Control.

"Sugar, rum, and tobacco are commodities which are nowhere necessaries of life, which are become objects of almost universal consumption, and which are therefore extremely proper subjects of taxation.

— Adam Smith, Wealth of Nations

MAP 28.2

Tobacco packaging restrictions: use of graphic warning labels and plain packaging



In 2018, the World Trade Organization (WTO) Dispute Settlement Body ruled that Australia's plain packaging law does not violate the country's commitments to the WTO agreement.

VACCINES

Highly effective and safe vaccines are available to prevent HBV and HPV infections and associated cancers.

An estimated 257 million people are living with hepatitis B virus (HBV) infection globally. HBV is responsible for nearly 900,000 deaths annually, including more than 300,000 deaths from hepatocellular carcinoma (HCC). HCC results from chronic HBV infection, and the risk of chronic infection is greatest if transmission occurs during birth or early childhood. The vaccines for HBV have been available since 1982 as a three-dose series, and can prevent chronic infection and sequelae including cirrhosis and HCC. As of 2017, 186 countries had introduced HBV vaccination, and globally 3-dose vaccination coverage among children reached 84%. MAP 29.1 To prevent mother-to-child transmission, the first dose should be given within 24 hours after birth; however, only 101 countries (55%) had introduced universal HBV vaccine birth dose, and coverage globally was estimated at 43%.

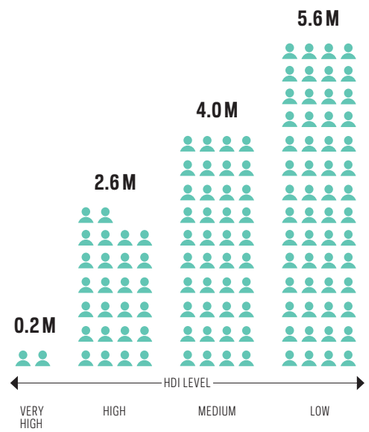
Human papillomavirus (HPV) is the cause of 630,000 cancers annually, 83% of which are cervical cancers, 10.9% other anogenital, and 4.6% oropharyngeal cancers. FIGURE 29.1 Two HPV vaccines, a bivalent and a quadrivalent vaccine, have been available since 2006. A third vaccine, a nonavalent vaccine, has been available since 2015. These vaccines, combined with screening, have the potential to avert millions of cervical cancer deaths over the coming decades. FIGURE 29.2 They are given as a three-dose or a two-dose series, are highly effective and safe, and target HPV types 16 and 18 (which cause over 70% of all cervical cancers) and most other cancers that are caused by HPV. The nonavalent vaccine targets HPV types 16 and 18 as well as five additional cancer-causing HPV types; these seven types cause over 90% of cervical cancers. In most countries, the target group for HPV vaccination is young adolescent girls; some countries also recommend vaccination for boys. The first countries to introduce HPV vaccine were high-income countries, due to the cost of vaccines. Middle- and low-income countries started to introduce vaccines three to six years later. By 2019, over 96 countries had introduced HPV vaccination. MAP 29.2

ACCESS CREATES PROGRESS

Rwanda has some of the highest cervical cancer rates in the world. However, this country has achieved greater than 98% coverage in its HPV vaccine target population due to government commitment, school-based delivery, and a strategy to reach out-of-school girls.

FIGURE 29.2

Cervical cancer cases averted (millions) in 2020–2069 with implementation of screening twice per lifetime and 80–100% female-only vaccine coverage with nonavalent HPV vaccine, by Human Development Index level (HDI)

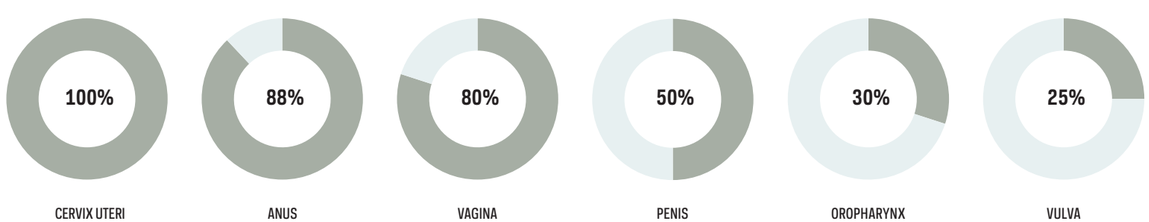


Through a scale-up of HPV vaccination and screening, millions of cervical cancer cases could be avoided in the coming decades, particularly in lower-HDI countries.

FIGURE 29.1

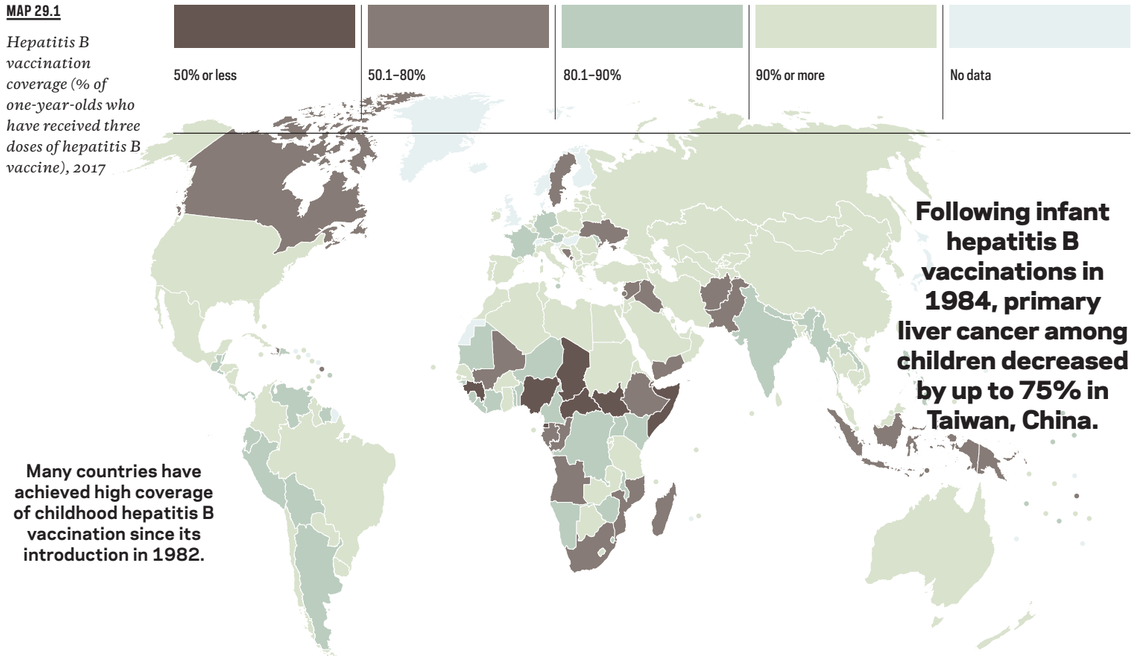
Cancers associated with HPV and percent of cases attributable to HPV infection

HPV is responsible for nearly all cervical cancers and a substantial proportion of other anogenital and oropharyngeal cancers.



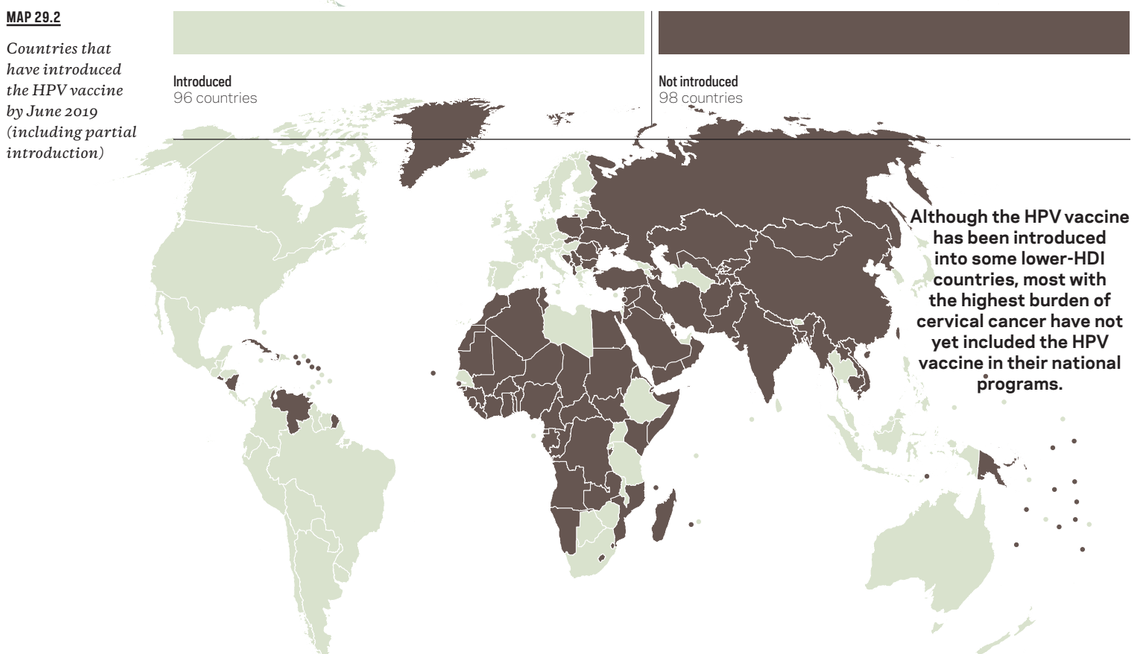
MAP 29.1

Hepatitis B vaccination coverage (% of one-year-olds who have received three doses of hepatitis B vaccine), 2017



MAP 29.2

Countries that have introduced the HPV vaccine by June 2019 (including partial introduction)



EARLY DETECTION

Early detection allows more effective treatment when the cancer is at an earlier, much more curable stage.

Detection of some cancers at an early stage combined with prompt treatment permits less aggressive treatment, leading to a better quality of life of the patient, and is associated with significantly reduced mortality. There are two distinct approaches to early detection—screening and early diagnosis.

Screening involves systematic examination of an apparently healthy and asymptomatic population at risk with a test to detect the disease at an early stage. However, implementation is quite complex and resource-intensive. Screening may be population-based (inviting the entire target population at the appropriate intervals) or opportunistic (at the initiation of the patient or upon invitation at an unrelated clinical encounter). To date, screening of the general population is recommended only for cervical, colorectal, and female breast cancer, depending on resources of the country. **MAP 30.1–3** Oral cancer screening is recommended for habitual users of tobacco or alcohol. Lung cancer screening is recommended in the United States for current and former heavy smokers aged 55–74 years. In addition to detection at an early stage, screening can prevent cervical and colorectal cancers through detection and removal of premalignant conditions. **FIGURE 30.2**

Early diagnosis is detection of a cancer at the earliest possible stage, usually through patient awareness of the early symptoms of common cancers, and training of healthcare workers to recognize and appropriately refer patients with probable early cancer symptoms. **FIGURE 30.1** While not as effective as screening, it can be used for many of the most common cancers including breast, skin, and stomach, and in low-resource settings where screening may not be feasible. Early diagnosis is an important component of any early detection program because not all adults are invited to screening or attend screening, and screening programs fail to detect some cancers.

Population awareness, trained healthcare providers, prompt referral systems, and diagnostic and therapeutic infrastructure are necessary for both screening and early diagnosis to function well.

ACCESS CREATES PROGRESS

Programs to raise awareness of breast cancer and promote clinical breast examination in countries where mammography screening is not feasible have resulted in more breast cancers being diagnosed at an early stage.

FIGURE 30.1

Recommended activities for early detection of selected cancers

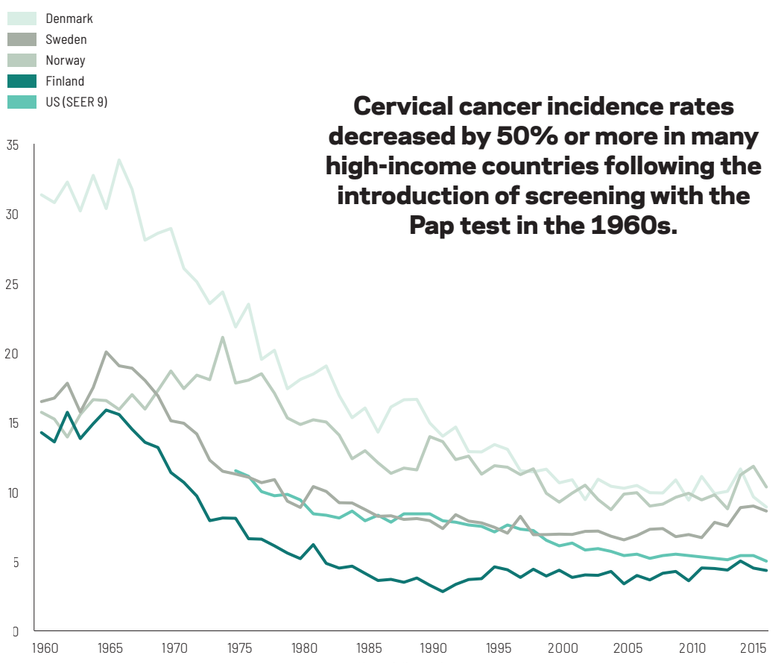
● Yes
✕ No

SITES OF CANCER	EARLY DIAGNOSIS	SCREENING
Breast*	●	●
Cervix	●	●
Colon and rectum*	●	●
Oral cavity	●	●
Nasopharynx	●	✕
Larynx	●	✕
Stomach	●	✕
Skin melanoma	●	✕
Other skin cancers	●	✕
Urinary bladder	●	✕
Prostate	●	✕
Retinoblastoma	●	✕
Testis	●	✕
Lung	✕	✕
Esophagus	✕	✕
Ovary	✕	✕

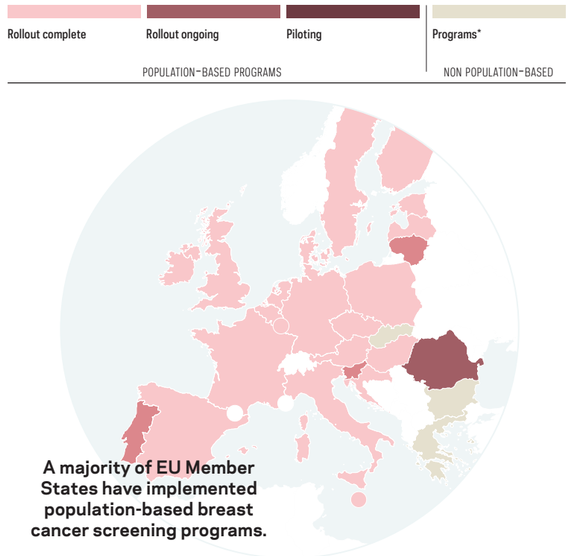
*Screening for colorectal cancer or using breast mammography is recommended in high-resource settings only.

FIGURE 30.2

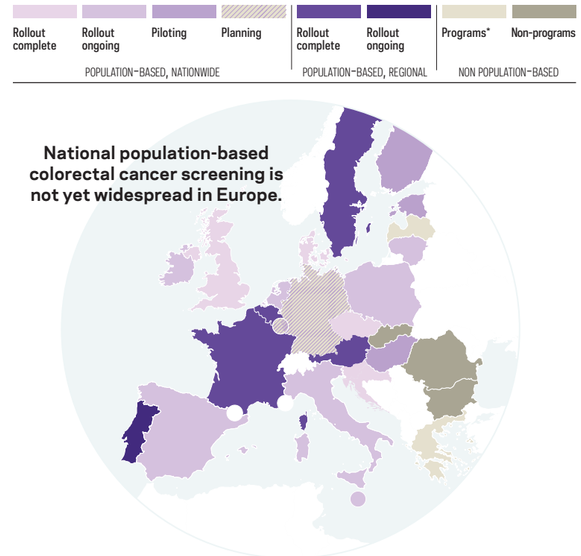
Decreases in cervical cancer incidence rates between 1960–2016, age-standardized rate (world) per 100,000



MAP 30.1 *Breast cancer screening in the European Union (EU), 2016*



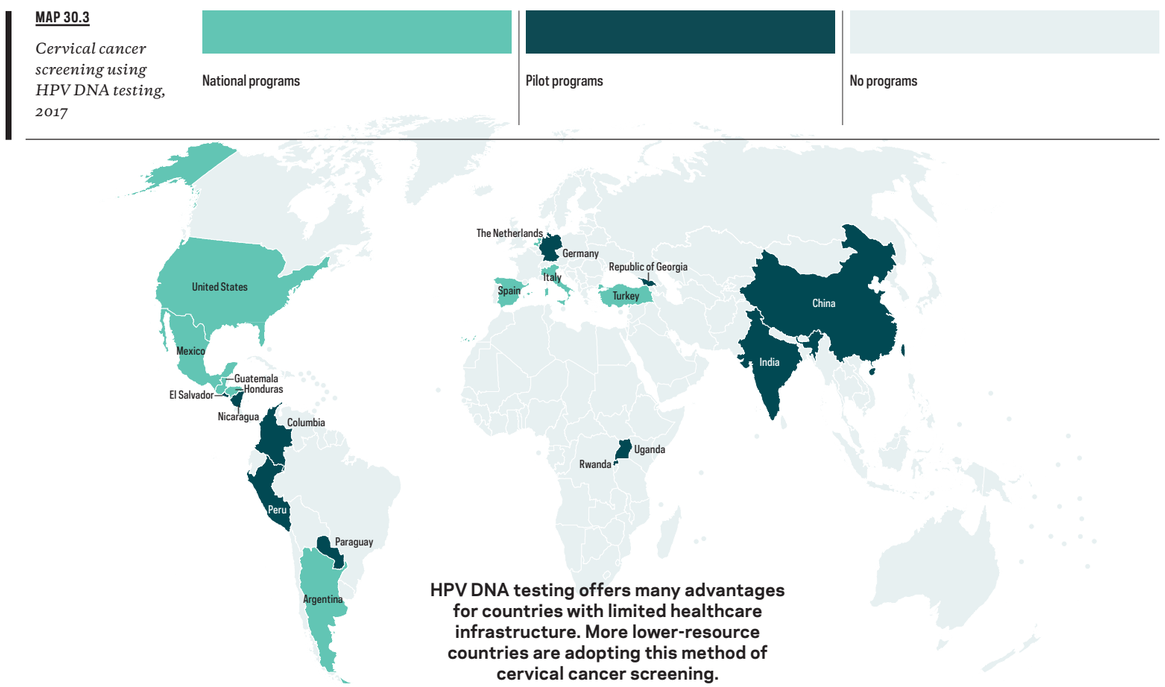
MAP 30.2 *Colorectal cancer screening in the EU, 2016*



*A program is defined as being established in a documented public screening policy.

MAP 30.3

Cervical cancer screening using HPV DNA testing, 2017



MANAGEMENT & TREATMENT

Existing cost-effective interventions such as surgery, radiotherapy, and access to essential oncologic drugs can greatly improve cancer survival worldwide.

Cancer management starts with obtaining a valid diagnosis. However, lack of diagnostic imaging and pathologists are major barriers to receipt of high-quality oncologic care in many parts of the world. **FIGURE 31.1** Indeed, 8 million people die annually due to poor-quality care in low- and middle-income countries (LMICs), including many due to cancer.

Surgery is needed for 80% of early-stage cancer patients, and as a palliative measure for a substantial proportion of late-stage cancer patients. However, surgery is only delivered to one in four eligible patients globally due to infrastructure and workforce limitations, as well as lack of affordability, particularly in LMICs. Furthermore, although specialized surgery performed by an oncologic surgeon is crucial to patient outcomes, due to shortages of these specialists, cancer patients in LMICs usually receive surgery from a general surgeon. As surgery is a key contributor to improving the survival of cancer patients, the inequities in LMICs must be tackled.

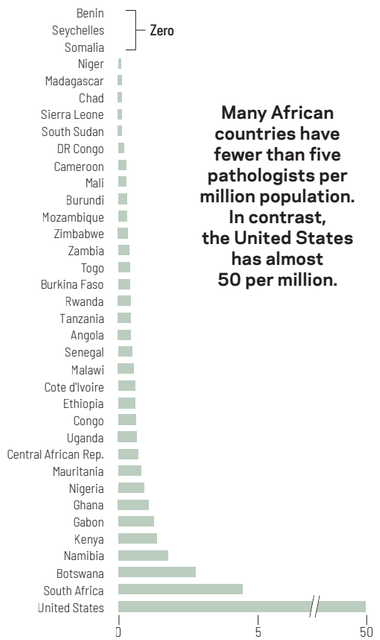
Radiotherapy is indicated for about 60% of cancer patients to relieve symptoms (palliative treatment), shrink tumors before surgery, or kill remaining cancer cells after surgery to avoid recurrence. For example, within 5 years after a diagnosis of cervical cancer, radiotherapy prevents recurrence in 1 in 3 patients and death in 1 in 5 patients. Radiotherapy coverage is less than optimal in many LMICs, with about one-third in Africa, about two-thirds in Asia Pacific, and around 90% in Europe and Latin America. **MAP 31.1** In Ethiopia, for example, a population of nearly 100 million is served by a single radiotherapy center. Newly implementing radiotherapy (mostly in Africa) and scaling up coverage (in South-East Asia) will require financial and human resources as well as continuous technical support.

Systemic therapy has changed over time, from administration of chemotherapy to all patients to personalized approaches considering receptor status, RNA expression, underlying DNA mutations, tumor environment and immunologic responses. Meanwhile, the cost of cancer drugs continues to rise, with over US$100,000 per treatment in many high-income countries. Still there are many low-cost and effective cancer drugs for broad and equitable application in LMICs, which are on the WHO essential drug list. **FIGURE 31.2, 31.3**

Political will and stewardship at the national level, as well as greater awareness and engagement across stakeholders, are necessary to close the cancer divide. This also requires health system improvements critical to addressing the delays in diagnosis and the lack of access to therapy that lead to disparities in premature death and survival between countries. Evidence-based guidelines to perform phased implementation are provided by the National Cancer Control Network according to different geographic regions. **FIGURE 31.4**

FIGURE 31.1

Pathologists per million population, select countries, 2011–2013



Many African countries have fewer than five pathologists per million population. In contrast, the United States has almost 50 per million.

FIGURE 31.3

Cancer therapy included on the World Health Organization essential medicines list, and the proportion of countries including the medication on their national essential medicines list

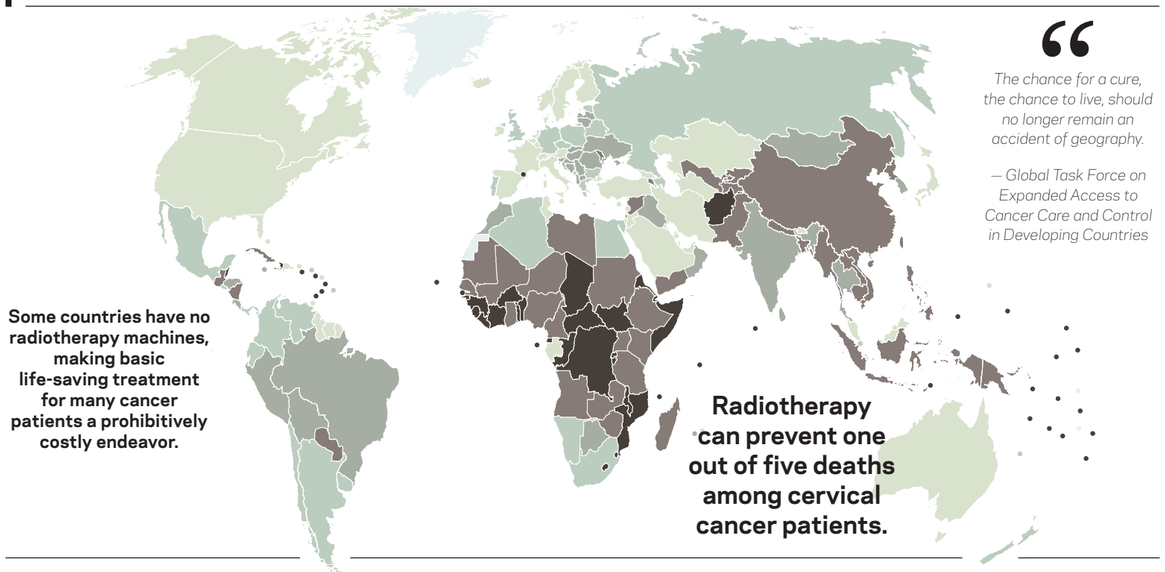
A substantial proportion of countries do not include major cancer therapies on their national essential medicine list.

MEDICINE	PERCENT (OF 135 COUNTRIES)	USED FOR THE FOLLOWING CANCERS
Methotrexate	95%	Breast, bladder, leukemia, sarcoma
Cyclophosphamide	89	Breast, lymphoma
Tamoxifen	83	Breast
Vincristine	82	Lymphoma, acute leukemia, sarcoma
Fluorouracil	81	Breast, gastrointestinal
Doxorubicin	73	Breast, lymphoma, sarcoma, bladder
Cisplatin	72	Lung, head & neck, ovary, osteosarcoma, cervix
Bleomycin	70	Germ cell tumor, Hodgkin lymphoma
Cytarabine	65	Acute leukemia
Hydroxycarbamide	65	Chronic myeloid leukemia
Mercaptopurine	64	Acute lymphocytic leukemia
Calcium folinate	62	Colorectum
Chlorambucil	62	Chronic lymphocytic leukemia
Etoposide	62	Lung, ovary, germ cell tumor

MAP 31.1

Number of radiotherapy machines per 1,000 cancer patients

Zero | 0.01–0.50 | 0.51–0.75 | 0.76–1.00 | 1.01 or more | No data



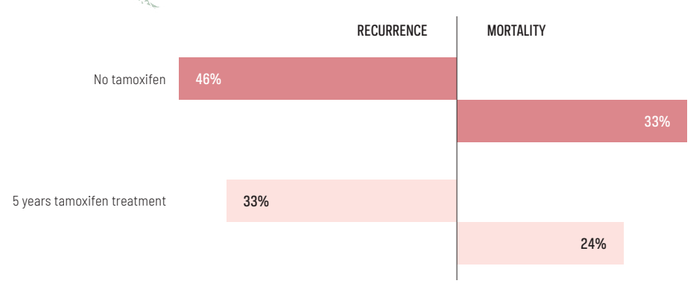
Some countries have no radiotherapy machines, making basic life-saving treatment for many cancer patients a prohibitively costly endeavor.

Radiotherapy can prevent one out of five deaths among cervical cancer patients.

> *The chance for a cure, the chance to live, should no longer remain an accident of geography.*
>
> *— Global Task Force on Expanded Access to Cancer Care and Control in Developing Countries*

FIGURE 31.2

Breast cancer recurrence and mortality (%) with and without 5 initial years of tamoxifen treatment, 15 years after diagnosis



Certain cancer therapeutics have greatly improved cancer outcomes. For example, tamoxifen endocrine therapy for hormone receptor-positive breast cancer patients substantially reduces local recurrence and disease-specific mortality.

FIGURE 31.4

Initiatives to improve access and quality of cancer care in low- and middle-income countries

NATIONAL CANCER CONTROL NETWORK (NCCN)

Resource stratified guidelines help to define appropriate treatment pathways based on available resources—Basic, Core, Enhanced, and NCCN Guidelines®—and deliver a tool for healthcare providers to identify treatment options that will provide the best possible outcomes given specific resource constraints.

Regional guidelines are targeted regional resources created as part of a collaborative effort to combat skyrocketing cancer rates and unique care circumstances. They represent both the optimal care that low- and mid-resource countries aspire to provide, and pragmatic approaches that provide effective treatment options for resource-constrained settings.

DISEASE CONTROL PRIORITIES 3: CANCER

Disease Control Priorities provides a periodic review of the most up-to-date evidence on cost-effective interventions to address the burden of disease in low-resource settings. This textbook provides evidence for investments in cancer control, from prevention to treatment, worldwide.

THE NATIONAL ACADEMIES OF SCIENCES, ENGINEERING, AND MEDICINE

The report "Crossing the Global Quality Chasm: Improving Health Care Worldwide" examines the global impacts of poor-quality health care and recommends measures to improve quality while expanding universal healthcare coverage, particularly in low-resource areas.

LANCET JOURNAL COMMISSIONS

Responding to the Cancer Crisis: Expanding Global Access to Radiotherapy: This Commission presents research that quantifies the worldwide coverage of radiotherapy services by country, also providing evidence that investment in radiotherapy not only enables treatment of large number of cancer cases to save lives but also brings positive economic benefits.

Global Surgery: This Commission describes the role of surgical and anesthesia care in improving health and economic productivity. It presents findings on the state of surgical care in LMICs, as well as recommendations, indicators, and targets needed to achieve the vision of universal access to safe, affordable surgical and anesthesia care when needed.

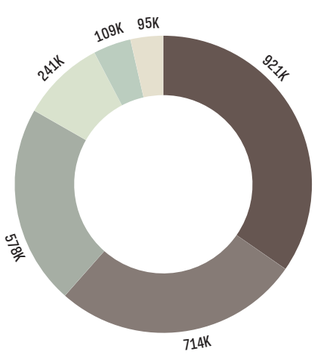
PAIN CONTROL

Millions of cancer patients, almost entirely in low- and middle-income countries, lack access to essential pain medicines.

FIGURE 32.3

Untreated deaths in pain by region, 2016

- East Asia & Pacific
- South Asia
- Sub-Saharan Africa
- Europe & Central Asia
- Latin America & Caribbean
- Middle East & North Africa
- North America*



The greatest numbers of untreated deaths in pain are in East Asia and the Pacific; South Asia; and sub-Saharan Africa.

*Zero untreated deaths in pain in North America, 2016.

Essential medicine lists of the World Health Organization and many countries include opioid analgesics, such as morphine. The moderate or severe pain experienced by approximately 80% of people with advanced cancer cannot be relieved without them.

But access to opioid analgesics is limited in low- and middle-income countries, where 85% of the world's population consumes just 7% of the medicinal opioids. **FIGURE 32.2** Legal and regulatory restrictions, cultural misperceptions about pain, inadequate training of healthcare providers, poorly functioning markets, weak health systems, and concern about addiction and non-medical use all contribute to limited access, even though morphine, the most effective treatment for severe pain, is safe, effective, inexpensive, and easy to use.

Meanwhile, some high-income countries are dealing with a very different challenge related to pain relief, as rates of addiction continue to rise due to harmful and non-medical use of opioids.

Worldwide, the number of cancer patients in need of pain relief is projected to increase 48% from 2018 to 2035, but the increase is likely to be considerably higher in the regions with more rapidly increasing cancer rates and with the lowest access to pain relief, including South-Eastern Asia (projected 54% increase in cancer cases) and Africa (72% increase), where consumption of pain relief is sufficient to cover less than 25% of deaths in pain. **FIGURE 32.3** A balanced approach to access to opioids with sufficient measures to prevent harmful and non-medical use has been achieved by many Western European countries and in some low- and low-middle income countries.

FIGURE 32.2

Total cancer and HIV deaths in pain and those treated for pain, by income level, 2016

Treated deaths in pain, based on opioid consumption

Total deaths in pain due to cancer or HIV, treated and untreated

HIGH INCOME

99.9%
2,091,578 Treated deaths

2,094,499 Total deaths

MIDDLE INCOME

57%
3,022,701 Treated deaths

5,306,664 Total deaths

LOW INCOME

17%
76,163 Treated deaths

447,538 Total deaths

86% of untreated deaths in pain are in middle-income countries.

"Improved access to oral morphine is mandatory for the treatment of moderate to severe cancer pain, suffered by over 80% of cancer patients in terminal phase.

— World Health Organization

MAP 32.1

Untreated deaths in pain, 2016

Zero | 1–1,598 | 1,599–5,270 | 5,271–13,604 | 13,605 or more | No data

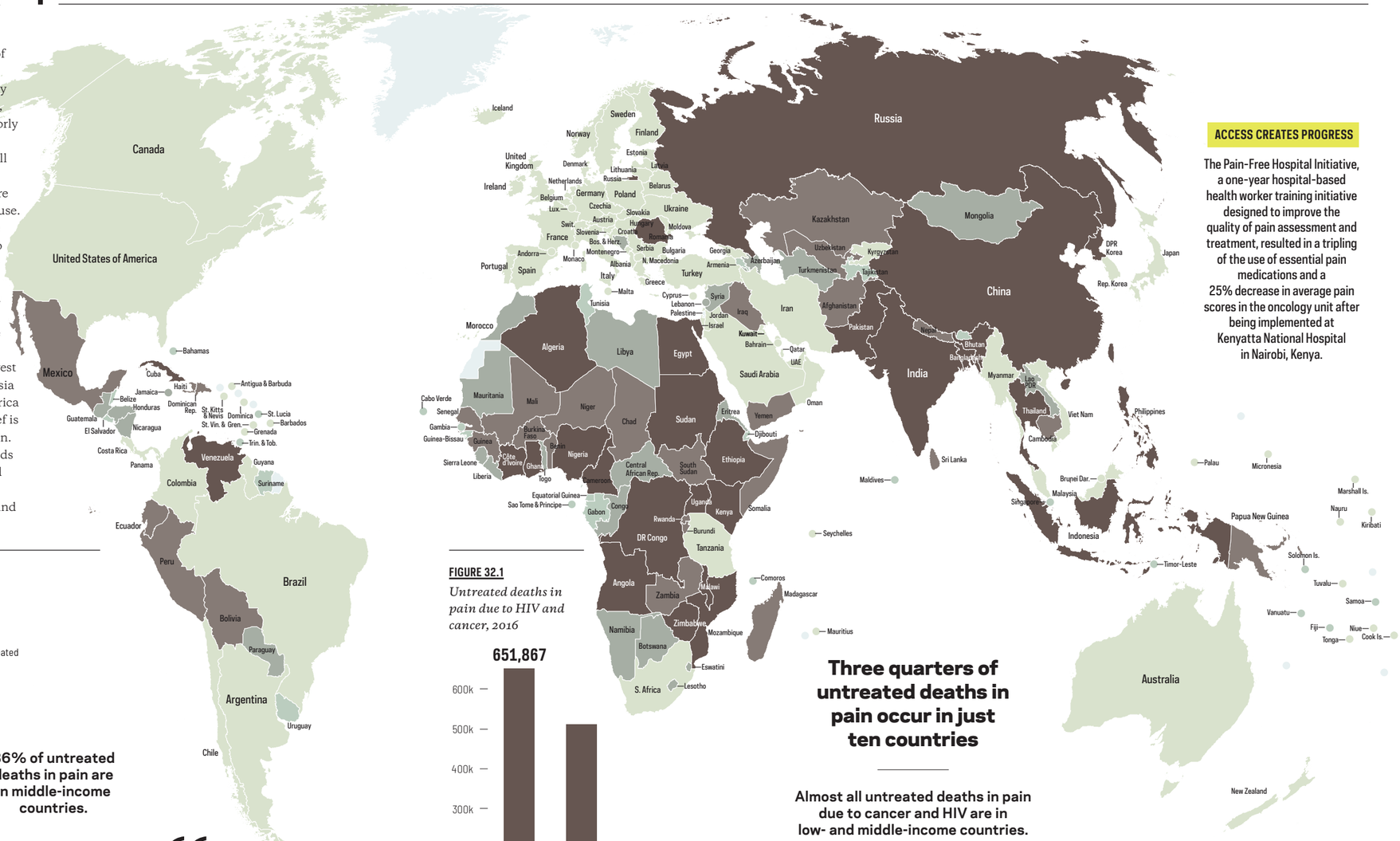


FIGURE 32.1

Untreated deaths in pain due to HIV and cancer, 2016

Three quarters of untreated deaths in pain occur in just ten countries

Almost all untreated deaths in pain due to cancer and HIV are in low- and middle-income countries.

ACCESS CREATES PROGRESS

The Pain-Free Hospital Initiative, a one-year hospital-based health worker training initiative designed to improve the quality of pain assessment and treatment, resulted in a tripling of the use of essential pain medications and a 25% decrease in average pain scores in the oncology unit after being implemented at Kenyatta National Hospital in Nairobi, Kenya.

CANCER SURVEILLANCE

Reliable cancer incidence and mortality data are essential to cancer control. To better equip countries, a global strategy is underway to strengthen capacity in cancer surveillance, prioritizing support in low- and middle-income countries.

Reliable cancer data are essential for planning and monitoring the effectiveness of cancer control programs, for examining cancer care delivery patterns, and other types of research. Population-based cancer registries (PBCRs) fulfill this requirement by systematically collecting cancer incidence data for defined populations. This includes information on patient and tumor characteristics at diagnosis, as well as additional information including receipt of treatment and vital status where resources permit.

Cancer registry data are primarily used to describe the scale and profile of the cancer burden and changes in cancer patterns across time and geographic areas. A PBCR may cover an entire country, but most cover smaller regions within a country, particularly in large or resource-constrained countries. Registry quality varies widely by geographic region. **MAP 33.1**

Although there are significant disparities in the status, population coverage, and quality of cancer registries worldwide, the number of high-quality cancer registries is increasing. **FIGURE 33.1** Volume I of the Cancer Incidence in Five Continents series, covering the early 1960s, included datasets from 31 cancer registries in 28 countries. The most recent volume (Volume XI), covering 2008–2012, has data from 343 registries in 68 countries. The Global Initiative for Cancer Registry Development (*http://gicr.iarc.fr*) was established by the International Agency for Research on Cancer (IARC) in 2011 in partnership with international and national organizations aiming to improve the availability of high-quality cancer registry data via support for within-country capacity building. Six IARC Regional Hubs and accompanying IARC Collaborating Centres work with local and regional partners to provide direct support to registries, deliver training, conduct research, and develop networks.

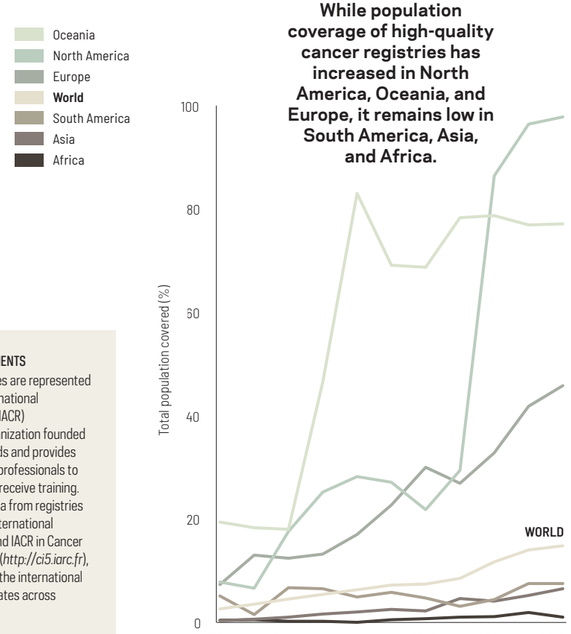
Cancer mortality data, predominantly collected through vital registration systems, are also important for planning and monitoring cancer control programs as well as for research. As with cancer registry data, the availability and quality of death certificate information varies widely, with many low- and middle-income countries having either poor quality data or a complete absence of vital registration. **MAP 33.2**

In many countries, mortality data complements the cancer registry database as a means to identify a patient's status (alive or dead) to estimate cancer survival. Survival studies remain sparse in many transitioning countries, in part due to the absence or low quality of national mortality information systems. Cancer survival is nevertheless a key indicator of the effectiveness of cancer services in a country or region, and a positive measure of prognosis that can reflect the prospects of clinical cure.

In the early 1960s, there were only 31 high quality population-based cancer registries in 28 countries. This number has increased to 343 registries in 68 countries in 2008–2012, providing essential data for health planning and prioritization.

FIGURE 33.1

Coverage (%) of high-quality population-based cancer registries by period and world region, as published in Cancer Incidence in 5 Continents

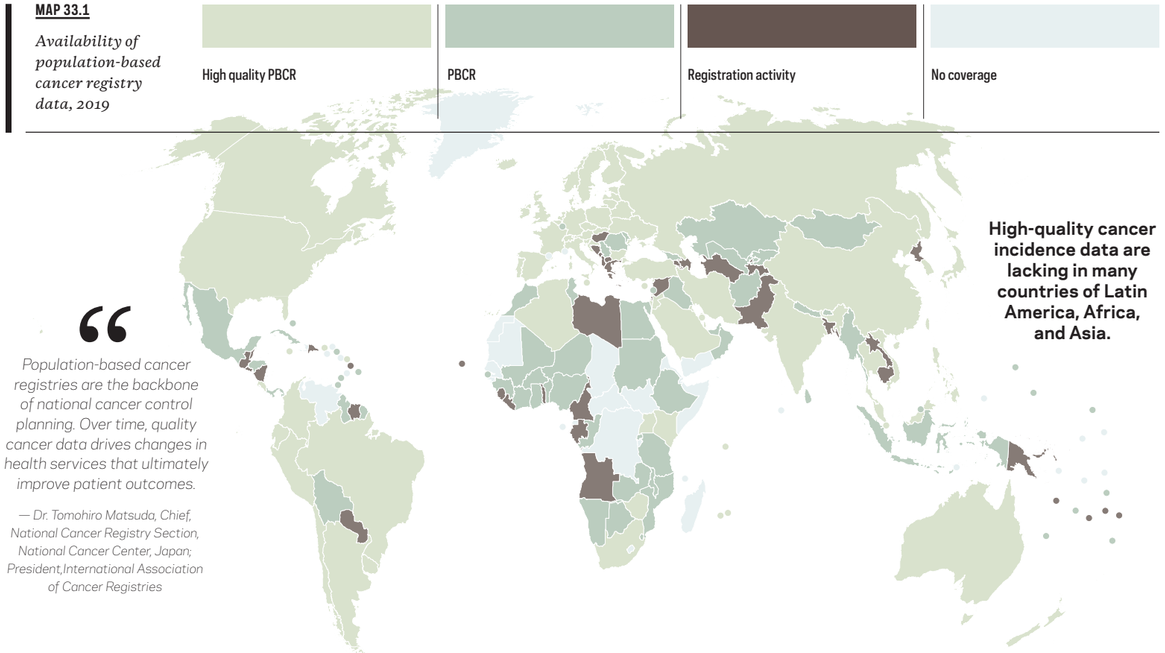


CANCER INCIDENCE IN FIVE CONTINENTS

Population-based cancer registries are represented throughout the world by the International Association of Cancer Registries (IACR) (*http://www.iacr.com.fr/*), an organization founded in 1966 that establishes standards and provides opportunities for cancer registry professionals to meet, exchange information, and receive training. High-quality cancer incidence data from registries worldwide are published by the International Agency for Research on Cancer and IACR in Cancer Incidence in Five Continents (CI5) (*http://ci5.iarc.fr*), now in its 11th volume, to enable the international comparison of cancer incidence rates across populations and time.

MAP 33.1

Availability of population-based cancer registry data, 2019

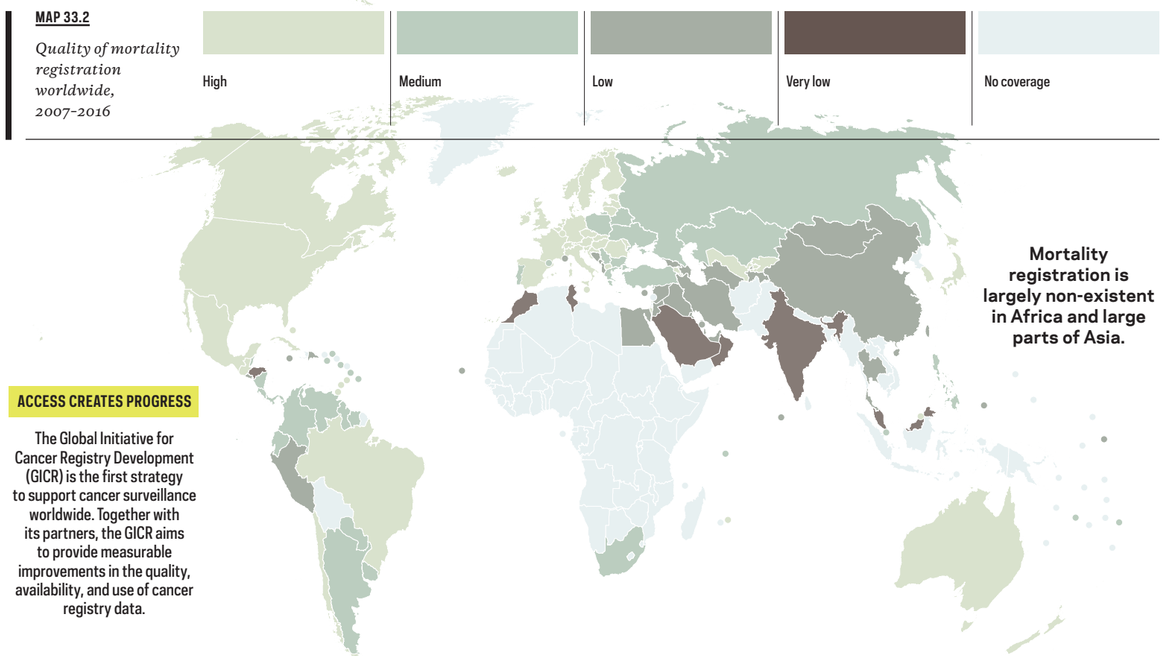


Population-based cancer registries are the backbone of national cancer control planning. Over time, quality cancer data drives changes in health services that ultimately improve patient outcomes.

— Dr. Tomohiro Matsuda, Chief, National Cancer Registry Section, National Cancer Center, Japan; President, International Association of Cancer Registries

MAP 33.2

Quality of mortality registration worldwide, 2007–2016



ACCESS CREATES PROGRESS

The Global Initiative for Cancer Registry Development (GICR) is the first strategy to support cancer surveillance worldwide. Together with its partners, the GICR aims to provide measurable improvements in the quality, availability, and use of cancer registry data.

RESEARCH

Each country and locality needs cancer research tailored to local disease burdens and knowledge gaps to improve population health.

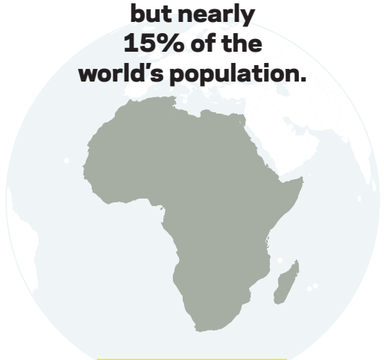
For national or regional cancer control programs, research is an essential component of planning, implementation, and monitoring the program's effectiveness. In addition, research improves patient outcomes and creates national wealth through innovation. However, bibliometrics reveal a large disparity in research activities across countries. **FIGURE 34.1, 34.2** The United States and a few wealthy European countries account for the majority of publications.

Barriers to development of strong, sustainable cancer research output in low-income countries include lack of funds, competing disease priorities, weak infrastructure, and work load and protected time to do research. For example, expenditure on science and technology research represents less than 1% of gross domestic product in many low-income countries, compared to over 2.5% in several high-income countries. **FIGURE 34.3** However, there is renewed commitment from private and public institutions in high-income countries to help build sustainable research capacity in low-income countries through north-south partnerships.

In addition to regional variation in publication output, there is a mismatch between cancer research output/funding and societal cancer burden. Some common cancer sites, such as pancreas and lung in the United States and Europe, are under-funded and under-studied compared to less common cancers. **FIGURE 34.4** Further, in many countries the bulk of research funding is allotted to basic science, with very little to cancer prevention and control research.

Increased cancer research tailored to local disease burdens and knowledge gaps is needed for continuous improvement of population health in each country and locality. In low- and middle-income countries, research should focus on identifying local, common risk factors (for example, local alcoholic brews), evaluating preventive interventions, and conducting implementation and operational research. Research in high-income countries should also focus on implementation research as well as biological markers and precision medicine.

Africa accounts for less than 1% of worldwide research publications, but nearly 15% of the world's population.

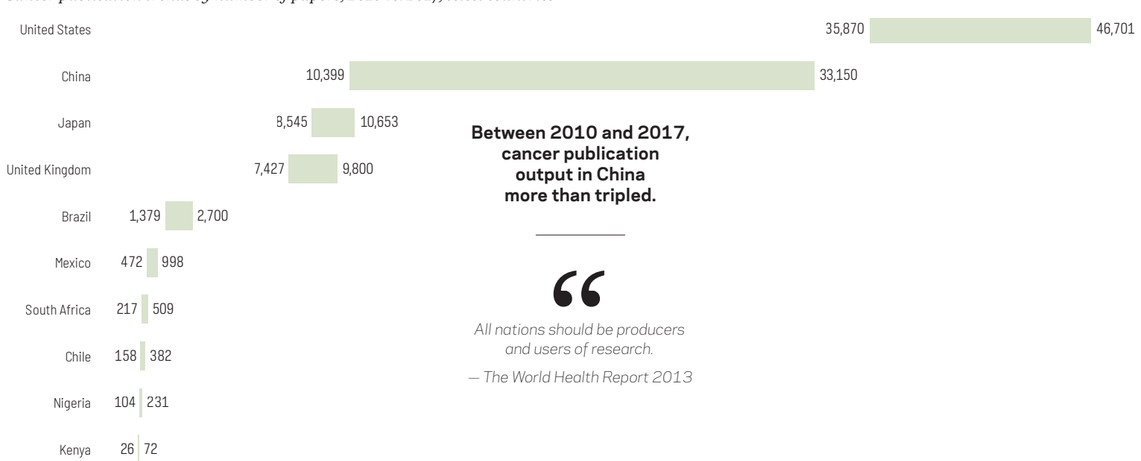


ACCESS CREATES PROGRESS

International research collaborations such as the African Research Group for Oncology, a partnership between hospitals and universities in Nigeria, the United States, and the United Kingdom, can advance cancer knowledge and provide evidence and data for making health policy decisions.

FIGURE 34.1

Cancer publication trends by number of papers, 2010 vs. 2017, select countries



Between 2010 and 2017, cancer publication output in China more than tripled.

> *All nations should be producers and users of research.*
>
> *— The World Health Report 2013*

FIGURE 34.2

Cancer publications (2002-2013) compared with gross domestic product (GDP) for 31 European countries

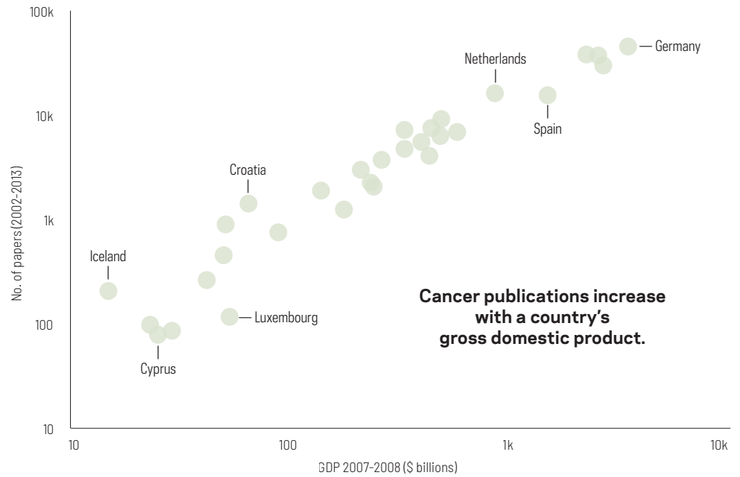


FIGURE 34.4

Research priorities by cancer site in number of publications, proportion of US National Cancer Institute (NCI) funding (2012), and disability-adjusted life years (DALYs, 2011)*

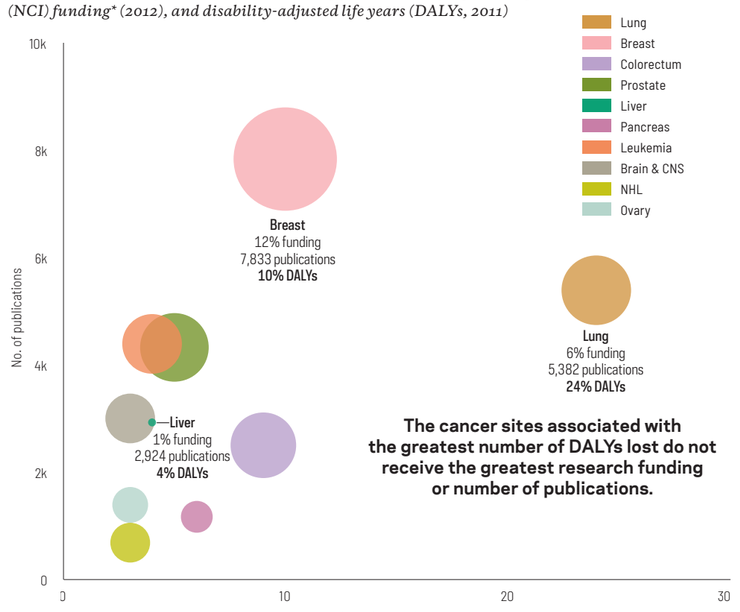
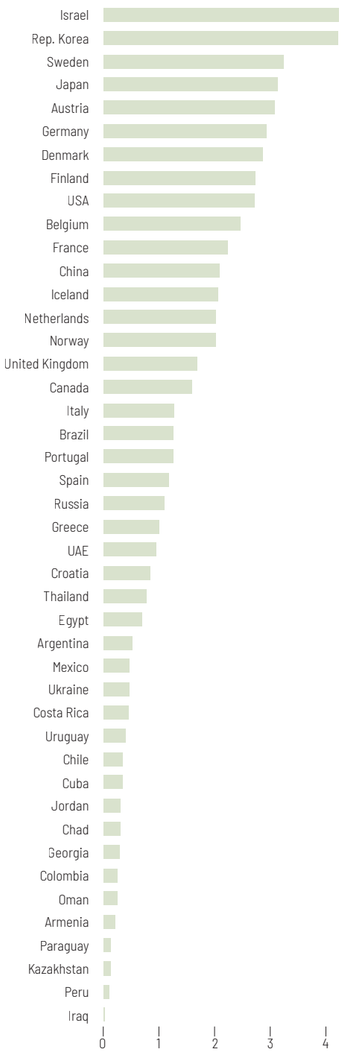


FIGURE 34.3

Percent (%) of gross domestic product (GDP) spent on research, 2016 estimates, select countries

A greater percentage of GDP is spent on research in higher-HDI countries.



THE ECONOMIC BURDEN OF CANCER

The economic burden of cancer is substantial in all countries and reflects health care spending as well as lost productivity due to morbidity and premature death from cancer. As cancer treatment costs increase, prevention and early detection efforts become more cost-effective, and potentially cost-saving.

The economic burden of lost productivity due to morbidity and premature death from cancer is nearly 60% of the total economic burden associated with cancer in European Union countries.

Cancer results in economic burden for patients, healthcare systems, and countries due to healthcare spending, and productivity losses from morbidity and premature mortality. Economic analyses can inform resource allocation decisions and investments in cancer control programs, including prevention, early detection, treatment, survivorship, and end-of-life care.

The global economic burden of cancer is unknown, although data are available in some countries. In the US in 2017, estimated cancer healthcare spending was US$161.2 billion; productivity loss from morbidity, US$30.3 billion; and premature mortality, US$150.7 billion. The economic burden of cancer in the US is approximately 1.8% of gross domestic product (GDP). In the European Union, healthcare spending was €57.3 billion, and productivity losses due to morbidity and premature death were €10.6 billion and €47.9 billion, respectively. With informal care costs of €26.1 billion, total burden rose to €141.8 billion, 1.07% of GDP. FIGURE 35.1

Productivity losses due to premature deaths vary in transitioning countries. FIGURE 35.2

Cancer treatment costs are increasing worldwide, making prevention and screening efforts more cost-effective and sometimes cost-saving. For example, when more expensive chemotherapies were considered in comparisons of colorectal cancer screening to no screening, treatment savings from preventing advanced cancer and death more than doubled in the US. Vaccination against human papillomavirus infection, which is responsible for most cervical cancers, in 73 countries supported by Gavi, the Vaccine Alliance, could avert nearly $5.6 billion in treatment costs and productivity losses between 2001–2020. Smoking is a strong risk factor for lung and other cancers. The cost of smoking globally is nearly $2.05 trillion annually, almost 2% of the world's economic output. FIGURE 35.3 Most of this cost is productivity losses from premature death.

FIGURE 35.1

*Total costs of cancer in billions of Euro including cancer care and productivity losses in 2009, select European countries**

The cost of cancer varies widely in European Union countries, reflecting differences in population size, age distribution, healthcare delivery systems, employment patterns and wages, and cancer incidence and mortality rates.

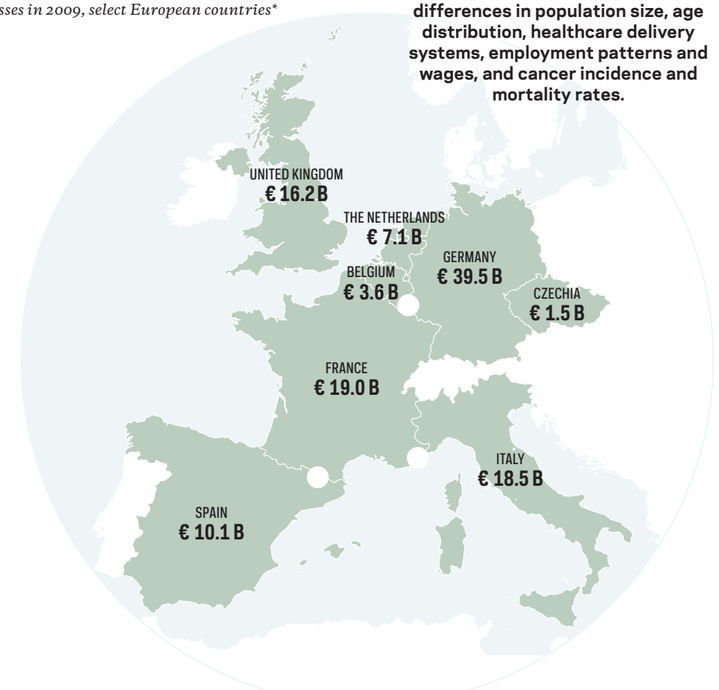
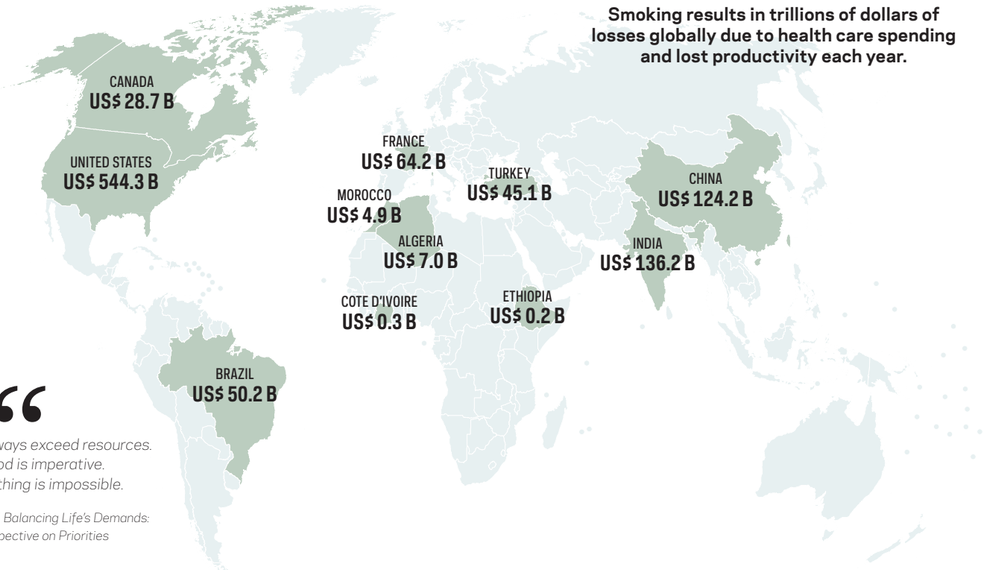


FIGURE 35.3 *Economic cost of smoking-attributable diseases annually (healthcare spending and productivity losses)**

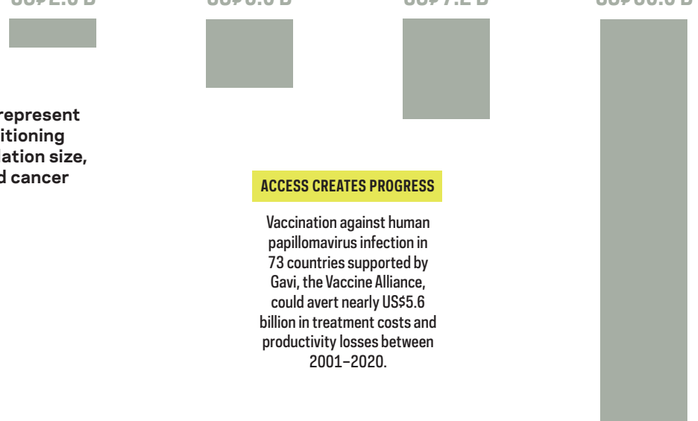
Smoking results in trillions of dollars of losses globally due to health care spending and lost productivity each year.



> *Requests will always exceed resources. Doing good is imperative. Doing everything is impossible.*
>
> *— J. Grant Howard, Balancing Life's Demands: A New Perspective on Priorities*

FIGURE 35.2 *Productivity losses due to premature deaths from cancer in transitioning economies**

	SOUTH AFRICA	BRAZIL	INDIA	CHINA
COST PER CANCER DEATH	US$108,320	US$57,186	US$21,096	US$61,594
TOTAL COST AS % OF GROSS DOMESTIC PRODUCT	0.49%	0.21%	0.36%	0.34%
TOTAL PRODUCTIVITY LOSS	US$2.0 B	US$5.0 B	US$7.2 B	US$30.0 B



Productivity losses due to cancer represent a large economic burden in transitioning economies. Variation reflects population size, employment patterns, wages, and cancer mortality rates.

ACCESS CREATES PROGRESS

Vaccination against human papillomavirus infection in 73 countries supported by Gavi, the Vaccine Alliance, could avert nearly US$5.6 billion in treatment costs and productivity losses between 2001–2020.

*For details on inflation adjustment, see Sources and Methods, page 124.

BUILDING SYNERGIES

Building synergies between diseases as well as health systems improves cancer prevention and treatment.

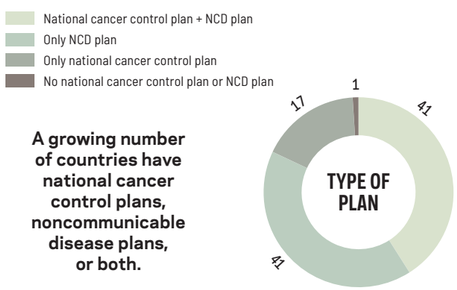
In 2011, the global community adopted the Global Action Plan (GAP) for the prevention and Control of Non-communicable Diseases (NCDs). The GAP urged countries to set national targets to address premature death from four major NCDs (cancer, cardiovascular disease, diabetes, and respiratory disease). Built into the GAP is the opportunity to address various risk factors across NCDs that contribute to premature mortality, known as "best buys". **FIGURE 36.1** In addition to focusing on these proven strategies, countries can turn to successful programs in maternal and child health and HIV prevention and control, among others, to reach the target population to promote cancer prevention and control. Adequately funded and staffed National Cancer Control Plans are the best approach to address the cancer burden in the existing health context. **FIGURE 36.2**

The growing cancer burden in low- and middle-income countries necessitates building on existing infrastructure. **MAP 36.1 & 2** In Rwanda, cervical cancer control has been successfully integrated into women's health services. In Kenya, leaders built on the existing HIV-treatment infrastructure to screen and treat women for cervical cancer. The American Society for Clinical Oncology* trains primary care physicians in countries with limited oncology infrastructure to recognize the signs and symptoms of cancer, and to better integrate cancer services into existing resources. Partners who can help country planners see the whole health landscape, including cancer, are critical in supporting this integration at the country level. For example, the International Cancer Control Partnership was formed by the US National Cancer Institute and the Union for International Cancer Control to support country development of national cancer plans or to encourage countries to include cancer control activities within their NCD plan. The International Cancer Control Partnership portal (*https://www.iccp-portal.org*) contains resources for plan development, including examples of plans that integrate across the health system.

Essentially, cancer cannot be addressed alone. It shares many common risk factors with other NCDs, and the health systems that work to prevent and treat NCDs as well as infectious diseases can be leveraged to effectively incorporate cancer control.

FIGURE 36.2

Countries with national cancer control and noncommunicable disease (NCD) plans (%), 2015



A growing number of countries have national cancer control plans, noncommunicable disease plans, or both.

> *The transformed health systems established through investment in HIV programming in sub-Saharan Africa present a unique opportunity for countries to tackle the rapidly rising burden of NCDs.*
>
> *— Wafaa M. El-Sadr, Director, International Center for AIDS Care and Treatment Programs; and Eric Goosby, UN Special Envoy on Tuberculosis and former US Global AIDS Coordinator*

FIGURE 36.1

"Best buy" interventions to reduce noncommunicable diseases and contribute to Sustainable Development Goal 3.4

Addressing multiple risk factors can reduce the overall noncommunicable disease burden and premature mortality. "Best buys" are a set of affordable, feasible and cost-effective intervention strategies to achieve these goals.

GOAL 3.4

By 2030, reduce by one third premature mortality from non-communicable diseases (NCDs) through prevention and treatment and promote mental health and well-being.

SUSTAINABLE DEVELOPMENT GOALS

REDUCE TOBACCO USE
- -Tax increases
- -Smoke-free indoor workplaces and public places
- -Health information and warnings
- -Bans on tobacco advertising, promotion and sponsorship

REDUCE HARMFUL USE OF ALCOHOL
- -Tax increases
- -Restricted access to retailed alcohol
- -Bans on alcohol advertising

REDUCE UNHEALTHY DIET
- -Reduced salt intake in food
- -Replacement of trans fat with polyunsaturated fat
- -Public awareness through mass media on diet

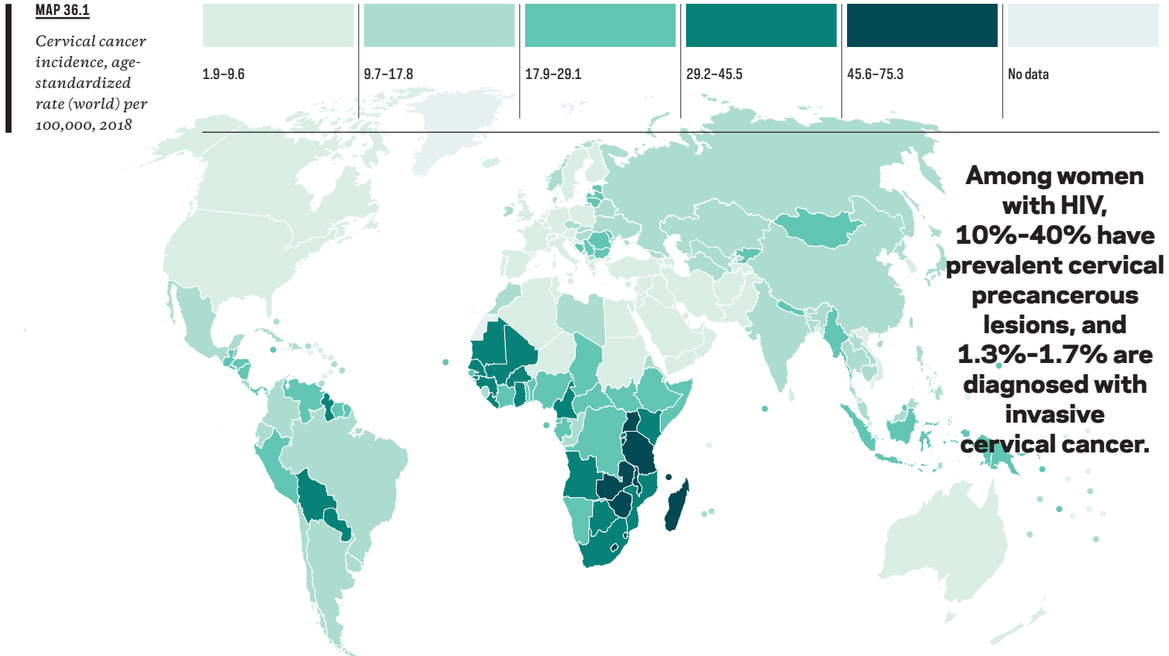
REDUCE PHYSICAL INACTIVITY
- -Public awareness through mass media on physical activity

MANAGE CARDIOVASCULAR DISEASE (CVD) AND DIABETES
- -Counseling and multi-drug therapy for people with a high risk of developing heart attacks and strokes (including those with established CVD)
- -Treatment of heart attacks with aspirin

PREVENT AND MANAGE CANCER
- -Hepatitis B immunization to prevent liver cancer
- -Screening and treatment of pre-cancerous lesions to prevent cervical cancer

MAP 36.1

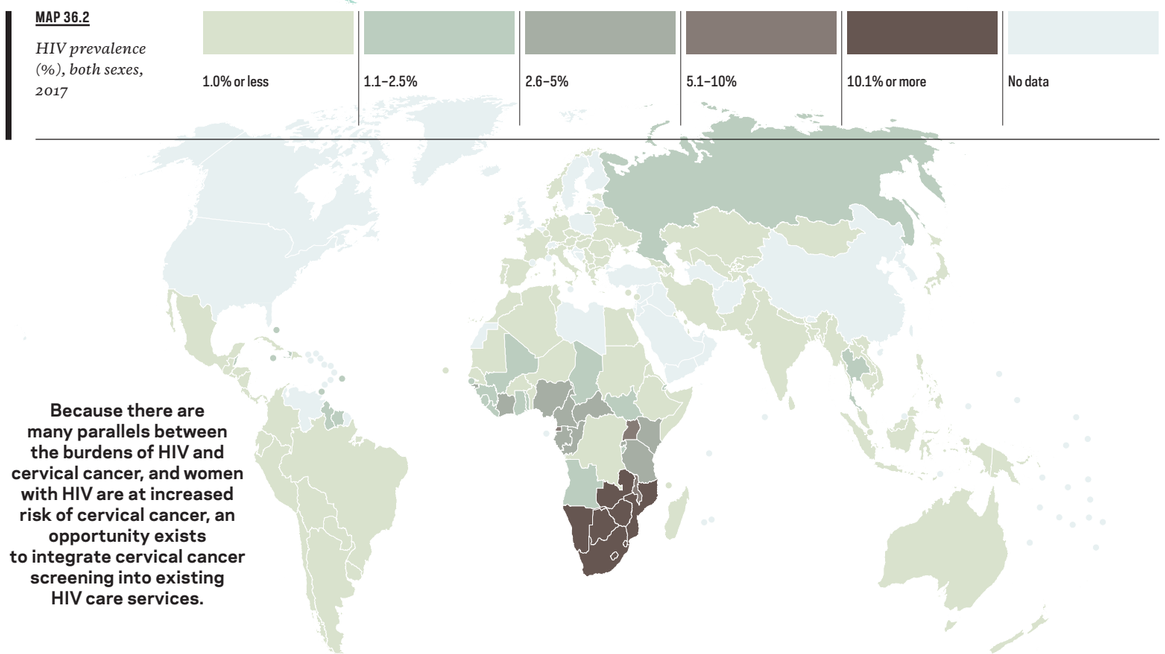
Cervical cancer incidence, age-standardized rate (world) per 100,000, 2018



Among women with HIV, 10%–40% have prevalent cervical precancerous lesions, and 1.3%–1.7% are diagnosed with invasive cervical cancer.

MAP 36.2

HIV prevalence (%), both sexes, 2017



Because there are many parallels between the burdens of HIV and cervical cancer, and women with HIV are at increased risk of cervical cancer, an opportunity exists to integrate cervical cancer screening into existing HIV care services.

*https://www.asco.org/international-programs/international-meetings-educational-opportunities/cancer-control-primary-care

UNITING ORGANIZATIONS

A cancer community united behind implementation of the commitments from the World Health Assembly 2017 cancer resolution will harness the political drive for real national impact.

Now is the time to drive national action to reduce cancer deaths. Governments are following up on major global commitments including the Sustainable Development Goals (SDGs), the United Nations (UN) Political Declaration on the Prevention and Control of non-communicable diseases (NCDs), and the 2017 World Health Assembly cancer resolution, which outlines a clear roadmap to scale up action on cancer control, irrespective of income level. Because cancer knows no borders, cooperation is necessary to reduce the burden of cancer nationally and internationally. **FIGURE 37.3** Working in partnership has benefits such as amplifying cancer control initiatives and bringing them to the attention of key decision-makers, expanding the reach and scale-up of interventions, stimulating idea generation and peer-to-peer support, and shaping cancer policies that can leave a long-lasting footprint around the world. The global cancer community—including the UN, WHO, Ministries of Health, national cancer institutes, cancer societies, research and treatment centers, academia, patient support groups, appropriate private sector, and survivors at the local, national and global levels—is collaborating on a broad spectrum of activities that support cancer surveillance, early detection, treatment and care, and the delivery of palliative care. **FIGURE 37.1** Many of these organizations work on the development, implementation, and monitoring of National Cancer Control Plans (NCCPs) that are the foundation for the prevention and control of cancer in their countries. **MAP 37.1**

The 2017 World Health Assembly cancer resolution entitled "Cancer prevention and control in the context of an integrated approach" (WHA 70.12) aligns national cancer control with the growing dialogue on universal health coverage, emphasizing the links and opportunities for integration across health platforms to deliver sustainable cancer care and stronger health systems. The resolution also emphasizes the importance of partnerships where these are fundamental to achieving the SDGs by 2030. **FIGURE 37.2**

MEXICO
JUNTOS CONTRA EL CÁNCER

More than 50 civil society organizations from Mexico have created the "Juntos Contra el Cáncer" (Together Against Cancer) coalition to position cancer in the national health agenda and be the voice of patients in the country.

FIGURE 37.1 *Treatment for All, an advocacy campaign run by UICC*

TREATMENT FOR ALL

Improved cancer data for public health use	Access to early detection and diagnosis	Timely and accurate treatment	Supportive and palliative care

Treatment for All aims to decrease the 4.3 million premature deaths from cancer worldwide through a global campaign engaging a growing network of motivated national cancer organizations intent on helping governments fulfill their obligations to deliver a 25% reduction in premature deaths through cancer and other NCDs by 2025. UICC is working with its members in countries to help them develop an advocacy plan to address a specific priority related to one of the four levers for change on cancer treatment and care.

MAP 37.1

A global network of cancer organizations

There are over 1,100 Union for International Cancer Control (UICC) members in 170 countries.

UNION FOR INTERNATIONAL CANCER CONTROL (UICC), based in Geneva, is the largest and oldest international cancer organization dedicated to taking the lead in convening, capacity building, and advocacy initiatives that unite and support the cancer community to reduce the global cancer burden, promote greater equity, and ensure cancer control continues to be a priority in the world health and development agenda.

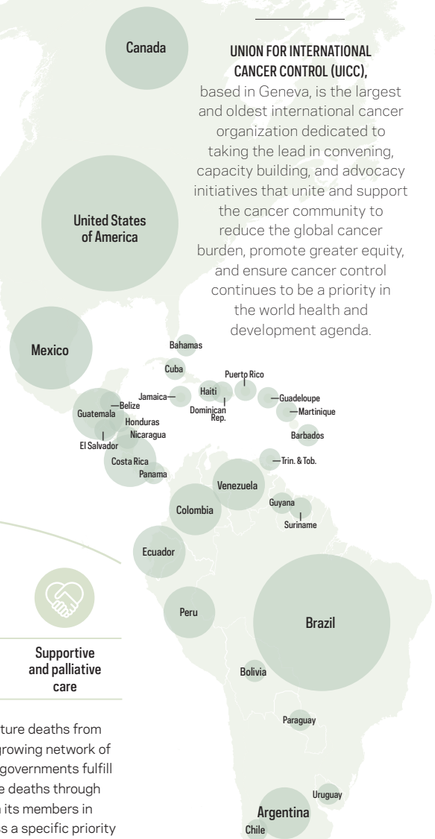


FIGURE 37.3
Creative opportunities to convene stakeholders within and beyond the cancer community

World Cancer Leaders' Summit

This high-level policy meeting is an opportunity to reach key decision-makers, and identify new and innovative solutions with thought-leaders in the cancer field.

UICC World Cancer Congress

The biennial World Cancer Congress provides a forum for cancer control experts, practitioners, and advocates to share best practice and the latest advances in cancer control.

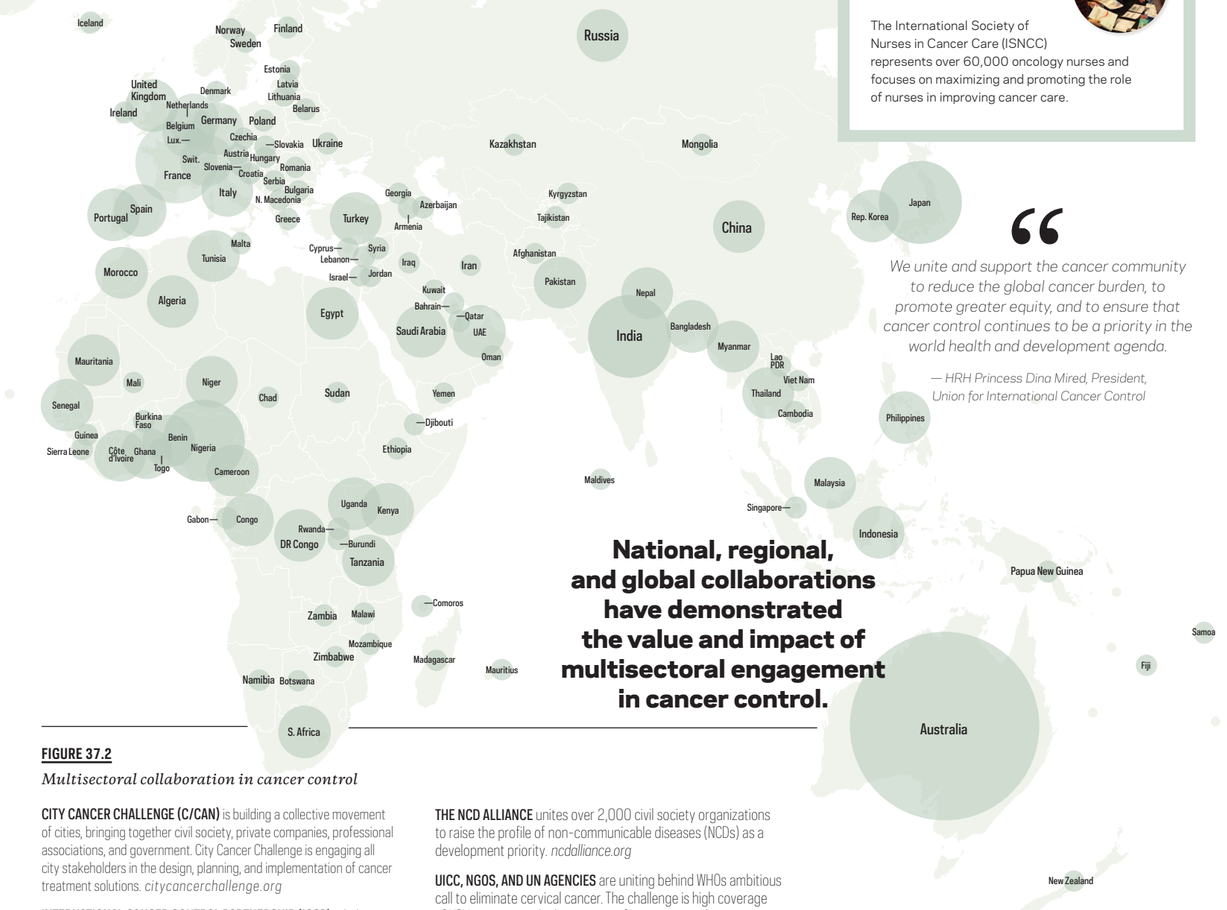
World Cancer Day 4 February

World Cancer Day (February 4) unites the entire world in the global fight against cancer, raising general awareness around the disease.

Small — SIZE OF CIRCLES REPRESENTS NUMBER OF UICC ORGANIZATIONS — Large
1 — 190

GLOBAL
INTERNATIONAL SOCIETY OF NURSES IN CANCER CARE (ISNCC)

The International Society of Nurses in Cancer Care (ISNCC) represents over 60,000 oncology nurses and focuses on maximizing and promoting the role of nurses in improving cancer care.



National, regional, and global collaborations have demonstrated the value and impact of multisectoral engagement in cancer control.

> "We unite and support the cancer community to reduce the global cancer burden, to promote greater equity, and to ensure that cancer control continues to be a priority in the world health and development agenda."
>
> — HRH Princess Dina Mired, President, Union for International Cancer Control

These innovative and strategic partnerships are working to achieve the SDG target of reducing premature deaths from cancer and other NCDs.

FIGURE 37.2

Multisectoral collaboration in cancer control

CITY CANCER CHALLENGE (C/CAN) is building a collective movement of cities, bringing together civil society, private companies, professional associations, and government. City Cancer Challenge is engaging all city stakeholders in the design, planning, and implementation of cancer treatment solutions. *citycancerchallenge.org*

INTERNATIONAL CANCER CONTROL PARTNERSHIP (ICCP) is helping governments to develop and implement effective national cancer control plans. *iccp-portal.org*

FRAMEWORK CONVENTION ALLIANCE is supporting global tobacco control efforts through the WHO Framework Convention on Tobacco Control. (FCTC). *fctc.org*

THE MCCABE CENTRE FOR LAW AND CANCER is building capacity for the effective use of law in cancer control. *mccabecentre.org*

THE NCD ALLIANCE unites over 2,000 civil society organizations to raise the profile of non-communicable diseases (NCDs) as a development priority. *ncdalliance.org*

UICC, NGOS, AND UN AGENCIES are uniting behind WHOs ambitious call to eliminate cervical cancer. The challenge is high coverage of HPV vaccination, high coverage of screening, and access to diagnosis, treatment, and care of invasive cancers for all. *who.int/reproductivehealth/call-to-action-elimination-cervical-cancer/en/*

eHOSPICE is a palliative care advocacy network that includes palliative care organizations from countries around the world working to position palliative care and pain relief within Universal Health Coverage (UHC) policy and programs. *ehospice.com*

GLOBAL RELAY FOR LIFE

Global Relay For Life celebrates survivors, remembers loved ones lost and mobilizes communities to take a stand against cancer.

> *When the Cancer Association of South Africa was given the "gift" of Relay For Life 13 years ago, no one thought this event would unite our nation in the fight against cancer—and provide such a strong platform for advocating against a disease that is affecting 1 out of 4 South Africans. Relay For Life has created the opportunity for our cancer survivors to celebrate their lives and for all of us to stand as one—TOGETHER WE CAN!*
>
> — *Maria Scholtz, Head Sustainability, Cancer Association of South Africa (CANSA)*

What started with one person in the USA more than 30 years ago to raise money and awareness has become a true global movement against cancer, uniting people in 29 countries to do what no one country or organization can do alone: build a world free from cancer. Across the globe, Relay For Life fosters hope, healing and inspiration in more than 5,000 communities. **MAP & FIGURE 38.1**

The American Cancer Society's Global Relay For Life program engages global organizations to empower communities and accelerate the fight for a world without cancer. Across the world, cancer organizations are utilizing Relay For Life as a platform to deliver on their mission. With the Danish Cancer Society, Relay extends their advocacy initiatives, engaging participants, survivors and volunteers in anti-tobacco and caregiver advocacy events. The Japan Cancer Society found Relay For Life has attracted more students to volunteer work and "their interests tend to shift to learning the value of life and having compassion for others and self." The Cancer Society of New Zealand utilizes funds from the event to promote, deliver and facilitate more than 19,000 rides to treatment and nearly 62,000 nights of accommodation for patients.

This network of Relay For Life participants is bringing hope and help to millions across the globe. To learn more about the Relay For Life movement, please visit *relayforlife.org/global* or contact globalrelayforlife@cancer.org.

MAP & FIGURE 38.1

Global Relay For Life countries and numbers within continents, 2017

PARTICIPANTS IN UNITED KINGDOM

PARTICIPANTS IN PORTUGAL

PARTICIPANTS IN ZAMBIA

PARTICIPANTS IN SOUTH AFRICA

PARTICIPANTS IN MALAYSIA

REGION
EUROPE

Relays	199
Participants	203,029
Survivors	12,269
Caregivers	1,248
Luminaria*	197,199

REGION
AFRICA

Relays	70
Participants	39,451
Survivors	5,029
Caregivers	3,728
Luminaria*	42,142

REGION
THE AMERICAS

Relays	3,933
Participants	1,028,484
Survivors	227,893
Caregivers	7,009
Luminaria*	5,446

REGION
ASIA

Relays	56
Participants	45,949
Survivors	5,798
Caregivers	31,718
Luminaria*	46,567

REGION
AUSTRALASIA

Relays	167
Participants	92,658
Survivors	7,457
Caregivers	6,517
Luminaria*	29,636

A quarter of a million cancer survivors walked the track at their local Relay For Life in 2017

STORIES OF PARTICIPANTS

MALAYSIA
DALJIT SINGH

Six years as a survivor; 9 years as a caregiver to my wife, who had stomach cancer. I became involved in Relay For Life in 2005 as a volunteer at the event in Penang Malaysia. I have been a committee member and chair for the Luminaria for the last three years, along with my wife who is the Co-chair for survivors and Chair for team recruitment. It has been a very rewarding journey altogether.

STORIES OF PARTICIPANTS

DENMARK
STINE HENRIKSEN

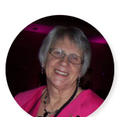
I live in Sorø, Denmark and have met cancer from both sides. Ten years ago, I lost my sister to cancer. A few years later, I was diagnosed with the same type of cancer. That left me in an indefinable state of gratitude—had it not been for my sisters' death, I probably would not have survived.
When I came across Relay For Life, it immediately made sense, simply because of the solidarity that lies in the 24-hour event. My approach to Relay For Life is that every single participant should go home feeling part of a larger whole. In Relay For Life, we celebrate life!

ACCESS CREATES PROGRESS

The world's largest fundraiser, Relay For Life attracted nearly 1.3 million participants in 2017.

STORIES OF PARTICIPANTS

AUSTRALIA
SUE KING



In 2005 I founded my team, the "Ridgley Rascals" from my small community of Ridgley, Tasmania. In 2012 I was diagnosed with breast cancer, which gave me a whole different feel for the Relay. The compassion, friendship, support and love I received from so many people at the Relay brought me to tears many times. I was experiencing the Relay through different eyes. I finally really understood what it was all about, and how all those survivors and their families felt about the Relay. I love it with a passion.

*Luminaria bags and candles are lit in remembrance of a life touched by cancer during Relay For Life.

POLICIES & LEGISLATION

Policy and legislation are essential to address the burden of cancer globally and locally. The effective use of law to achieve population health goals requires collaboration across sectors.

In 2011, a landmark high-level meeting of the United Nations General Assembly resulted in a commitment to address non-communicable diseases (NCDs) as a major development challenge. In 2013, the World Health Assembly adopted the World Health Organization Global Action Plan on NCDs, emphasizing whole-of-society approaches to reduce the major drivers of preventable NCDs. The plan also endorsed a global monitoring framework including nine voluntary global targets. **FIGURE 39.1** In 2015, a goal to reduce premature mortality from NCDs by one-third was included in the United Nations Sustainable Development Goals. **FIGURE 39.2**

The effective use of law is critical to addressing cancer and other NCDs. This is true across the cancer and NCD continuum, including prevention (reducing exposure to risk factors such as tobacco, alcohol, unhealthy diet, air pollution, and occupational exposures); conduct of research and collection and management of personal health information (protection of individual privacy, while allowing for the conduct and dissemination of essential medical and public health research); screening, diagnosis, treatment and care (access, affordability, quality, safety, regulation of health practitioners, and protection of the rights of patients, their families and carers); and life after a diagnosis (employment protection, access to insurance, pension funds, and loans).

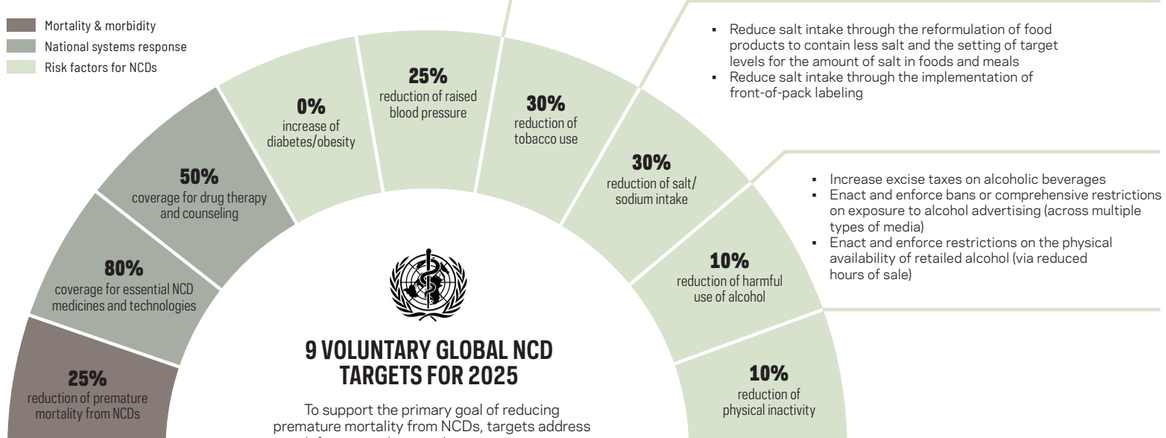
The effective use of law requires collaboration across sectors: government; civil society; academia; health professionals; communities; people affected by cancer or NCDs, their families and caregivers; and, as appropriate, the private sector. Collaboration across different parts of government is also needed, as few problems can be addressed by health ministries acting alone.

Addressing cancer and NCDs through law involves engaging with domestic, regional and international legal and governance frameworks, including those dealing with health, human rights, international trade, intellectual property and investment law, environment, and occupational health and safety. It also requires being able to defend against litigation, or threats of litigation, by corporate interests—such as the tobacco, alcohol and food industries—which is becoming increasingly common. **FIGURE 39.3** Legal capacity is an essential component of the cancer/NCD workforce.

FIGURE 39.1

Nine voluntary global targets endorsed by governments in the World Health Organization (WHO) Global Action Plan on NCDs

Law is essential to implement a number of the globally agreed 'best buys' for NCDs—the evidence-based interventions considered the most cost-effective and feasible for implementation in low- and lower middle-income countries.



The Australian Government has successfully defended against three sets of legal challenges to its tobacco plain packaging laws: a constitutional challenge in its highest domestic court, an investment treaty claim, and a dispute in the World Trade Organization. These victories demonstrate the power governments have to legislate for public health.

FIGURE 39.3

International trade and investment litigation against tobacco control laws

ACCESS CREATES PROGRESS

Australia and Uruguay have successfully defended litigation against their tobacco packaging laws under international trade, intellectual property and investment laws.

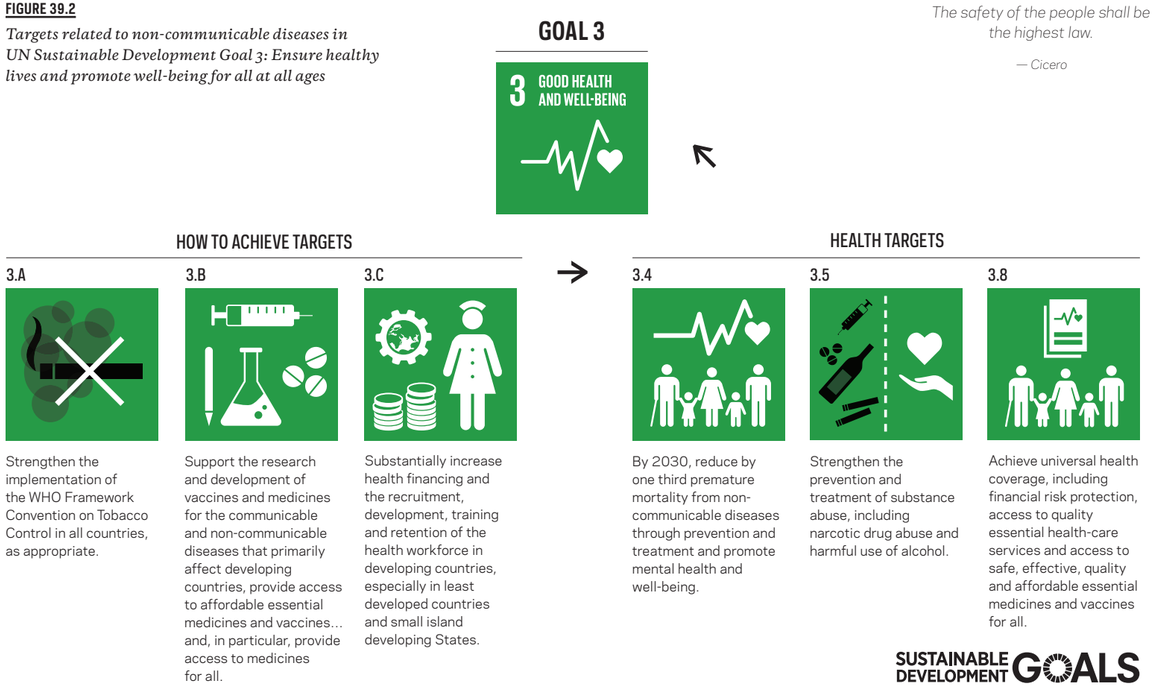
	AUSTRALIA	URUGUAY
Action	Australia was challenged under a bilateral investment treaty between Australia and Hong Kong by Philip Morris Asia, claiming expropriation and a breach of obligations to provide fair and equitable treatment (case decided in Australia's favor in December 2015), and in the World Trade Organization by Cuba, Dominican Republic, Honduras, and Indonesia, claiming breaches of obligations relating to trade restrictiveness and intellectual property protection (case decided in Australia's favor in June 2018).	Uruguay was challenged under a bilateral investment treaty between Uruguay and Switzerland by Philip Morris Switzerland, claiming expropriation and a breach of obligations to provide fair and equitable treatment (case decided in Uruguay's favor in July 2016).
Result	Australia's and Uruguay's successes have confirmed the policy space that countries have under international trade, intellectual property, and investment agreements to implement evidence-based tobacco control measures. However, litigation of this nature is resource-intensive and expensive to defend.	

The safety of the people shall be the highest law.

— Cicero

FIGURE 39.2

Targets related to non-communicable diseases in UN Sustainable Development Goal 3: Ensure healthy lives and promote well-being for all at all ages



UNIVERSAL HEALTH COVERAGE

Universal health coverage improves cancer outcomes equitably and promotes financial protection as well.

Universal health coverage (UHC) means that all people have access to the healthcare services they need, and that the services are of high quality without resulting in financial hardship for patients and their families. UHC has become an important policy goal in many countries, and plays a key role in the health-related United Nations Sustainable Development Goals.

Countries should progress towards UHC through a process of progressive realization by moving sequentially along 3 dimensions: (1) increase the proportion of the population covered; (2) increase the proportion of prepaid funds and reduce out-of-pocket payments; and (3) expand the number of services available to the population. FIGURE 40.1 As a starting point, the most effective way to improve cancer outcomes and achieve greater equity is to maximize the number of individuals who have access to effective services while ensuring financial protection before introducing new services. FIGURE 40.2

Governments provide a pre-specified set of services to a distinct population using a pool of funds as part of a "benefits package." However, comprehensive cancer services are not covered in the majority of countries, and effective health promotion, prevention, early detection, treatment, and palliative and survivorship care are frequently unavailable. FIGURE 40.3 For individuals diagnosed with cancer, high out-of-pocket payments and the indirect costs of treatment often result in financial hardship, impoverishment, loss of income due to limitations in or inability to work, and worsened health for that individual and their family. FIGURE 40.4 To realize UHC, cancer services must be included in benefit packages and sustainably financed through domestic public resources, and cancer patients must be protected against financial ruin.

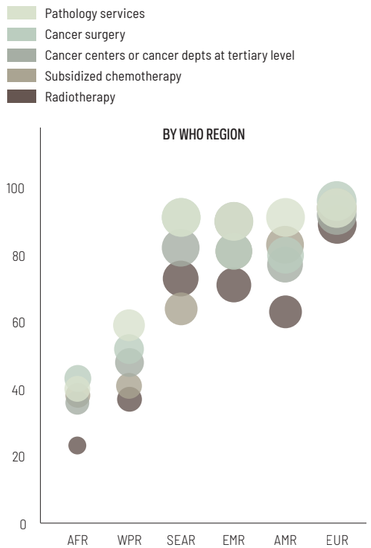
Each country may utilize a different approach to attain UHC. Yet, there are critical implementation principles. First, multi-sectoral dialogue is important to set priorities and define a health benefits package based on health needs, health system capacity, budget envelope, equity, and other guiding principles. Second, investing in health system capacity and equitable models for delivering services promotes access, particularly for vulnerable communities. Finally, utilizing sustainable financing mechanisms based on public and compulsory funding sources ensures financial protection. By including comprehensive cancer services as part of UHC, countries can achieve better overall outcomes, more efficiently and with greater equity.

ACCESS CREATES PROGRESS

The creation of Seguro Popular in Mexico, making universal health coverage mandatory through a system of social protection, has improved access to care and survival from breast and childhood cancers.

FIGURE 40.3

Percentage of countries with generally available cancer diagnosis and treatment services in the public sector, by WHO region and World Bank income group



Cancer patients in lower-income countries are the least likely to have access to cancer care services in the public sector.

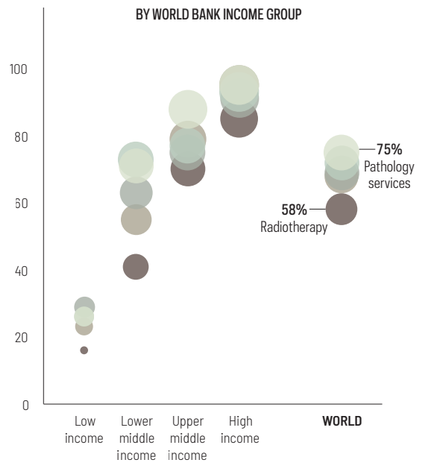


FIGURE 40.4

The percentage of the cancer population who pays more than 30% of total household income for healthcare costs, select countries in Asia

In many countries, a substantial proportion of cancer patients face financial catastrophe due to the costs of cancer treatment.

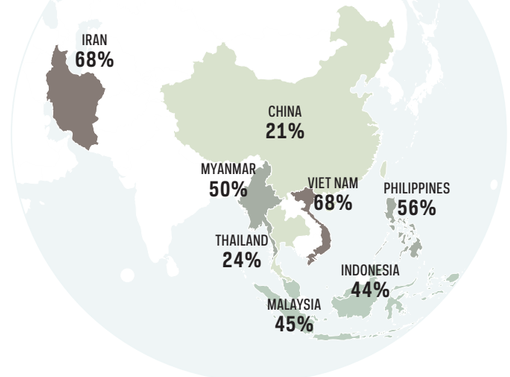
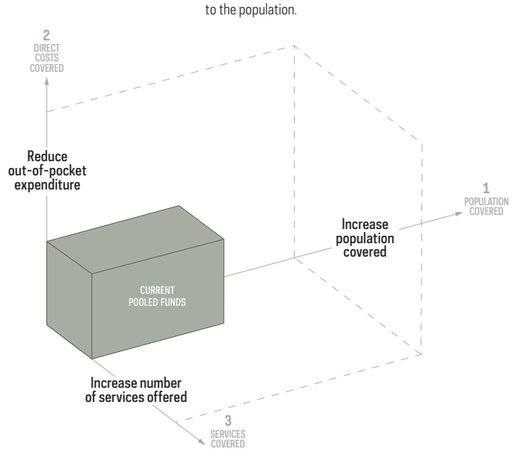


FIGURE 40.1 *Considerations for progressing towards universal health coverage*

MODEL FOR UNIVERSAL HEALTH COVERAGE PROGRESSION

UHC comprises three dimensions: the proportion of the population covered, the proportion of prepaid funds and reduced out-of-pocket payments, and the number of services available to the population.

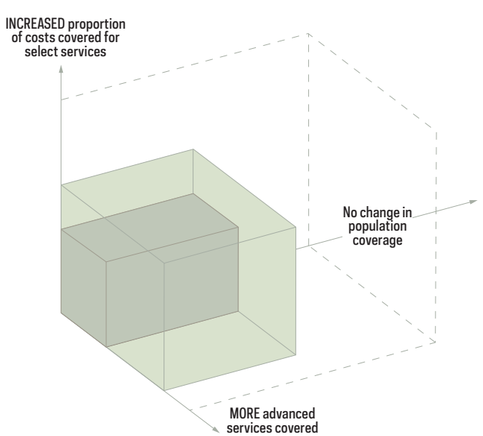


> *Achieving UHC is not quick or easy. It takes time, and it takes sustained political will, and community participation and ownership. But UHC is not something you achieve once. It must be constantly sustained.*
>
> *— Dr. Tedros Adhanom Ghebreyesus, WHO Director-General*

FIGURE 40.2 *The universal healthcare coverage approach to cancer care*

ADVANCED SERVICES APPROACH TO CANCER CARE

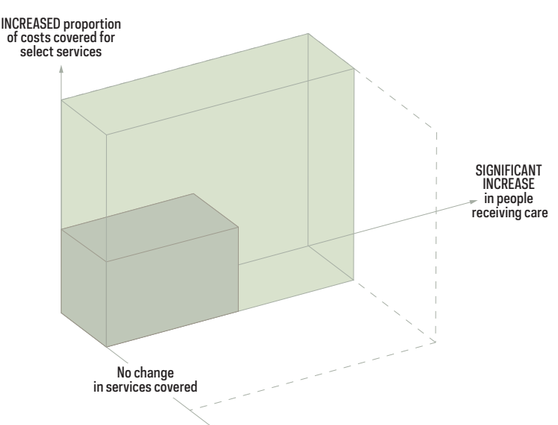
Introducing advanced services, such as screening or targeted therapies, available only to select populations results in minor improvements in population outcomes.



Making basic services and financial protection available to all results in major improvements in outcomes.

UHC APPROACH TO CANCER CARE

Expanding core services, such as pathology and basic treatment, to entire population and ensuring financial protection of such results in a *major improvement* in population outcomes.



BCE–18TH CENTURY

Hippocrates
FATHER OF MEDICINE

Christopher Columbus
BRINGS TOBACCO FROM AMERICAS TO EUROPE

Zacharias Janssen
INVENTED THE COMPOUND MICROSCOPE

Dr. John Hill
PUBLISHED FIRST REPORT LINKING TOBACCO AND CANCER

First cancer hospital
FOUNDED 1779

70–80 million years ago
Evidence of cancer cells in dinosaur fossils, found in 2003.

4.2–3.9 million years ago
The oldest known hominid malignant tumor was found in Homo erectus or Australopithecus by Louis Leakey in 1932.

3000 BCE
EGYPT

Evidence of cancerous cells in mummies

1900–1600 BCE
Cancer found in remains of Bronze Age human female skull.

1750 BCE
Babylonian code of Hammurabi set standard fee for surgical removal of tumors (ten shekels) and penalties for failure.

1600 BCE
EGYPT

The Egyptians blamed cancer on the gods. Ancient Egyptian scrolls describe eight cases of breast tumors treated by cauterization. Stomach cancer treated with boiled barley mixed with dates; cancer of the uterus by a concoction of fresh dates mixed with pig's brain introduced into the vagina.

1100–400 BCE
CHINA

Physicians specializing in treating swellings and ulcerations were referred to in The Rites of the Zhou Dynasty.

500 BCE
INDIA

Indian epic tale, the Ramayana, described treatment with arsenic paste to thwart tumor growth.

400 BCE
PERU

Pre-Colombian Inca mummies found to contain lesions suggestive of malignant melanoma.

400 BCE
GREECE

Greek physician Hippocrates (460–370 BCE), the "Father of Medicine," believed illness was caused by imbalance of four bodily humors: yellow bile, black bile, blood, and phlegm. He was the first to recognize differences between benign and malignant tumors.

Circa 250 BCE
CHINA

The first clinical picture of breast cancer, including progression, metastasis, and death, and prognosis approximately ten years after diagnosis, was described in The Nei Ching, or The Yellow Emperor's Classic of Internal Medicine. It gave the first description of tumors and five forms of therapy: spiritual, pharmacological, diet, acupuncture, and treatment of respiratory diseases.

50 AD
ITALY

The Romans found some tumors could be removed by surgery and cauterized, but thought medicine did not work. They noted some tumors grew again.

100 AD
ITALY

Greek doctor Claudius Galen (129–216 AD) removed some tumors surgically, but he generally believed that cancer was best left untreated. Galen believed melancholia the chief factor in causing breast cancer, and recommended special diets, exorcism, and topical applications.

500–1500
EUROPE

Surgery and cautery were used on smaller tumors. Caustic pastes, usually containing arsenic, were used on more extensive cancers, as well as phlebotomy (blood-letting), diet, herbal medicines, powder of crab, and symbolic charms.

1400–1500s
ITALY

Leonardo da Vinci (1452–1519) dissected cadavers for artistic and scientific purposes, adding to the knowledge of the human body.

1492
EUROPE

Christopher Columbus returned to Europe from the Americas with the first tobacco leaves and seeds ever seen on the continent. A crew member, Rodrigo de Jerez, was seen smoking and was imprisoned by the Inquisition, which believed he was possessed by the devil.

1500
EUROPE

Autopsies were conducted more often and understanding of internal cancers grew.

1595
NETHERLANDS

Zacharias Janssen invented the compound microscope.

17th century
GERMANY

Cancer surgery techniques improved, but lack of anesthesia and antiseptic conditions made surgery a risky choice. German surgeon Wilhelm Fabricius Hildanus (1560–1634) removed enlarged lymph nodes in breast cancer operations, while Johann Scultetus (1595–1645) performed total mastectomies.

17th century
FRANCE

Physician Claude Gendron (1663–1750) concluded that cancer arises locally as a hard, growing mass, untreatable with drugs, and that it must be removed with all its "filaments."

17th century
NETHERLANDS

Professor Hermann Boerhaave (1668–1738) believed inflammation could result in cancer.

17th–18th centuries
NETHERLANDS

Antony van Leeuwenhoek (1632–1723) refined the single lens microscope and was the first to see blood cells and bacteria, aiding the better understanding of cells, blood, and lymphatic system—major steps in improving the understanding of cancer.

FRANCE

Physician Le Dran (1685–1770) first recognized that breast cancer could spread to the regional auxiliary lymph nodes, carrying a poorer prognosis.

1713
ITALY

Dr. Bernardino Ramazzini (1633–1714), a founder of occupational/industrial medicine, reported the virtual absence of cervical cancer and relatively high incidence of breast cancer in nuns. This observation was an important step toward identifying hormonal factors such as pregnancy and infections related to sexual contact in cancer risk, and was the first indication that lifestyle might affect the development of cancer.

1733–1788
FRANCE

Physicians and scientists performed systematic experiments on cancer, leading to oncology as a medical specialty. Two French scientists—physician Jean Astruc and chemist Bernard Peyrilhe—were key to these new investigations.

1761
ITALY

Giovanni Morgagni performed the first autopsies to relate the patient's illness to the science of disease, laying the foundation for modern pathology.

1761
UNITED KINGDOM

Dr. John Hill published "Cautions Against the Immoderate Use of Snuff," the first report linking tobacco and cancer.

1775
UNITED KINGDOM

Dr. Percival Pott of Saint Bartholomew's Hospital in London described cancer in chimney sweeps caused by soot collecting under the scrotum, the first indication that exposure to chemicals in the environment could cause cancer. This research led to many additional studies that identified other occupational carcinogens and thence to public health measures to reduce cancer risk.

1779
FRANCE

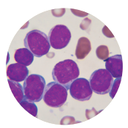
First cancer hospital founded in Reims. It was forced to move from the city because people believed cancer was contagious.

18th century
UNITED KINGDOM

Scottish surgeon John Hunter (1728–93) stated that tumors originated in the lymph system and then seeded around the body. He suggested that some cancers might be cured by surgery, especially those that had not invaded nearby tissue.

19TH CENTURY

Joseph Recamier
COINED THE TERM "METASTASIS"



LEUKEMIA DESCRIBED AS A PROLIFERATION OF BLOOD CELLS
by John Hughes Bennett

William Stewart Halsted
DEVELOPED THE RADICAL MASTECTOMY FOR BREAST CANCER

FIRST X-RAY
Discovered by
Wilhelm Konrad Roentgen

19th century
UNITED KINGDOM

In the early 1800s, Scottish physician John Waldrop proposed that "glioma of the retina," which typically appeared within the eyes of newborns and young children and was usually lethal, might be cured via early removal of affected organs.

1829
FRANCE

Gynecologist Joseph Recamier described the invasion of the bloodstream by cancer cells, coining the term metastasis, which came to mean the distant spread of cancer from its primary site to other places in the body.

1838
GERMANY

Pathologist Johannes Müller demonstrated that cancer is made up of cells and not lymph. His student, Rudolph Virchow (1821–1902), later proposed that chronic inflammation—the site of a wound that never heals—was the cause of cancer.

1842
ITALY

Domenico Antonio Rigoni-Stern undertook the first major statistical analysis of cancer incidence and mortality using 1760–1839 data from Verona. This showed that more women than men died from tumors, and that the most common female cancers were breast and uterine (each accounting for a third of total deaths). He found cancer death rates for both sexes were rising, and concluded that incidence of cancer increases with age, that cancer is found less in the country than in the city, and that unmarried people are more likely to contract the disease.

1845
UNITED KINGDOM

John Hughes Bennett, the Edinburgh physician, was the first to describe leukemia as an excessive proliferation of blood cells.

1851–1971
UNITED KINGDOM

Decennial reports linked cancer death to occupation and social class.

1880

Earlier invention of general anesthesia (chloroform, ether, nitrous oxide) became more widespread, making cancer surgery more acceptable.

1881
USA

First practical cigarette-making machine patented by James Bonsack. It could produce 120,000 cigarettes a day, each machine doing the work of 48 people. Production costs plummeted, and—with the invention of the safety match a few decades later—cigarette smoking began its explosive growth.

1886
BRAZIL

Hereditary basis for cancer first suggested after Professor Hilario de Gouvea of the Medical School in Rio de Janeiro reported a family with increased susceptibility to retinoblastoma.

1890s
USA

Professor William Stewart Halsted at Johns Hopkins University developed the radical mastectomy for breast cancer, removing breast, underlying muscles, and lymph nodes under the arm.

1895
GERMANY

Physicist Wilhelm Konrad Roentgen (1845–1923) discovered x-rays, used in the diagnosis of cancer. Within a few years, this led to the use of radiation for cancer treatment.

1897
USA

Walter B. Cannon (1871–1945) was still a college student when he fed bismuth and barium mixtures to geese, outlining their gullets on an x-ray plate (the forerunner of the barium meal examination).

20TH CENTURY

19th century

Invention and use of the modern microscope, which later helped identify cancer cells.

19th century
GERMANY

Rudolph Virchow (1821–1902), "the founder of cellular pathology," also determined that all cells, including cancer cells, are derived from other cells. He was the first to coin the term "leukemia" and believed that chronic inflammation was the cause of cancer.

19th century
GERMANY

Surgeon Karl Thiersch showed that cancers metastasize through the spread of malignant cells.

19th century
UNITED KINGDOM

Surgeon Stephen Paget (1855–1926) first deduced that cancer cells spread to all organs of the body by the bloodstream, but only grow in the organ ("soil") they find compatible. This laid the groundwork for the true understanding of metastasis.

1895
UNITED KINGDOM

Dr. Thomas Beatson discovered that the breasts of rabbits stopped producing milk after he removed the ovaries. This control of one organ over another led Beatson to test what would happen if the ovaries were removed in patients suffering from advanced breast cancer, and he found that oophorectomy often resulted in improvement. He thus discovered the stimulating effect of estrogen on breast tumors long before the hormone was discovered. This work provided a foundation for the modern use of hormones and analogs (e.g. tamoxifen, taxol) for treatment and prevention of breast cancer.

Before 1900

Lung cancer was extremely rare; now it is one of the most common cancers.

First Cancer Society
FOUNDED 1910

Marie Curie
AWARDED NOBEL PRIZE IN RECOGNITION OF HER WORK IN RADIOACTIVITY

American Cancer Society
FOUNDED 1913

Janet Lane-Claypon
PUBLISHED RISK FACTORS IN BREAST CANCER

George Papanicolaou
CONDUCTS FIRST PAP SMEAR

By 1900

Hundreds of materials, both man-made and natural, were recognized as causes of cancer (carcinogens).

1902

X-ray exposure led to skin cancer on the hand of a lab technician. Within a decade, many more physicians and scientists, unaware of the dangers of radiation, developed a variety of cancers.

1905
UNITED KINGDOM

Physicians at the Royal Ophthalmology Hospital reported the first case of "hereditary" retinal glioma, which presented in the child of a parent cured of the disease.

1907
USA

Epidemiological study found that meat-eating Germans, Irish, and Scandinavians living in Chicago had higher rates of cancer than did Italians and Chinese, who ate considerably less meat.

1910
AUSTRIA

First national cancer society founded: Austrian Cancer Society.

1911
FRANCE

Marie Curie was awarded a second Nobel Prize, this time in chemistry, in recognition of her work in radioactivity.

1900–1950

Radiotherapy—the use of radiation to kill cancer cells or stop them dividing—was developed as a treatment.

1911
USA

Peyton Rous (1879–1970) proved that viruses caused cancer in chickens, for which he was eventually awarded the Nobel Prize in 1966.

1913
USA

The American Cancer Society was founded as the American Society for the Control of Cancer (ASCC) by 15 physicians and business leaders in New York City. In 1945, the ASCC was renamed the American Cancer Society. It remains the world's largest voluntary health organization.

1915
JAPAN

Cancer was induced in laboratory animals for the first time by a chemical, coal tar, applied to rabbits' skin at Tokyo University. Soon many other substances were observed to be carcinogens, including benzene, hydrocarbons, aniline, asbestos, and tobacco.

1926
UNITED KINGDOM

Physician and epidemiologist Janet Lane-Claypon (1877–1967) published results from a study that demonstrated some of the major contemporary risk factors for breast cancer among women, including not breastfeeding, being childless, and older age at first pregnancy.

1928
GREECE

George Papanicolaou (1883–1962) identified malignant cells among the normal cast-off vaginal cells of women with cancer of the cervix, which led to the Pap smear test.

1930
GERMANY

Researchers in Cologne drew the first statistical connection between smoking and cancer.

1930s
PUERTO RICO

Dr. Cornelius Rhoads, a pathologist, allegedly injected his Puerto Rican subjects with cancer cells—13 people died.

1933
The Union for International Cancer Control (UICC) founded.

1933
SPAIN

First World Cancer Congress held in Madrid.

1930s–1950s
Classification of breast cancer introduced, enabling the planning of more rational treatment tailored to the individual.

1934
UNITED KINGDOM

Drs. W. Burton Wood and S. R. Gloyne reported the first two cases of lung cancer linked to asbestos.

1937
USA

National Cancer Institute inaugurated.

1939
USA

Drs. Alton Ochsner and Michael DeBakey first reported the association of smoking and lung cancer.

1939–1945
During the Second World War, the US Army discovered that nitrogen mustard was effective in treating cancer of the lymph nodes (lymphoma). This was the birth of chemotherapy—the use of drugs to treat cancer.

1943–1945
DENMARK, UNITED KINGDOM

First national cancer registries established.

1947
CANADA

Dr. Norman Delarue compared 50 patients with lung cancer with 50 patients hospitalized with other diseases. He discovered that over 90% of the first group—but only half of the second—were smokers, and confidently predicted that by 1950 no one would be smoking.

1947
USA

Sidney Farber (1903–73), one of the founders of the specialty of pediatric pathology, used a derivative of folic acid, methotrexate, to inhibit acute leukemia in children.

Gertrude Elion
CREATED NEW LEUKEMIA TREATMENT

Dr. Min Chiu Li
FIRST DEMONSTRATED CLINICALLY THAT CHEMOTHERAPY COULD CURE A MALIGNANT DISEASE

E. Cuyler Hammond and Daniel Horn
LAUNCHED THE HAMMOND-HORN STUDY

H. PYLORI BACTERIA FIRST IDENTIFIED
by Barry Marshall and J. Robin Warren

1940s–1950s
USA

Dr. Charles B. Huggins' (1901–97) research on prostate cancer changed the way scientists regard the behavior of all cancer cells, and for the first time brought hope to the prospect of treating advanced cancers. He showed that cancer cells were not autonomous and self-perpetuating but were dependent on chemical signals such as hormones to grow and survive, and that depriving cancer cells of these signals could restore the health of patients with widespread metastases. He was awarded the Nobel Prize in 1966 (shared with Peyton Rous).

1950
USA

Gertrude Elion (1918–99) created a purine chemical, which she developed into 6-mercaptopurine, or 6-MP. It was rapidly approved for use in childhood leukemia. She received the Nobel Prize in 1988.

1950
USA

The link between smoking and lung cancer was confirmed. A landmark article from *The Journal of the American Medical Association* appeared on May 27th, 1950: "Tobacco smoking as a possible etiologic factor in bronchogenic carcinoma" by E.L. Wynder and Evarts Graham. The same issue featured a full-page ad for Chesterfields with the actress Gene Tierney and golfer Ben Hogan; the journal accepted tobacco ads until 1953.

1951
UNITED KINGDOM

Dr. Richard Doll and Prof. Austin Bradford Hill conducted the first large-scale study of the link between smoking and lung cancer.

1952
USA

Epidemiologists at the American Cancer Society launched the Hammond-Horn Study, a long-term follow-up study of 188,000 men designed to examine the association of cigarette smoking with death from cancer and other diseases.

1953
UNITED KINGDOM

James Watson and Francis Crick described the double helical structure of DNA, marking the beginning of the modern era of genetics.

1954
USA

First tobacco litigation against the cigarette companies, brought by a widow on behalf of her smoker husband, who died from cancer. The cigarette companies won.

1956
USA

Dr. Min Chiu Li (1919–1980) first demonstrated clinically that chemotherapy could result in the cure of a widely metastatic malignant disease.

1960
JAPAN

Group cancer screening for stomach cancer began with a mobile clinic in Tohoku region.

1960
USA

Dr. Min Chiu Li published another important and original finding: the use of multiple-agent combination chemotherapy for the treatment of metastatic cancers of the testis. Twenty years later, it was demonstrated that combination chemotherapy, combined with techniques for local control, had virtually eliminated deaths from testicular malignancy.

1963
JAPAN

Cancer research programs were established by the Ministry of Health and Welfare and the Ministry of Education, Science, and Culture.

1964
USA

Physician Irving J. Selikoff (1915–92) published the results from a study linking asbestos exposure to the development of mesothelioma.

1964
USA

First US Surgeon General's report on smoking and health.

1965
FRANCE

WHO established the International Agency for Research on Cancer (IARC), based in Lyon, France.

1966
International Association of Cancer Registries (IACR) founded.

1960s–1970s
Trials in several countries demonstrated the effectiveness of mammography screening for breast cancer.

1970s
USA, ITALY

Bernard Fisher in the USA and Umberto Veronesi in Italy both launched long-term studies as to whether lumpectomy followed by radiation therapy was an alternative to radical mastectomy in early breast cancer. These studies concluded that total mastectomy offered no advantage over either lumpectomy or lumpectomy plus radiation therapy.

1971
USA

The National Cancer Act in President Nixon's "War on Cancer" mandated financial support for cancer research, outlined intervention strategies, and, in 1973, established the Surveillance, Epidemiology, and End Results (SEER) program, a network of population-based cancer registries.

1973
USA

Bone marrow transplantation first performed successfully on a dog in Seattle by Dr. E. Donnall Thomas (1920–2012). This led to human bone marrow transplantation, resulting in cures for leukemias and lymphomas. In 1990, Dr. Thomas won a Nobel Prize for his work.

1970s
Childhood leukemia became one of the first cancers that could be cured by a combination of drugs.

1970s
USA

Discovery of the first cancer gene (the oncogene, which in certain circumstances can transform a cell into a tumor cell).

1970s onwards
WHO, UICC, and others promoted national cancer planning for nations to prioritize and focus their cancer control activities.

1981
JAPAN

Professor Takeshi Hirayama (1923–95) published the first report linking passive smoking and lung cancer in the non-smoking wives of men who smoked.

1981
ITALY

Dr. G. Bonnadona in Milan performed the first study of adjuvant chemotherapy for breast cancer using cyclophosphamide, methotrexate, and 5-fluorouracil, resulting in reduction of cancer relapse. Adjuvant chemotherapy is now standard treatment for lung, breast, colon, stomach, and ovary cancers.

1980s
USA

Kaposi's sarcoma and T-cell lymphoma linked to AIDS.

1982
USA

Nobel Laureate Baruch S. Blumberg was instrumental in developing a reliable and safe vaccine against hepatitis B (which causes primary liver cancer).

1980s
AUSTRALIA

Barry Marshall and J. Robin Warren identified bacterium *H. pylori*, noting it caused duodenal and gastric ulcers and increased the risk of gastric cancer.

1980s
USA

Vincent DeVita developed a four-drug combination to significantly raise the cure rate of Hodgkin disease to 80%.

MID-1980s
Human Genome Project was initiated to pinpoint location and function of estimated 50,000–100,000 genes that make up the inherited set of "instructions" for functions and behavior of human beings.

1980s
WHO Program on Cancer Control established.

1988
First WHO World No Tobacco Day, subsequently an annual event.

1989
European Network of Cancer Registries (ENCR) established.

1989
USA

National Institutes of Health researchers performed the first approved gene therapy, inserting foreign genes to track tumor-killing cells in cancer patients. This project proved the safety of gene therapy.

1991
Evidence linking specific environmental carcinogens to telltale DNA damage emerged, e.g. sun radiation was found to produce change in tumor suppressor genes in skin cells, aflatoxin (a fungus poison) or hepatitis B virus to cause a mutation in the liver, and chemicals in cigarette smoke to switch on a gene that makes lung cells vulnerable to the chemicals' cancer-causing properties.

1994
USA, CANADA, UNITED KINGDOM, FRANCE, JAPAN

Scientists collaborated and discovered *BRCA1*, the first known breast and ovarian cancer predisposing gene.

1994
USA

National Program of Cancer Registries (NPCR) established.

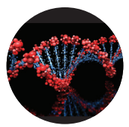
1995
Gene therapy, immune system modulation, and genetically engineered antibodies used to treat cancer.

1999
NETHERLANDS, USA

Jan Walboomers of the Free University of Amsterdam and Michele Manos of Johns Hopkins University provided evidence that the human papillomavirus (HPV) is present in 99.7% of all cases of cervical cancer.

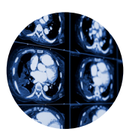
1999
The Bill & Melinda Gates Foundation awarded a five-year, $50 million grant to the Alliance for Cervical Cancer Prevention (ACCP), a group of five international organizations with a shared goal of working to prevent cervical cancer in developing countries.

21ST CENTURY



HUMAN GENOME IS MAPPED

FIRST HPV VACCINE



CT SCAN SCREENING FOR LUNG CANCER

2000
53rd World Health Assembly presided over by Dr. Libertina Amathila (Namibia) endorsed "Global strategy for non-communicable disease (NCD) prevention and control," which outlined major objectives for monitoring, preventing, and managing NCDs, with special emphasis on major NCDs with common risk factors and determinants—cardiovascular disease, cancer, diabetes, and chronic respiratory disease.

2000
The entire human genome is mapped.

2000
Charter of Paris against Cancer is signed.

2001
LUXEMBOURG

International Childhood Cancer Day was launched, its aim to raise awareness of the 250,000 children worldwide who get cancer every year. Some 80% of these children have little or no access to treatment. The first annual event in 2002 was supported in 30 countries around the world and raised over US$100,000 for parent organizations to help children in their own countries.

2004
SWITZERLAND

WHO cancer prevention and control resolution approved by World Health Assembly.

2005
WHO Framework Convention on Tobacco Control came into force, using international law to further public health and prevent cancer.

2006
USA

The US Food and Drug Administration (FDA) approved the first HPV vaccine to prevent infections that cause cervical cancer.

2011
Lung cancer deaths reduced by low-dose computed tomography (CT) scanning of people at high risk.

2011
First UN High Level Meeting on Non-communicable Diseases in New York, USA.

2013
The US FDA approved sofosbuvir for use in combination with other agents for the treatment of chronic HCV infection in adults, reducing treatment time and toxicity compared with earlier treatments and increasing cure rates to more than 80%.

2015
A goal to reduce premature mortality from NCDs including cancer by one-third by 2030 was added to the United Nations Development Programme's Sustainable Development Goals.

2015
Achievement of universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all, was added to the United Nations Sustainable Development Goals.

2017
The US FDA approved the first adoptive cell immunotherapy, also known as chimeric antigen receptor (CAR) T-cell therapy.

2018
World Health Organization Director General Dr. Tedros Adhanom Ghebreyesus calls for coordinated global action for the elimination of cervical cancer.

2018
The World Health Organization announces the Global Initiative for Childhood Cancer with the aim of reaching at least a 60% survival rate for children with cancer by 2030, representing a doubling of the global cure rate for children with cancer.

GLOSSARY

Aflatoxin:
A harmful, cancer-causing chemical made by certain types of Aspergillus mold that may be found on poorly stored grains and nuts. Consumption of foods contaminated with aflatoxin is an important risk factor for hepatocellular (liver) cancer.

Age-specific rate:
A rate for a specified age group, in which the numerator and denominator refer to the same age group.

Age-standardization:
A technique that allows comparison of incidence (or mortality) rates between populations, adjusting for any differences in their respective age distributions.

Asbestos:
A natural material that is made of tiny fibers and used in insulation and as a fire retardant. Asbestos exposure is an important risk factor for cancer, especially mesothelioma (lining of the chest, abdomen and heart) and also lung cancer.

Benign tumor:
An abnormal growth that is not cancer and does not spread to other areas of the body.

Body mass index (BMI):
A measure of a person's weight in relation to his or her height, calculated as weight in kilograms divided by height in meters squared.

Cancer:
A disease in which abnormal cells divide uncontrollably. Cancer cells can invade nearby tissues and spread through the bloodstream and lymphatic system to other parts of the body.

Cancer registry:
An institution that performs the systematic collection and maintenance of a file or register of all cancer cases occurring in a defined population. Registries continuously and systematically collect information from various data sources on the personal characteristics of cancer patients (e.g. age, sex, and race) and the clinical and pathological characteristics (e.g. stage, histologic classification) of the cancers.

Cancer screening programs:
Programs organized at a national or regional level that aim to decrease the incidence and mortality of a specific type of cancer by identifying precancerous lesions or tumors at an early stage, when they can be effectively treated. Programs usually have: 1) an explicit policy; 2) a team responsible for organizing the screening and delivering appropriate healthcare; and 3) a structure for assuring quality screening and follow-up of abnormal screening tests.

Carcinogen:
Any agent —chemical, physical or biological— that causes cancer. Examples include tobacco smoke, asbestos, human papillomavirus (HPV), and ultraviolet (UV) radiation.

Carcinoma:
A cancerous tumor that begins in the lining layer (epithelial cells) of organs. At least 80% of all cancers are carcinomas.

Chemotherapy:
Treatment with a drug or drugs to destroy cancer cells. Chemotherapy may be used, either alone or in combination with surgery or radiation treatment, to treat cancer when it is at an early stage, when the cancer has spread, when the cancer has come back (recurred), or when there is a strong chance that the cancer could recur.

Colonoscopy:
Examination of the large bowel with a long, flexible, lighted tube called a colonoscope. The physician looks for polyps or early cancers during the exam, and removes them using a wire passed through the colonoscope.

Computerized tomography (CT):
A series of detailed pictures of areas inside the body taken from different angles; the pictures are created by a computer linked to an x-ray machine. Also called computerized axial tomography (CAT) scan. A special kind of CT machine, the spiral CT, has been used to look for early lung cancer.

Diagnosis:
The process of identifying a disease by its signs and symptoms, as well as medical tests and tissue sampling and examination as needed.

Dioxins:
Organic chemical byproducts of industrial processes; considered highly toxic environmental pollutants due to their effects on the immune and endocrine systems and on encouraging tumor growth.

Direct costs:
Expenditures for medical procedures and services associated with the treatment and care of people with cancer.

Disability-adjusted life year (DALY):
A measurement of the years of healthy life lost due to disease in a population. DALYs are the sum of two components: the years of life lost due to premature death, and the years of life lost due to disability.

E-cigarette:
A device that contains a solution of nicotine, flavorings, and other chemicals that turns into a mist that can be inhaled into the lungs. Also called electronic cigarette.

Endometrial cancer:
Cancer of the layer of tissue that lines the uterus.

Epidemic:
Occurrence of an illness, condition, or behavior that affects many people in the same region during a specified period of time. To constitute an epidemic, this occurrence must exceed normal occurrence of the disease in the region.

Estradiol:
A form of the hormone estrogen.

Fecal occult blood test (FOBT):
A test used to screen for large bowel cancer. It looks for blood in the stools, the presence of which may be a sign of cancer.

***Helicobacter pylori (H. pylori)*:**
A type of bacterium that causes inflammation and ulcers in the stomach or small intestine. People with *H. pylori* infections may be more likely to develop cancer in the stomach.

Hematopoietic system:
Organs and tissues involved in the production of blood, including the bone marrow, lymph nodes, spleen, and tonsils.

Hepatitis B and C viruses (HBV and HCV):
Viruses that cause hepatitis, a condition that is characterized by inflammation of the liver. Long-term infection may lead to cirrhosis (scarring of the liver) and liver cancer. Persons infected with HCV may also have an increased risk for certain types of non-Hodgkin lymphoma.

Hepatocellular carcinoma:
The most common type of cancer originating in the liver.

High-/middle-/low-income country:
For the 2020 fiscal year, according to the World Bank, a high-income country has a gross national income (GNI) per capita of more than US$12,375; a middle-income country between US$1026 and US$12,375; and a low-income country less than US$1025.

Hormone replacement therapy (HRT):
Hormones (estrogen, progesterone, or other types) given to women after menopause to replace the hormones no longer produced by the ovaries. HRT can be a risk factor for cancers of the endometrium and breast.

Human development index (HDI):
A measure of health, education and income at the country level produced by the United Nations Development Programme as an alternative to purely economic assessments of national progress, such as GDP growth.

Human herpesvirus 8 (HHV-8):
A type of virus that causes Kaposi sarcoma. Patients with acquired immunodeficiency syndrome frequently suffer from HHV-8-associated diseases. Infection with HHV-8 can also cause certain types of lymphoma and severe lymph node enlargement, known as Castleman's disease. HHV-8 is also known as Kaposi sarcoma-associated herpesvirus, or KSHV.

Human immunodeficiency virus (HIV):
The virus that causes acquired immune deficiency syndrome (AIDS). It is transmitted through blood and other body fluids, and infants born to infected mothers may also become infected. Infection with both HIV and HHV-8 increases the risk of developing Kaposi sarcoma.

Human papillomavirus (HPV):
A type of virus that can cause abnormal tissue growth (for example, warts) and other changes to cells. Long-term infection with certain types of human papillomavirus (e.g., types 16 and 18) can cause cervical cancer. HPV is also a risk factor for anal, vaginal, vulvar, penile, oropharyngeal, and squamous cell skin cancers. It is transmitted through sexual contact.

Incidence:
The number of new cases arising in a given period in a specified population. This information, collected routinely by cancer registries, can be expressed as an absolute number of cases per year or as a rate per 100,000 persons per year.

Kaposi sarcoma:
A type of cancer characterized by the abnormal growth of blood vessels that develop into lesions on the skin, lymph nodes, lining of the mouth, nose, and throat, and other tissues of the body. It is caused by human herpesvirus-8 (HHV-8). The risk of developing Kaposi sarcoma in a person who has HHV-8 increases significantly if the person is also infected with human immunodeficiency virus (HIV).

Keratinocyte (nonmelanoma) skin cancer:
Also known as basal or squamous cell skin cancer. A cancer that occurs in keratinocyte cells, which are located in the epidermis (top layer of skin) and are responsible for producing keratin. Keratinocytes are divided into squamous cells on the surface of the epidermis and basal cells located within the deeper basal layer of the epidermis.

Leukemia:
A cancer of the blood or blood-forming organs.

Lumpectomy:
Surgery to remove a breast lump or tumor and a small amount of surrounding normal tissue.

Lymphoma:
A cancer of the lymphatic system. The lymphatic system is a network of thin vessels and nodes throughout the body. The two main types of lymphoma are Hodgkin lymphoma (or disease) and non-Hodgkin lymphoma.

Malignant tumor:
A mass of cancer cells that may invade surrounding tissues or spread (metastasize) to distant areas of the body. Synonymous with cancer.

Mammography:
A breast cancer screening method using an x-ray of the breast.

Mastectomy:
Surgery to remove the entire breast. There are different types of mastectomy that differ in the amount of tissue and lymph nodes removed.

Melanoma:
A cancerous (malignant) tumor that begins in the cells that produce the skin coloring (melanocytes). Melanoma is almost always curable in its early stages. However, it is likely to spread, and once it has spread to other parts of the body the likelihood of cure decreases.

Menarche:
The first menstrual period, usually occurring during puberty.

Menopause:
The time period marked by the permanent cessation of menstruation, usually occurring between the ages of 45 and 55 years.

Mesothelioma:
A benign (not cancer) or malignant (cancer) tumor affecting the lining of the chest or abdomen. Exposure to asbestos particles in the air increases the risk of developing malignant mesothelioma, which is extremely lethal.

Metastasis:
The distant spread of cancer from its primary site to other places in the body.

Morbidity:
Any departure from physiological or psychological well-being. Measures of morbidity for people living with cancer may include disability, pain, time away from work, or days spent in the hospital.

Mortality:
The number of deaths occurring in a given period in a specified population. It can be expressed as an absolute number of deaths per year or as a rate per 100,000 persons per year.

Neoplasm:
An abnormal growth (tumor) that starts from a single altered cell; a neoplasm may be benign or malignant. Cancer is a malignant neoplasm.

Neuroblastoma:
Cancer that arises in immature nerve cells; affects mostly infants and children.

Overweight/obese:
Persons who are considered overweight have a body mass index (BMI) greater than 25; a BMI greater than 30 is considered obese.

Particulate matter:
Microscopic solid or liquid particles associated with the atmosphere that can penetrate the lungs and cause damage that can lead to lung cancer. Particulate matter can be naturally occurring (e.g. originating from volcanoes or dust storms) or synthetic (e.g. vehicle emissions). The smallest class of particulate matter (<2.5 micrometers diameter) is the deadliest.

Palliative care:
An approach that aims to improve the quality of life for patients and families facing the problems associated with life-threatening cancers. It provides for prevention and relief of suffering through treatment for pain and other symptoms as well as through spiritual and psychosocial support, at the time of cancer diagnosis, through the end of life, and during family bereavement.

Prevalence:
The number of persons in a defined population who have been diagnosed with a specific type of cancer, and who are still alive at the end of a given year (the survivors). Five-year prevalence limits the number of patients to those diagnosed in the past 5 years. It is a particularly useful measure of cancer burden because for most cancers, patients who are still alive five years after diagnosis are usually considered cured. However, exceptions to this include breast cancer patients, who continue to die from the disease 5 years after diagnosis.

Prognosis:
Prediction of the course of cancer, and the outlook for a cure of the cancer.

Radiotherapy:
The use of radiation treatment to kill cancer cells or stop them from dividing.

Radon:
A radioactive gas that is released by uranium—a substance found in soil and rock—and is an important risk factor for lung cancer.

Rate:
See Incidence and Mortality

Retinoblastoma:
A rare form of eye cancer that affects the retina of infants and young children.

Sarcoma:
A cancer of the bone, cartilage, fat, muscle, blood vessels, or other connective or supportive tissue.

Sigmoidoscopy:
An examination to help find cancer or polyps within the rectum and distal part of the colon. A slender, hollow, lighted tube is placed into the rectum, allowing the physician to look for polyps or other abnormalities. The sigmoidoscope is shorter than the colonoscope.

Solar irradiation:
See UV radiation.

Solid fuels:
Solid materials burned usually for heating purposes, including wood, peat, charcoal, coal, and grains. In certain conditions, excess exposure can be an important risk factor for lung cancer.

Survival (rate, estimate):
The proportion (or percentage) of persons with a given cancer who are still alive after a specified time period (e.g., 1, 3, or 5 years) following a diagnosis.

Systemic therapy:
Treatment using substances that travel through the bloodstream, reaching and affecting cells all over the body.

Targeted therapy:
A cancer treatment that uses drugs or other substances to identify and attack cancer cells while avoiding harm to normal cells better than many other cancer treatments. Some targeted therapies block the mechanisms involved in the growth and spread of cancer cells. Other types of targeted therapies help the immune system kill cancer cells or deliver toxic substances directly to cancer cells.

Ultraviolet (UV) radiation:
Invisible rays that are part of the energy that comes from the sun. UV radiation also comes from sun lamps and tanning beds. UV radiation can damage the skin, lead to premature aging, and cause melanoma and other types of skin cancer.

Vital registration:
The continuous, permanent, compulsory and universal recording of the occurrence and characteristics of vital events (e.g., births and deaths) pertaining to the population, as provided through decree or regulation in accordance with the legal requirements of a country.

Wilms tumor:
A type of kidney cancer that usually occurs in children younger than 5 years of age.

Years of life lost (YLL):
A statistic that measures the burden of premature death in a population due to a specific cause (such as cancer) within a specified time frame by aggregating the difference between expected life span and years lived among those who died due to the cause of interest.

Please refer to the U.S. National Cancer Institute's "Dictionary of Cancer Terms" for additional definitions (http://www.cancer.gov/dictionary).

SOURCES & METHODS

A note about maps in this edition of *The Cancer Atlas*: Many maps throughout the Atlas were created using data from GLOBOCAN, a database of estimated cancer statistics created and maintained by the International Agency for Research on Cancer. A full description of the methods for creating these estimates can be found on the Global Cancer Observatory website (http://gco.iarc.fr/today/data-sources-methods).

Foreword

Romero Y, Trapani D, Johnson S, et al. National cancer control plans: a global analysis. *Lancet Oncol.* 2018;19(10):e546-e555.

Introduction

Ferlay J, Ervik M, Lam F, Plummer M, Vignat J, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC, 2018. Available from: https://gco.iarc.fr/today.

RISK FACTORS

Section Divider:
WHO global report on trends in prevalence of tobacco smoking 2000–2025, 2nd edition. Geneva: World Health Organization; 2018.

WHO report on the global tobacco epidemic, 2017: monitoring tobacco use and prevention policies. Geneva: World Health Organization; 2017. Licence: CC BY-NC-SA 3.0 IGO.

Overview of Risk Factors

Potentially modifiable risk factors:
Stanaway JD, Afshin A, Gakidou E, Lim SS, Abate D, Abate KH, et al. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet.* 2018;392(10159):1923–94.

Islami F, Chen W, Yu XQ, et al. Cancer deaths and cases attributable to lifestyle factors and infections in China, 2013. *Ann Oncol.* 2017;28(10):2567–2574.

Islami F, Goding Sauer A, Miller KD, et al. Proportion and number of cancer cases and deaths attributable to potentially modifiable risk factors in the United States. *CA Cancer J Clin.* 2018;68(1):31–54.

Access creates progress:
Turner, PC, et al. Reduction in exposure to carcinogenic aflatoxins by postharvest intervention measures in west Africa: a community-based intervention study. *Lancet.* 2005;365(9475):1950–1956.

Text:
Bouvard V, Baan R, Straif K, et al. A review of human carcinogens--Part B: biological agents. *Lancet Oncol.* 2009;10(4):321–322.

Bruni L, Diaz M, Barrionuevo-Rosas L, et al. Global estimates of human papillomavirus vaccination coverage by region and income level: a pooled analysis. *Lancet Glob Health.* 2016;4(7):e453-463.

Bruni L, Diaz M, Castellsague X, Ferrer E, Bosch FX, de Sanjose S. Cervical human papillomavirus prevalence in 5 continents: meta-analysis of 1 million women with normal cytological findings. *J Infect Dis.* 2010;202(12):1789–1799.

El Ghissassi F, Baan R, Straif K, et al. A review of human carcinogens--part D: radiation. *Lancet Oncol.* 2009;10(8):751–752.

GBD Risk Factors Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet.* 2017;390(10100):1345–1422.

GBD Tobacco Collaborators. Smoking prevalence and attributable disease burden in 195 countries and territories, 1990-2015: a systematic analysis from the Global Burden of Disease Study 2015. Lancet. 2017;389(10082):1885-1906. *Global status report on alcohol and health 2018.* Geneva: World Health Organization; 2018.

IARC Working Group. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, vol 100E: Personal Habits and Indoor Combustions.* Lyon: IARC Press; 2012.

Islami F, Chen W, Yu XQ, et al. Cancer deaths and cases attributable to lifestyle factors and infections in China, 2013. *Ann Oncol.* 2017;28(10):2567–2574.

Islami F, Goding Sauer A, Miller KD, et al. Proportion and number of cancer cases and deaths attributable to potentially modifiable risk factors in the United States. *CA Cancer J Clin.* 2018;68(1):31–54.

Islami F, Stoklosa M, Drope J, Jemal A. Global and regional patterns of tobacco smoking and tobacco control policies. *Eur Urol Focus.* 2015(1):3–16.

Liu Y, Wu F. Global burden of aflatoxin-induced hepatocellular carcinoma: a risk assessment. *Environ Health Perspect.* 2010;118(6):818–824.

Pearson-Stuttard J, Zhou B, Kontis V, Bentham J, Gunter MJ, Ezzati M. Worldwide burden of cancer attributable to diabetes and high body-mass index: a comparative risk assessment. *Lancet Diabetes Endocrinol.* 2018;6(6):e6-e15.

Plummer M, de Martel C, Vignat J, Ferlay J, Bray F, Franceschi S. Global burden of cancers attributable to infections in 2012: a synthetic analysis. *Lancet Glob Health.* 2016;4(9):e609-616.

Prüss-Ustün A, Wolf J, Corvalán C, Bos R, Neira M. *Preventing disease through healthy environments: a global assessment of the burden of disease from environmental risks.* Switzerland, Geneva: WHO Press; 2016.

Schuz J, Espina C, Villain P, et al. European Code against Cancer 4th Edition: 12 ways to reduce your cancer risk. *Cancer Epidemiol.* 2015;39 Suppl 1:S1-10.

World Cancer Research Fund/American Institute for Cancer Research. *Diet, nutrition, physical activity and cancer: a global perspective. Continuous Update Project Expert Report 2018.* Available at dietandcancerreport.org.

Xia C, Zheng R, Zeng H, et al. Provincial-level cancer burden attributable to active and second-hand smoking in China. *Tob Control.* 2018.

Map:
World Health Organization. *Global status report on alcohol and health 2018.* Geneva: World Health Organization; 2018. Available at: https://www.who.int/substance_abuse/publications/global_alcohol_report/en/

Figure 1:
Bouvard V, Baan R, Straif K, et al. A review of human carcinogens--Part B: biological agents. *Lancet Oncol.* 2009;10(4):321–322.

Plummer M, de Martel C, Vignat J, Ferlay J, Bray F, Franceschi S. Global burden of cancers attributable to infections in 2012: A synthetic analysis. Lancet Glob Health. 2016;4(9):e609-616.

Figure 2:
Bruni L, Diaz M, Castellsague X, Ferrer E, Bosch FX, de Sanjose S. Cervical human papillomavirus prevalence in 5 continents: Meta-analysis of 1 million women with normal cytological findings. *J Infect Dis.* 2010;202(12):1789–1799.

Bruni L, Diaz M, Barrionuevo-Rosas L, et al. Global estimates of human papillomavirus vaccination c overage by region and income level: A pooled analysis. *Lancet Glob Health.* 2016;4(7):e453-463.

Figure 3:
Liu Y, Wu F. Global burden of aflatoxin-induced hepatocellular carcinoma: a risk assessment. *Environ Health Perspect.* 2010;118(6):818–824.

Figure 4:
Prüss-Ustün A, Wolf J, Corvalán C, Bos R, Neira M. *Preventing disease through healthy environments: a global assessment of the burden of disease from environmental risks.* Geneva: WHO Press; 2016.

Text box:
Schuz J, Espina C, Villain P, et al. European Code against Cancer 4th Edition: 12 ways to reduce your cancer risk. *Cancer Epidemiol.* 2015;39 Suppl 1:S1-10.

Risks of Tobacco

Male smoking prevalence:
Dr. Michael Thun, personal communication

Access creates progress:
Siu AL, for the US Preventive Services Task Force. Behavioral and Pharmacotherapy Interventions for Tobacco Smoking Cessation in Adults, Including Pregnant Women: USPSTF Recommendation Statement for Interventions for Tobacco Smoking Cessation. *Ann Intern Med.* 2015;163(8):622–634.

Text:
Asma S, Mackay J, Song SY, et al. *The GATS Atlas.* Atlanta, GA: CDC Foundation 2015. Available at www.gatsatlas.org.

Drope J, Schluger N, Cahn Z, et al. *The Tobacco Atlas.* Atlanta: American Cancer Society and Vital Strategies, 2018 Available at https://tobaccoatlas.org/topic/prevalence/.

Thun MJ, Freedman ND. Tobacco. In: Thun MJ, Linet MS, Cerhan JR, Haiman CA, Schottenfeld (Eds), Schottenfeld and Fraumeni. *Cancer Epidemiology and Prevention,* (4th ed., pp 185–211). New York: Oxford University Press, 2018

Gentzke AS, Creamer M, Cullen KA, et al. Vital Signs: Tobacco Product Use Among Middle and High School Students — United States, 2011–2018. *MMWR Morb Mortal Wkly* Rep. 2019;68:157–164.

Huang J, Duan Z, Kwok J, et al. Vaping versus JUULing: How the extraordinary growth and marketing of JUUL transformed the US retail e-cigarette market. *Tobacco Control.* 2019;28:146–151.

US National Cancer Institute. Patterns of tobacco use, exposure, and health consequences. In: *The Economics of Tobacco and Tobacco Control, Tobacco Control Monograph 21.* Bethesda, MD and Geneva: U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute and World Health Organization. 2016.

IARC. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 100: A Review of Human Carcinogens. Part E: Personal Habits and Indoor Combustions.* Lyon, France: IARC,2012.

US Department of *Health and Human Services. The Health Consequences of Smoking- 50 Years of Progress: A Report of the Surgeon General.* U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2014.

Map:
Tobacco Atlas 6th edition, https://tobaccoatlas.org/topic/prevalence/

Figure 1:
Gentzke AS, Creamer M, Cullen KA, et al. Vital Signs: Tobacco Product Use Among Middle and High School Students — United States, 2011–2018. *MMWR Morb Mortal Wkly Rep.* 2019;68:157–164.

Figure 2:
Notes: Lip cancer classified as causal in 1964, other oropharyngeal cancers in 1971. Lung cancer classified as causal in men in 1964 and in women in 1968. Esophagus, lung, and kidney include multiple histologic subtypes.Source: Modified from US Department of Health and Human Services. The Health Consequences of Smoking—*50 Years of Progress: A Report of the Surgeon General.* Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2014.

Infection

Cancer in sub-Saharan Africa related to infection:
Plummer M, de Martel C, Vignat J, Ferlay J, Bray F, Franceschi S. Global burden of cancers attributable to infections in 2012: a synthetic analysis. *Lancet Glob Health.* 2016 Sep;4(9):e609-16.

Text:
de Martel C, Plummer M, Vignat J, Franceschi S. Worldwide burden of cancer attributable to HPV by site, country and HPV type. *Int J Cancer.* 2017 Aug 15;141(4):664–670.

de Martel C, Shiels MS, Franceschi S, et al. Cancers attributable to infections among adults with HIV in the United States. *AIDS.* Oct 23 2015;29(16):2173–2181.

Plummer M, de Martel C, Vignat J, Ferlay J, Bray F, Franceschi S. Global burden of cancers attributable to infections in 2012: a synthetic analysis. *Lancet Glob Health.* 2016 Sep;4(9):e609-16.

Map & Figures 1-3:
Plummer M, de Martel C, Vignat J, Ferlay J, Bray F, Franceschi S. Global burden of cancers attributable to infections in 2012: a synthetic analysis. *Lancet Glob Health.* 2016 Sep;4(9):e609-16.

Figure 3:
Notes: Stomach includes cardia, non-cardia, and NHL of gastric location. Liver includes cholangiocarcinoma. Other anogenital includes vulva, vagina, penile, and anus. Head and neck includes oropharynx, nasopharynx, oral cavity, and larynx. Other includes Hodgkin lymphoma, non-Hodgkin lymphoma, Burkitt adult T cell lymphoma, Kaposi sarcoma, and bladder.

Body Weight, Physical Activity, Diet, and Alcohol

Alcoholic beverage consumption:
International Agency for Research on Cancer. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Alcohol consumption and ethyl carbamate.* Vol. 96. Lyon, France: IARC Press; 2010.

Department of Health and Human Services [USA] 2018 Physical Activity Guidelines Advisory Committee. *2018 Physical Activity Guidelines Advisory Committee Scientific Report.* Washington, DC: U.S. Department of Health and Human Services, 2018.

https://health.gov/paguidelines/second-edition/report/ Accessed Feb. 28, 2019.

Text:
Arnold M, Pandeya N, Byrnes G, et al. Global burden of cancer attributable to high body-mass index in 2012: A population-based study. *Lancet Oncol.* 2015 Jan; 16(1): 36–46.

Department of Health and Human Services [USA] 2018 Physical Activity Guidelines Advisory Committee. *2018 Physical Activity Guidelines Advisory Committee Scientific Report.* Washington, DC: U.S. Department of Health and Human Services, 2018. https://health.gov/paguidelines/second-edition/report/

International Agency for Research on Cancer. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Alcohol consumption and ethyl carbamate.* Vol. 96. Lyon, France: IARC Press; 2010.

Lauby-Secretan B, Scoccianti C, Loomis D, et al. Body Fatness and Cancer: Viewpoint of the IARC Working Group. *N Engl J Med.* 2016;375:794–798.

World Cancer Research Fund/American Institute for Cancer Research. *Diet, nutrition, physical activity and cancer: A global perspective. Continuous Update Project Expert Report 2018.* Available at dietandcancerreport.org. Accessed Nov. 9, 2018.

World Health Organization. *Global status report on alcohol and health 2018.* Geneva: World Health Organization; 2018. https://www.who.int/substance_abuse/publications/global_alcohol_report/en/ Accessed Feb. 28, 2019.

World Health Organization. *Obesity and Overweight.* http://www.who.int/gho/ncd/risk_factors/physical_activity_text/en/ Accessed October 30, 2018.

Map:
Adult obesity is defined as BMI greater than or equal to 30.

World Health Organization Global Health Observatory Data Repository. https://www.who.int/gho/en/. Accessed May 30, 2019.

Figure 1:
World Cancer Research Fund/American Institute for Cancer Research. *Diet, nutrition, physical activity and cancer: A global perspective. Continuous Update Project Expert Report 2018.* Available at dietandcancerreport.org.

Figure 2:
World Health Organization. *Global status report on alcohol and health 2018.* Geneva: World Health Organization; 2018. License: CC BY-NC-SA 3.0.
See page 89 of the report.

Ultraviolet Radiation

Prevention of skin cancer by use of sun protection:
Armstrong BK, Kricker A. How much melanoma is caused by sun exposure? *Melanoma Res.* 1993;3(6):395–401.

Lucas RM, McMichael AJ, Armstrong BK, Smith WT. Estimating the global disease burden due to ultraviolet radiation exposure. *Int J Epidemiol.* 2008;37(3):654–667.

Text:
Gordon LG, Rowell D. Health system costs of skin cancer and cost-effectiveness of skin cancer prevention and screening: a systematic review. *Euro J Cancer Prevention.* 2015; 24:141–149.

Green AC, Wallingford SC, McBride P. Childhood exposure to ultraviolet radiation and harmful skin effects: epidemiological evidence. *Progr Biophysics Mol Biol.* 2011; 107:349–55.

Guy GP, Jr., Zhang Y, Ekwueme DU, Rim SH, Watson M. The potential impact of reducing indoor tanning on melanoma prevention and treatment costs in the United States: An economic analysis. *J Am Acad Dermatol.* 2017;76:226–233.

IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. *IARC Monographs. Radiation. Volume 100D. A review of human carcinogens.* Lyon, France: 2012.

Karimkhani C, Fitzmaurice C, Green AC, et al. The global burden of melanoma: Results from Global Burden of Disease Study 2015. *Brit J Dermatol.* 2017; 177:134–40.

Wallingford SC, Iannacone MR, Youlden DR, et al. Comparison of melanoma incidence and trends among youth under 25 years in Australia and England, 1990-2010. *Int J Cancer.* 2015; 137: 2227–2233.

World Health Organization. *Solar Ultraviolet Radiation: Global Burden of Disease from solar ultraviolet radiation.* 2012.

Map:
Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC, 2018. Available from: https://gco.iarc.fr/today.

Figure 1:
Gordon LG, Rowell D. Health system costs of skin cancer and cost-effectiveness of skin cancer prevention and screening: a systematic review. *Euro J Cancer Prev.* 2015; 24:141–149.

Figure 2:
Rodriguez-Acevedo A, et al. Unpublished meta-analysis, multiple published surveys:

Andrulonis R, Secrest AM, Patton TJ, Grandinetti LM, Ferris LK. A cross-sectional study of indoor tanning use among patients seeking skin cancer screening. *J Am Acad Dermatol.* 2017;76(1):164–5.

Basch CH, Hillyer GC, Basch CE, Neugut AI. Improving understanding about tanning behaviors in college students: a pilot study. *J Am Coll Health.* 2012;60(3):250–6.

Benmarhnia T, Leon C, Beck F. Exposure to indoor tanning in France: a population based study. *BMC Dermatol.* 2013;13:6.

Coups EJ, Stapleton JL, Delnevo CD. Indoor tanning among New Jersey high school students before and after the enactment of youth access restrictions. *J Am Acad Dermatol.* 2016;75(2):440–2.

Guy GP, Jr., Berkowitz Z, Holman DM, Hartman AM. Recent Changes in the Prevalence of and Factors Associated With Frequency of Indoor Tanning Among US Adults. *JAMA Dermatol.* 2015;151(11):1256–9.

Guy GP, Jr., Berkowitz Z, Tai E, Holman DM, Everett Jones S, Richardson LC. Indoor tanning among high school students in the United States, 2009 and 2011. *JAMA Dermatol.* 2014;150(5):501–11.

Guy GP, Jr., Berkowitz Z, Watson M, Holman DM, Richardson LC. Indoor tanning among young non-Hispanic white females. *JAMA Intern Med.* 2013;173(20):1920–2.

Guy GP, Jr., Watson M, Seidenberg AB, Hartman AM, Holman DM, Perna F. Trends in indoor tanning and its association with sunburn among US adults. *J Am Acad Dermatol.* 2017;76(6):1191–3.

Hillhouse J, Stapleton JL, Florence LC, Pagoto S. Prevalence and Correlates of Indoor Tanning in Non-salon Locations Among a National Sample of Young Women. *JAMA Dermatol.* 2015;151(10):1134–6.

Kann L, McManus T, Harris WA, Shanklin SL, Flint KH, Queen B, et al. Youth Risk Behavior Surveillance - United States, 2017. *MMWR Surveill Summ.* 2018;67(8):1–114.

Koster B, Meyer MK, Andersson TM, Engholm G, Dalum P. Sunbed use 2007–2015 and skin cancer projections of campaign results 2007–2040 in the Danish population: repeated cross-sectional surveys. *BMJ Open.* 2018;8(8):e022094.

Lee SI, Macherianakis A, Roberts LM. Sunbed use, attitudes, and knowledge after the under-18s ban: a school-based survey of adolescents aged 15 to 17 years in Sandwell, United Kingdom. *J Prim Care Community Health.* 2013;4(4):265–74.

Meyer MKH, Koster B, Juul L, Tolstrup JS, Bendtsen P, Dalum P, et al. Sunbed use among 64,000 Danish students and the associations with demographic factors, health-related behaviours, and appearance-related factors. *Prev Med.* 2017;100:17–24.

Mosher CE, Danoff-Burg S. Indoor tanning, mental health, and substance use among college students: the significance of gender. *J Health Psychol.* 2010;15(6):819–27.

Nadalin V, Marrett L, Atkinson J, Tenkate T, Rosen CF. Tanning among Ontario adolescents pre-legislation: Prevalence and beliefs. *Prev Med.* 2016;91:244–9.

Nadalin V, Marrett LD, Cawley C, Minaker LM, Manske S. Intentional tanning among adolescents in seven Canadian provinces: Provincial comparisons (CRAYS 2015). *Prev Med.* 2018;111:225–30.

Neenan A, Lea CS, Lesesky EB. Reasons for tanning bed use: a survey of community college students in North Carolina. *N C Med J.* 2012;73(2):89–92.

Niu Z, Parmar V, Xu B, Coups EJ, Stapleton JL. Prevalence and correlates of intentional outdoor and indoor tanning among adolescents in the United States: Findings from the FLASHE survey. *Prev Med Rep.* 2018;11:187–90.

Rodriguez VM, Daniel CL, Welles BF, Geller AC, Hay JL. Friendly tanning: young adults' engagement with friends around indoor tanning. *J Behav Med.* 2017;40(4):631–40.

Say M, Beauchet A, Vouldoukis I, Beauchet P, Boudet M, Tella E, et al. Decrease in artificial tanning by French teenagers: 2011-2016. *Photodermatol Photoimmunol Photomed.* 2018;34(4):257–61.

Schneider S, Diehl K, Bock C, Schluter M, Breitbart EW, Volkmer B, et al. Sunbed use, user characteristics, and motivations for tanning: results from the German population-based SUN-Study 2012. *JAMA Dermatol.* 2013;149(1):43–9.

Stanganelli I, Gandini S, Magi S, Mazzoni L, Medri M, Agnoletti V, et al. Sunbed use among subjects at high risk of melanoma: an Italian survey after the ban. *Br J Dermatol.* 2013;169(2):351–7.

Tella E, Beauchet A, Vouldoukis I, Sei JF, Beaulieu P, Sigal ML, et al. French teenagers and artificial tanning. *J Eur Acad Dermatol Venereol.* 2013;27(3):e428–32.

Yang K, Han J. Indoor tanning use among white female students aged 18-30. *J Dermatol Sci.* 2017;85(3):253–6.

Figure 3:
Data provided by the Australian Institute of Health and Welfare and the South West Knowledge and Intelligence Team, Public Health England

Reproductive and Hormonal Factors

Breastfeeding duration:
Victora CG, et al. Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. *Lancet.* 2016;387(10017):475–490.

Text:
Brown SB, Hankinson SE. Endogenous estrogens and the risk of breast, endometrial, and ovarian cancers. *Steroids.* 2015;99(Pt A):8–10.

Islami F, Liu Y, Jemal A, et al. Breastfeeding and breast cancer risk by receptor status--a systematic review and meta-analysis. *Ann Oncol.* 2015;26(12):2398–2407.

Iversen L, Sivasubramaniam S, Lee AJ, Fielding S, Hannaford PC. Lifetime cancer risk and combined oral contraceptives: the Royal College of General Practitioners' Oral Contraception Study. *Am J Obstet Gynecol.* 2017;216(6):580 e581–580 e589.

Murphy N, Ward HA, Jenab M, et al. Heterogeneity of colorectal cancer risk factors by anatomical subsite in 10 European Countries: A multinational cohort study. *Clin Gastroenterol Hepatol.* 2018.

Williams CL, Jones ME, Swerdlow AJ, et al. Risks of ovarian, breast, and corpus uteri cancer in women treated with assisted reproductive technology in Great Britain, 1991-2010: data linkage study including 2.2 million person years of observation. *BMJ.* 2018;362:k2644.

Map 1 and Figure 1:
Victora CG, et al. Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. *Lancet.* 2016;387(10017): 475–490.

Quigley MA, Carson C. Breastfeeding in the 21st century. *Lancet.* 2016;387(10033): 2087–2088.

Map 2:
United Nations, Department of Economic and Social Affairs, Population Division (2017). World Population Prospects: The 2017 Revision, custom data acquired via website.

Figure 2:
United Nations, Department of Economic and Social Affairs, Population Division (2017). World Population Prospects: The 2017 Revision, custom data acquired via website.

Figure 3:
Note: Etiologic heterogeneity is an active area of research for most of these cancers. For example, there is active research into the disparate role of parity in the etiology of estrogen receptor positive compared to triple negative breast cancer. The table considers the hormonal and reproductive risk factors in association to risk of the cancer site overall.

Evidence is based more strongly on studies with prospective exposure assessment.

An N. Oral Contraceptives Use and Liver Cancer Risk: A Dose-Response Meta-Analysis of Observational Studies. *Medicine.* 2015;94(43):e1619.

Appleby P, Beral V, et al. for the International Collaboration of Epidemiological Studies of Cervical Cancer. Cervical cancer and hormonal contraceptives: collaborative reanalysis of individual data for 16,573 women with cervical cancer and 35,509 women without cervical cancer from 24 epidemiological studies. *Lancet.* 2007;370(9599): 1609–1621.

Ben Khedher S, Neri M, Papadopoulos A, et al. Menstrual and reproductive factors and lung cancer risk: A pooled analysis from the international lung cancer consortium. *Int J Cancer.* 2017;141(2):309–323.

Brinton LA, Felix AS. Menopausal hormone therapy and risk of endometrial cancer. *Journal Steroid Biochem Molecular Biol.* 2014;142:83–89.

Brown SB, Hankinson SE. Endogenous estrogens and the risk of breast, endometrial, and ovarian cancers. *Steroids.* 2015;99(Pt A):8–10.

Camargo MC, Goto Y, Zabaleta J, Morgan DR, Correa P, Rabkin CS. Sex hormones, hormonal interventions, and gastric cancer risk: a meta-analysis. *Cancer Epidemiol Biomarkers Prev.* 2012;21(1): 20–38.

Chlebowski RT, Anderson GL, Sarto GE, et al. Continuous Combined Estrogen Plus Progestin and Endometrial Cancer: The Women's Health Initiative Randomized Trial. *J Natl Cancer Inst.* 2016;108(3).

Chlebowski RT, Schwartz AG, Wakelee H, et al. Oestrogen plus progestin and lung cancer in postmenopausal women (Women's Health Initiative trial): a post-hoc analysis of a randomised controlled trial. *Lancet.* 2009;374(9697):1243–1251.

Costas L, de Sanjose S, Infante-Rivard C. Reproductive factors and non-Hodgkin lymphoma: a systematic review. *Crit Rev Oncol Hematol.* 2014;92(3):181–193.

Cote ML, Alhajj T, Ruterbusch JJ, et al. Risk factors for endometrial cancer in black and white women: a pooled analysis from the Epidemiology of Endometrial Cancer Consortium (E2C2). *Cancer Causes Control.* 2015;26(2):287–296.

Gaudet MM, Gapstur SM, Sun J, Teras LR, Campbell PT, Patel AV. Oophorectomy and hysterectomy and cancer incidence in the Cancer Prevention Study-II Nutrition Cohort. *Obstet Gynecol.* 2014;123(6):1247–1255.

Gaudet MM, Gierach GL, Carter BD, et al. Pooled Analysis of Nine Cohorts Reveals Breast Cancer Risk Factors by Tumor Molecular Subtype. *Cancer Res.* 2018;78(20):6011–6021.

Green J, Roddam A, Pirie K, et al. Reproductive factors and risk of oesophageal and gastric cancer in the Million Women Study cohort. *Br J Cancer.* 2012;106(1):210–216.

International Collaboration of Epidemiological Studies of Cervical Cancer. Cervical carcinoma and reproductive factors: collaborative reanalysis of individual data on 16,563 women with cervical carcinoma and 33,542 women without cervical carcinoma from 25 epidemiological studies. *Int J Cancer.* 2006;119(5):1108–1124.

Iversen L, Sivasubramaniam S, Lee AJ, Fielding S, Hannaford PC. Lifetime cancer risk and combined oral contraceptives: the Royal College of General Practitioners' Oral Contraception Study. *Am J Obstet Gynecol.* 2017;216(6):580 e581–580 e589.

LaCroix AZ, Chlebowski RT, Manson JE, et al. Health outcomes after stopping conjugated equine estrogens among postmenopausal women with prior hysterectomy: a randomized controlled trial. *JAMA.* 2011;305(13):1305–1314.

Ma X, Zhao LG, Sun JW, et al. Association between breastfeeding and risk of endometrial cancer: a meta-analysis of epidemiological studies. *Eur J Cancer Prev.* 2018;27(2):144–151.

Murphy N, Strickler HD, Stanczyk FZ, et al. A Prospective Evaluation of Endogenous Sex Hormone Levels and Colorectal Cancer Risk in Postmenopausal Women. *J Natl Cancer Inst.* 2015;107(10).

Murphy N, Ward HA, Jenab M, et al. Heterogeneity of Colorectal Cancer Risk Factors by Anatomical Subsite in 10 European Countries: A Multinational Cohort Study. *Clinl Gastroenterol Hepatol.* 2019;17(7):1323–1331 e1326.

Roura E, Travier N, Waterboer T, et al. The Influence of Hormonal Factors on the Risk of Developing Cervical Cancer and Pre-Cancer: Results from the EPIC Cohort. *PloS one.* 2016;11(1):e0147029.

Setiawan VW, Yang HP, Pike MC, et al. Type I and II endometrial cancers: have they different risk factors? *J Clin Oncol.* 2013;31(20):2607–2618.

Tsilidis KK, Allen NE, Key TJ, et al. Oral contraceptives, reproductive history and risk of colorectal cancer in the European Prospective Investigation into Cancer and Nutrition. *Br J Cancer.* 2010;103(11):1755–1759.

Zhong GC, Liu Y, Chen N, et al. Reproductive factors, menopausal hormone therapies and primary liver cancer risk: a systematic review and dose-response meta-analysis of observational studies. *Hum Reprod Update.* 2016;23(1):126–138.

Environmental and Occupational Exposures

Outdoor air pollution exposure:

World Health Organization. *Global Health Observatory data repository.* https://www.who.int/gho/en/. Accessed April 24, 2019.

Percent of cancers worldwide attributed to occupational exposure:

Driscoll T, Takala J, Steenland K, Corvalan C, Fingerhut M. Review of estimates of the global burden of injury and illness due to occupational exposures. *Am J Ind Med.* 2005;48: 491–502.

Rushton L, Hutchings SJ, Fortunato L, et al. Occupational cancer burden in Great Britain. *Br J Cancer.* 2012;107 Suppl 1: S3-7.

Text:

Loomis D, Guha N, Straif K. Identifying occupational carcinogens: An update from the IARC Monographs. *Occupational Environ Med.* 2018;75:593-603.

World Health Organization Global Health Observatory Data Repository, http://apps.who.int/gho/data/node.home.

Maps 1-2, and Figure 1:

Health Effects Institute. *State of Global Air 2019.* Data source: Global Burden of Disease Study 2017. IHME, 2018.

Population-weighted annual average: Instead of calculating average air pollution levels where all areas receive equal weight, as is typically done, population-weighted averages give weight to the areas in proportion to their population, so that greater weight is given to exposures in areas where the most people live.

Figure 2:

Loomis D, Guha N, Straif K. Identifying occupational carcinogens: an update from the IARC Monographs. *Occupational Environ Med.* 2018;75:593-603.

Human Carcinogens Identified by the IARC Monographs Program

Text and Figures:

IARC. IARC Monographs on the Evolution of Carcinogenic Risks to Humans. Lyon, France: International Agency for Research on Cancer; accessed on September 20, 2018. https://monographs.iarc.fr/.

THE BURDEN

Section Divider:

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC, 2018. Available from: https://gco.iarc.fr/today.

World Health Organization. Global Initiative for Childhood Cancer. Available from URL: https://www.who.int/cancer/childhood-cancer/en/ [accessed 17 June, 2019].

The Burden of Cancer

Quote:

Atun R, Cavalli F. The global fight against cancer: challenges and opportunities. *Lancet.* 2018;391:412–413.

Cancer as a leading cause of premature death:

World Health Organization. *Global Health Estimates 2016: Deaths by Cause, Age, Sex, by Country and by Region, 2000–2016.* Geneva: WHO, 2018.

Text:

Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global Cancer Statistics 2018: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. *CA Cancer J Clin.* 2018. https://onlinelibrary.wiley.com/doi/full/10.3322/caac.21492.

Ferlay J, Colombet M, Soerjomataram I, et al. Estimating the global cancer incidence and mortality in 2018: GLOBOCAN sources and methods. *Int J Cancer.* 2018 Oct 23. doi: 10.1002/ijc.31937.

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC, 2018. Available from: https://gco.iarc.fr/today.

World Health Organization. Global Health Estimates 2016: *Deaths by Cause, Age, Sex, by Country and by Region, 2000–2016.* 2018.

Map:

World Health Organization. *Global Health Estimates 2016: Deaths by Cause, Age, Sex, by Country and by Region, 2000–2016.* 2018.

Figures 1-4:

Estimates include non-melanoma skin cancers.

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC, 2018. Available from: https://gco.iarc.fr/today.

Lung Cancer

Cause of lung cancer deaths:

The GBD Risk Factor Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990-2017: A systematic analysis for the Global Burden of Disease Study 2017. *Lancet.* 2018;392(10159):1923–94.

Access creates progress:

US Department of Health and Human Services. *The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General.* Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2014.

Text:

Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin.* 2018; 68(6):394–424.

Guo Y, Zeng H, Zheng R, et al. The burden of lung cancer mortality attributable to fine particles in China. *Sci Total Environ.* 2017;579:1460–6.

Jemal A, Miller KD, Ma J, et al. Higher lung cancer incidence in young women than young men in the United States. *N Engl J Med.* 2018;378(21): 1999–2009.

Lortet-Tieulent J, Soerjomataram I, Ferlay J, Rutherford M, Weiderpass E, Bray F. International trends in lung cancer incidence by histological subtype: adenocarcinoma stabilizing in men but still increasing in women. *Lung Cancer.* 2014;84(1):13–22.

Soerjomataram I, Shield K, Marant-Micallef C, et al. Cancers related to lifestyle and environmental factors in France in 2015. *Eur J Cancer.* 2018;105:103–13.

The GBD Risk Factor Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990-2017: A systematic analysis for the Global Burden of Disease Study 2017. *Lancet.* 2018;392(10159):1923–94.

Thun M, Peto R, Boreham J, Lopez AD. Stages of the cigarette epidemic on entering its second century. *Tob Control*. 2012;21(2):96–101.

Wang JB, Fan YG, Jiang Y, et al. Attributable causes of lung cancer incidence and mortality in China. *Thorac Cancer.* 2011;2(4):156–63.

Map and Figure 1:

Ferlay J, Ervik M, Lam F, et al.. *Global Cancer Observatory: Cancer Today.* Lyon, France: International Agency for Research on Cancer. Available from: https://gco.iarc.fr/today.

Figure 2:

Death rates: US Mortality Volumes 1930 to 1959, US Mortality Data 1960 to 2015, National Center for Health Statistics, Centers for Disease Control and Prevention.

Cigarette consumption: 1900–1999: US Department of Agriculture; 2000–2015: Wang, TW et al. (2016). "Consumption of Combustible and Smokeless Tobacco - United States, 2000-2015." *MMWR Morbidity and Mortality Weekly Report.* 65(48): 1357–1363.

Figure 3:

Rates smoothed using 5-year average.

World Health Organization Cancer Mortality Database, http://www-dep.iarc.fr/WHOdb/WHOdb.htm

Figure 4:

ibid.

Figure 5:

France: Soerjomataram I, Shield K, Marant-Micallef C, et al. Cancers related to lifestyle and environmental factors in France in 2015. *Eur J Cancer.* 2018;105:103–13.

China, air pollution: Guo Y, Zeng H, Zheng R, et al. The burden of lung cancer mortality attributable to fine particles in China. *Sci Total Environ.* 2017;579:1460–6.

China, smoking: Wang JB, Fan YG, Jiang Y, et al. Attributable causes of lung cancer incidence and mortality in China. *Thorac Cancer.* 2011;2(4): 156–63.

Breast Cancer

Access creates progress:

Lauby-Secretan B, Scoccianti C, Loomis D, et al. Breast-cancer screening – viewpoint of the IARC Working Group. *New Engl J Med.* 2015;372: 2353–2358.

Text:

Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin.* 2018; 68(6): 394–424.

Carioli G, Malvezzi M, Rodriguez T, Bertuccio P, Negri E, La Vecchia C. Trends and predictions to 2020 in breast cancer mortality in Europe. *Breast.* 2017; 36: 89–95.

Carioli G, Malvezzi M, Rodriguez T, Bertuccio P, Negri E, La Vecchia C. Trends and predictions to 2020 in breast cancer mortality: Americas and Australasia. *Breast.* 2018; 37: 163–9.

Torre LA, Islami F, Siegel RL, Ward EM, Jemal A. Global Cancer in Women: Burden and Trends. *Cancer Epidemiol Biomarkers Prev.* 2017; 26(4): 444–57.

Verdial FC, Etzioni R, Duggan C, Anderson BO. Demographic changes in breast cancer incidence, stage at diagnosis and age associated with population-based mammographic screening. *J Surg Oncol.* 2017; 115(5): 517–22.

Map and Figures 1 and 2:

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today

Figure 3:

Five-year moving average.

Ferlay J, Colombet M and Bray F. *Cancer Incidence in Five Continents, CI5plus: IARC CancerBase No. 9 [Internet].* Lyon, France: International Agency for Research on Cancer; 2018. Available from: http://ci5.iarc.fr.

Figure 4:

Five-year moving average.

World Health Organization Cancer Mortality Database, http://www-dep.iarc.fr/WHOdb/WHOdb.htm.

Cancer in Children

Childhood cancer survivors:

Phillips SM, Padgett LS, Leisenring WM, et al. Survivors of childhood cancer in the United States: prevalence and burden of morbidity. *Cancer Epidemiol Biomarkers Prev.* 2015;24(4):653–63.

Access creates progress:

Gelband H,Jha P, Sankaranarayanan R, Horton S, eds. 2015. *Disease Control Priorities, third edition. Volume 3, Cancer.* Chapter 7: Treating childhood cancer in low- and middle-income countries. Washington, DC: World Bank.

Text:

Amitay EL. Breastfeeding and Childhood Leukemia Incidence: A Meta-analysis and Systematic Review. *JAMA Pediatr.* 2015;169(6):e151025.

Bonaventure A, Harewood R, Stiller CA, et al. Worldwide comparison of survival from childhood leukaemia for 1995-2009, by subtype, age, and sex (CONCORD-2): a population-based study of individual data for 89 828 children from 198 registries in 53 countries. *Lancet Haematol.* 2017;4(5):e202-e17.

Braganza MZ, Kitahara CM, Berrington de González A, Inskip PD, Johnson KJ, Rajaraman P. Ionizing radiation and the risk of brain and central nervous system tumors: a systematic review. *Neuro-Oncology.* 2012;14(11):1316–24.

Cantarella CD, Ragusa D, Giammanco M, Tosi S. Folate deficiency as predisposing factor for childhood leukaemia: a review of the literature. *Genes Nutr.* 2017;12:14.

Caughey RW, Michels KB. Birth weight and childhood leukemia: a meta-analysis and review of the current evidence. *Int J Cancer.* 2009;124(11):2658–70.

Chiavarini M, Naldini G, Fabiani R. Maternal folate intake and risk of childhood brain and spinal cord tumors: A systematic review and meta-analysis. *Neuroepidemiology.* 2018;51(1–2):82-95.

Dahlhaus A, Prengel P, Spector L, Pieper D. Birth weight and subsequent risk of childhood primary brain tumors: An updated meta-analysis. *Pediatric Blood & Cancer.* 2017;64(5).

Howlader NN, Noone AM, Krapcho M, et al. (eds.). *SEER Cancer Statistics Review, 1975–2014.* Bethesda, MD: National Cancer Institute; 2017.

Phillips SM, Padgett LS, Leisenring WM, et al. Survivors of childhood cancer in the United States: prevalence and burden of morbidity. *Cancer Epidemiology Biomarkers Prev.* 2015;24(4):653-63.

Ripperger T, Bielack SS, Borkhardt A, et al. Childhood cancer predisposition syndromes-A concise review and recommendations by the Cancer Predisposition Working Group of the Society for Pediatric Oncology and Hematology. *Am J Med Genet A.* 2017;173(4):1017-37.

Steliarova-Foucher E, Colombet M, Ries LAG, et al. *International Incidence of Childhood Cancer, Volume III* (electronic version). Lyon: International Agency for Research on Cancer; 2017. Available from: http://iicc.iarc.fr/results/.

Steliarova-Foucher E, Colombet M, Ries LAG, et al. International incidence of childhood cancer, 2001–10: a population-based registry study. *Lancet Oncol.* 2017;18(6):719–31.

Steliarova-Foucher E, Fidler MM, Colombet M, et al. Changing geographical patterns and trends in cancer incidence in children and adolescents in Europe, 1991-2010: a population-based study. *Lancet Oncol.* 2018;19(9):1159-69.

Wang KL, Liu CL, Zhuang Y, Qu HY. Breastfeeding and the risk of childhood Hodgkin lymphoma: a systematic review and meta-analysis. *Asian Pacific J Cancer Prev.* 2013;14(8):4733-7.

Whitehead TP, Metayer C, Wiemels JL, Singer AW, Miller MD. Childhood leukemia and primary prevention. *Curr Probl Pediatr Adolesc Health Care.* 2016;46(10):317–52.

Figure 1:
Steliarova-Foucher E, Colombet M, Ries LAG, et al. *International Incidence of Childhood Cancer, Volume III* (electronic version). Lyon: International Agency for Research on Cancer; 2017. Available from: http://iicc.iarc.fr/results/.

Figure 2 and 3:
Steliarova-Foucher E, Colombet M, Ries LAG, et al. International incidence of childhood cancer, 2001–10: a population-based registry study. *Lancet Oncol.* Jun 2017;18(6):719–731.

Figure 4:
The estimates for regions were calculated as an average of 5-year age-standardized net survival observed in the most recent available period in all areas with at least 50 cases, weighted by the numbers of cases.

Bonaventure A, Harewood R, Stiller CA, et al. Worldwide comparison of survival from childhood leukaemia for 1995–2009, by subtype, age, and sex (CONCORD-2): a population-based study of individual data for 89 828 children from 198 registries in 53 countries. *Lancet Haematol.* 2017;4(5):e202-e17.

Figure 5:
ibid.

Human Development Index Transitions

Cancer burden in 2040:
Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today

Text:
Bray F, Jemal A, Grey N, Ferlay J, Forman D. Global cancer transitions according to the Human Development Index (2008–2030): a population-based study. *Lancet Oncol.* 2012;13,790-801.

Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin.* 2018;68(6):394–424.

Gersten O, Wilmoth JR. The cancer transition in Japan since 1951. *Demographic Research.* 2002;7:271–306.

Omran AR. The epidemiologic transition: A theory of the epidemiology of population change. *Milbank Mem Fund Q.* 1971; 49: 509–538.

United Nations Development Programme. *Human Development Report 2015.* Geneva: United Nations; 2015. 1–10. Available at: http://hdr.undp.org/sites/default/files/2015_human_development_report.pdf.

Map 1 and Figure 1:
HDI: United Nations Development Programme. Human Development Index. http://hdr.undp.org/en/content/human-development-index-hdi.

Cancer rates: Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today

Map 2 and Figure 2:
World Health Organization Global Health Observatory Data Repository, http://apps.who.int/gho/data/node.home.

Figures 3 and 4:
Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today

Cancer in Indigenous Populations

Statistics for indigenous populations:
Personal communication from Dr. Diana Sarfati

Text:
Anderson I, Robson B, Connolly M, et al. Indigenous and tribal peoples' health (The Lancet-Lowitja Institute Global Collaboration): a population study. *Lancet* (London, England). 2016;388:131–157.

Australian Institute of Health and Welfare. *Cancer in Aboriginal & Torres Strait Islander people of Australia,* https://www.aihw.gov.au/reports/cancer/cancer-in-indigenous-australians/contents/table-of-contents.

Sarfati D, Garvey G, Robson B, et al. Measuring cancer in indigenous populations. *Ann Epidemiol.* 2018;28:335–342.

Soeberg M, Blakely T, Sarfati D. Trends in ethnic and socioeconomic inequalities in cancer survival, New Zealand, 1991–2004. *Cancer Epidemiol.* 2015;39:860-862.

United Nations Department of Economic and Social Affairs. *State of the World's Indigenous Peoples.* United Nations Publications; 2015.

Withrow DR, Pole JD, Nishri ED, Tjepkema M, Marrett LD. Cancer Survival Disparities Between First Nation and Non-Aboriginal Adults in Canada: Follow-up of the 1991 Census Mortality Cohort. *Cancer Epidemiol Biomarkers Prev.* 2017;26: 145–151.

Figure 1:
Relative risk compares the risk of disease among people from two different groups. If the relative risk is more than 1.0, then the risk is higher. All relative risks are calculated on the basis of age-standardized rates. Age range varies slightly across studies.

Australia (2011–2015): Australian Institute of Health and Welfare. *Cancer in Aboriginal & Torres Strait Islander people of Australia,* https://www.aihw.gov.au/reports/cancer/cancer-in-indigenous-australians/contents/table-of-contents. AIHW. Accessed 21 Aug 2018.

United States (2012–2016): Siegel R, Miller K, Jemal A. Cancer statistics, 2019. *CA Cancer J Clin.* 2019 Jan;69(1):7–34.

New Zealand (2006–2011): Teng AM, Atkinson J, Disney G, et al. Ethnic inequalities in cancer incidence and mortality: census-linked cohort studies with 87 million years of person-time follow-up. *BMC Cancer.* 2016;16:755.

Canada (1991–2001, includes stomach and esophageal cancers): Tjepkema M, Wilkins R, Senécal S, Guimond E, Penney C. Mortality of Métis and registered Indian adults in Canada: an 11-year follow-up study. *Health Reports.* 2009;20:31-51.

Alaska (1999–2009): White MC, Espey DK, Swan J, Wiggins CL, Eheman C, Kaur JS. Disparities in cancer mortality and incidence among American Indians and Alaska Natives in the United States. *Am J Public Health.* 2014;104 Suppl 3:S377-387.

Figure 2:
Note: Prevalence estimates are taken from different time periods, in different population samples, and using different methods so are not necessarily directly comparable. In all cases, where non-Indigenous prevalence estimates were measured or estimated, prevalence of *H. pylori* was 2-3 times higher among Indigenous peoples.

Brazil (by age 8–9 years, 2007): Escobar-Pardo ML, Godoy APOd, Machado RS, et al. Prevalência da infecção por Helicobacter pylori e de parasitoses intestinais em crianças do Parque Indígena do Xingu. *Jornal de Pediatria.* 2011;87:393–398.

New Zealand (Pooled birth cohorts; 1926–1985): McDonald AM, Sarfati D, Baker MG, Blakely T. Trends in Helicobacter pylori infection among Maori, Pacific, and European Birth cohorts in New Zealand. *Helicobacter.* 2015;20:139–145.

Greenland (22–76 year olds, 1993–94): Milman N, Byg K-E, Andersen LP, Mulvad G, Pedersen HS, Bjerregaard P. Indigenous Greenlanders have a higher sero-prevalence of IgG antibodies to Helicobacter pylori than Danes. *Int J Circumpolar Health.* 2003;62:54–60.

Alaska Natives (prevalence by age 14 years, 1980–86): Parkinson AJ, Gold BD, Bulkow L, et al. High Prevalence of Helicobacter pylori in the Alaska Native Population and Association with Low Serum Ferritin Levels in Young Adults. *Clin Diagn Laboratory Immunol.* 2000;7:885–888.

Canada (prevalence by age 2 years, 1999): Sinha SK, Martin B, Sargent M, McConnell JP, Bernstein CN. Age at Acquisition of Helicobacter pylori in a Pediatric Canadian First Nations Population. *Helicobacter.* 2002;7:76–85.

Western Australia (3–75 year olds, 2003–4): Windsor H, Morrow S, Marshall B, Abioye-Kuteyi E, Leber J, Bulsara M. Prevalence of Helicobacter pylori in Indigenous Western Australians: comparison between urban and remote rural populations. *Med J Australia.* 2005;182:210–213.

Map:
The World Bank. 2015. Indigenous Latin America in the Twenty-First Century. Washington, DC: World Bank. License: Creative Commons Attribution CC BY 3.0 IGO.

Anderson I, Robson B, Connolly M, et al. Indigenous and tribal peoples' health (The Lancet-Lowitja Institute Global Collaboration): a population study. *Lancet.* 2016;388: 131–157.

Overview of Geographic Diversity

Quote:
Peto J. Cancer epidemiology in the last century and the next decade. *Nature.* 2001;411: 390–395.

Most commonly diagnosed cancers:
Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Text:
Bray F, Ferlay J, Laversanne M, et al. Cancer Incidence in Five Continents: Inclusion criteria, highlights from Volume X and the global status of cancer registration. *Int J Cancer.* 2015 Nov 1;137(9):2060–71.

Bray F, Soerjomataram I. Population attributable fractions continue to unmask the power of prevention. *Br J Cancer.* 2018 Apr;118(8):1031–1032.

Plummer M, de Martel C, Vignat J, Ferlay J, Bray F, Franceschi S. Global burden of cancers attributable to infections in 2012: a synthetic analysis. *Lancet Glob Health.* 2016;4(9):e609–16. (see http://gco.iarc.fr/causes/infections/home)

Map 1 and 2:
Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Figure 1:
Bray F, Colombet M, Mery L, Piñeros M, Znaor A, Zanetti R and Ferlay J, editors (2017) *Cancer Incidence in Five Continents, Vol. XI* . Lyon: IARC. Available from: http://ci5.iarc.fr.

Sub-Saharan Africa

Global cervical cancer deaths in sub-Saharan Africa:
Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Text:
Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin.* 2018; 68(6): 394–424.

Chokunonga E, Borok MZ, Chirenje ZM, Nyakabau AM, Parkin DM. Trends in the incidence of cancer in the black population of Harare, Zimbabwe 1991–2010. *Int J Cancer.* 2013; 133(3):721–9.

Jemal A, Bray F, Forman D, et al. Cancer burden in Africa and opportunities for prevention. *Cancer.* 2012; 118(18): 4372-84.

Somdyala NI, Parkin DM, Sithole N, Bradshaw D. Trends in cancer incidence in rural Eastern Cape Province; South Africa, 1998-2012. *Int J Cancer.* 2015; 136(5): E470-4.

Wabinga HR, Nambooze S, Amulen PM, Okello C, Mbus L, Parkin DM. Trends in the incidence of cancer in Kampala, Uganda 1991-2010. *Int J Cancer*. 2014; 135(2): 432-9.

Map and Figures 1, 2 and 4:

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Figure 3:

Bray F, Colombet M, Mery L, et al., eds. *Cancer Incidence in Five Continents, Vol. XI.* Lyon: IARC. Available from: http://ci5.iarc.fr.

Curado MP, Edwards B, Shin HR, Storm H, Ferlay J, Heanue M, Boyle P, eds. *Cancer Incidence in Five Continents, Vol. IX.* IARC Scientific Publications, No. 160. Lyon, IARC; 2007.

Forman D, Bray F, Brewster DH, et al., eds. *Cancer Incidence in Five Continents, Vol. X.* IARC Scientific Publication No. 164. Lyon: IARC; 2014.

Latin America and the Caribbean

Bolivia and Chile gallbladder cancer rates:

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Text:

Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin.* 2018; 68(6): 394-424.

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Map and Figures 1 and 2:

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Figures 3 and 4:

Rates are 5-year smoothed averages. WHO Cancer Mortality Database, http://www-dep.iarc.fr/WHOdb/WHOdb.htm

Northern America

Endometrial cancers in the US:

Islami F, Sauer AG, Miller KD, et al. Proportion and number of cancer cases and deaths attributable to potentially modifiable factors in the United States in 2014. *CA Cancer J Clin.* 2018;68: 31–54.

Text:

Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin.* 2018;68.

Copeland G, Green D, Firth R, et al. *Cancer in North America: 2011–2015. Volume One: Combined Cancer Incidence for the United States, Canada and North America.* Springfield, IL: North American Association of Central Cancer Registries, Inc., 2018.

de Martel C, Ferlay J, Franceschi S, et al. Global burden of cancers attributable to infections in 2008: a review and synthetic analysis. *Lancet Oncol.* 2012;13: 607–615.

Holford TR, Levy DT, McKay LA, et al. Patterns of birth cohort-specific smoking histories, 1965–2009. *Am J Prev Med.* 2014;46: e31-37.

Islami F, Sauer AG, Miller KD, et al. Proportion and number of cancer cases and deaths attributable to potentially modifiable factors in the United States in 2014. *CA Cancer J Clin.* 2018;68: 31–54.

Perdue DG, Haverkamp D, Perkins C, Daley CM, Provost E. Geographic variation in colorectal cancer incidence and mortality, age of onset, and stage at diagnosis among American Indian and Alaska Native people, 1990–2009. *Am J Public Health.* 2014;104 Suppl 3: S404-414.

The Global Burden of Disease Obesity Collaborators. Health effects of overweight and obesity in 195 countries over 25 years. *N Engl J Med.* 2017; 377: 13–27.

Tung J, Politis CE, Chadder J, et al. The north–south and east–west gradient in colorectal cancer risk: a look at the distribution of modifiable risk factors and incidence across Canada. *Curr Oncol.* 2018; 25: 231–5.

Map and Figure 1:

North American Association of Central Cancer Registries public use dataset

US mortality data, National Center for Health Statistics, Centers for Disease Control and Prevention, 2018.

Figure 2:

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Figures 3, 4, and 5:

Surveillance, Epidemiology, and End Results (SEER) Program (www.seer.cancer.gov) SEER*Stat Database: Incidence - SEER 9 Regs Research Data with Delay-Adjustment, Malignant Only, Nov 2018 Sub (1975–2016) <Katrina/Rita Population Adjustment> - Linked To County Attributes - Total U.S., 1969–2017 Counties, National Cancer Institute, DCCPS, Surveillance Research Program, released April 2019, based on the November 2018 submission.

Ferlay J, Colombet M and Bray F. Cancer Incidence in Five Continents, CI5plus: IARC CancerBase No. 9 [Internet]. Lyon, France: International Agency for Research on Cancer; 2018. Available from: http://ci5.iarc.fr.

Southern, Eastern, and South-Eastern Asia

Cancer burden contribution of this region:

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Text:

Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin.* 2018; 68(6): 394–424.

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Sinha DN, Gupta PC, Ray C, Singh PK. Prevalence of smokeless tobacco use among adults in WHO South-East Asia. *Indian J Cancer.* 2012 Oct-Dec;49(4):342–6.

Map and Figures 1–3:

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Europe

Quote:

Successes and failures of health policy in Europe. Four decades of divergent trends and converging challenges (2013). Mackenbach and Mckee, eds. Open University Press, 2013.

Disproportionate cancer representation among Europeans:

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Text:

Arnold M, Karim-Kos HE, Coebergh JW, et al. Recent trends in incidence of five common cancers in 26 European countries since 1988: Analysis of the European Cancer Observatory. *Eur J Cancer.* 2015; 51(9): 1164–87.

Ferlay J, Colombet M, Soerjomataram I, et al. Cancer incidence and mortality patterns in Europe: Estimates for 40 countries and 25 major cancers in 2018. *Eur J Cancer.* 2018 Nov;103:356–387.

Lortet-Tieulent J, Renteria E, Sharp L, et al. Convergence of decreasing male and increasing female incidence rates in major tobacco-related cancers in Europe in 1988–2010. *Eur J Cancer.* 2015; 51(9): 1144–63.

Map and Figures 1–2:

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Figure 3:

Rates have been smoothed using 5 years average.

Danckert B, Ferlay J, Engholm G , et al. *NORDCAN: Cancer Incidence, Mortality, Prevalence and Survival in the Nordic Countries, Version 8.2* (26.03.2019). Association of the Nordic Cancer Registries. Danish Cancer Society. Available from http://www.ancr.nu.

Ferlay J, Colombet M and Bray F. Cancer Incidence in Five Continents, CI5plus: IARC CancerBase No. 9 [Internet]. Lyon, France: International Agency for Research on Cancer; 2018. Available from: http://ci5.iarc.fr.

World Health Organization Cancer Mortality Database, http://www-dep.iarc.fr/WHOdb/WHOdb.htm.

Northern Africa, West and Central Asia

Cancer cases expected to double in this region:

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Text:

Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin.* 2018; 68(6): 394–424.

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Map 1 and Figures 1 and 2:

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Map 2:

Arnold M, Lam F, Ervik M, Soerjomataram I (2015). *Cancer and Obesity: Global burden of cancer attributable to excess weight.* Lyon, France: International Agency for Research on Cancer. Available from: http://gco.iarc.fr/obesity, accessed May 23, 2019.

Oceania

Australia HPV vaccine and cervical cancer screening coverage:

Hall MT, Simms KT, Lew J-B, et al. The projected timeframe until cervical cancer elimination in Australia: a modelling study. *The Lancet Public Health.* 2019;4: e19-e27.

Text:

Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin.* 2018; 68(6): 394–424.

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Map and Figures 1–3:

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Cancer Survival

Survival from childhood acute lymphoblastic leukemia:

Allemani C, Matsuda T, Di Carlo V, et al., for the CONCORD Working Group. Global surveillance of trends in cancer survival 2000–14 (CONCORD-3): analysis of individual records for 37 513 025 patients diagnosed with one of 18 cancers from 322 population-based registries in 71 countries. *Lancet.* 2018 Mar 17;391(10125):1023–1075.

Access creates progress:

ibid.

Allemani C, Weir HK, Carreira H, et al. Global surveillance of cancer survival 1995–2009: analysis of individual data for 25,676,887 patients from 279 population-based registries in 67 countries (CONCORD-2). *Lancet.* 2015;385: 977–1010.

Text:

Allemani C, Matsuda T, Di Carlo V, et al., for the CONCORD Working Group. Global surveillance of trends in cancer survival 2000–14 (CONCORD-3): analysis of individual records for 37 513 025 patients diagnosed with one of 18 cancers from 322 population-based registries in 71 countries. *Lancet.* 2018 Mar 17;391(10125):1023–1075.

SEER*Explorer: An interactive website for SEER cancer statistics [Internet]. Surveillance Research Program, National Cancer Institute. Available from https://seer.cancer.gov/explorer/.

Joko-Fru WY, Miranda-Filho A, Soerjomataram I, et al. Breast cancer survival in sub-Saharan Africa by age, stage at diagnosis and Human Development Index (HDI): A population-based registry study. *Int J Cancer.* 2019. doi: 10.1002/ijc.32406

Map:
Data quality varies according to cancer site and is typically better for more common cancer sites. Data quality determination in the map is based on breast cancer data.

Allemani C, Matsuda T, Di Carlo V, et al., for the CONCORD Working Group. Global surveillance of trends in cancer survival 2000–14 (CONCORD-3): analysis of individual records for 37 513 025 patients diagnosed with one of 18 cancers from 322 population-based registries in 71 countries. *Lancet.* 2018 Mar 17;391(10125):1023–1075. Licence CC BY 4.0

Additional data provided by the SURVCAN project: http://survival.iarc.fr/Survcan/en/

Figure 1 and 4:
Adapted from Allemani C, Matsuda T, Di Carlo V, et al., for the CONCORD Working Group. Global surveillance of trends in cancer survival 2000–14 (CONCORD-3): analysis of individual records for 37 513 025 patients diagnosed with one of 18 cancers from 322 population-based registries in 71 countries. *Lancet.* 2018 Mar 17;391(10125):1023–1075. Licence CC BY 4.0

Figure 2:
Joko-Fru WY, Miranda-Filho A, Soerjomataram I, et al. Breast cancer survival in sub-Saharan Africa by age, stage at diagnosis and Human Development Index (HDI): A population-based registry study. *Int J Cancer.* 2019. doi: 10.1002/ijc.32406 CC license BY-NC 4.0

Figure 3:
SEER*Explorer: An interactive website for SEER cancer statistics [Internet]. Surveillance Research Program, National Cancer Institute. Available from https://seer.cancer.gov/explorer/.

Cancer Survivorship

Quote:
Mullan F. Seasons of survival: Reflections of a physician with cancer. *N Engl J Med.* 1985;313(4):270–3.

Text:
Chan RJ, Yates P, Li Q, et al., for the STEP study collaborators. Oncology practitioners' perspectives and practice patterns of post-treatment cancer survivorship care in the Asia-Pacific region. *BMC Cancer.* 2017 Nov 6; 17(1):715.

Fitzmaurice C, Akinyemiju TF, Al Lami FH, et al., for the Global Burden of Disease Cancer Collaboration. Global, regional, and national cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life-years for 29 cancer groups, 1990 to 2016: A systematic analysis for the Global Burden of Disease Study. *JAMA Oncol.* 2018 Nov 1;4(11):1553–1568.

Hewitt M, Greenfield S, Stovall E (eds.). Committee on Cancer Survivorship: Improving Care and Quality of Life. *From Cancer Patient to Cancer Survivor: Lost in Transition.* National Cancer Policy Board. Institute of Medicine and National Research Council of the National Academies. Washington, DC: The National Academies Press, 2006.

Ganz PA. Survivorship: adult cancer survivors. *Prim Care.* 2009;36(4):721–41.

Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Molassiotis A, Yates P, Li Q, et al., for the STEP study collaborators. Mapping unmet supportive care needs, quality-of-life perceptions and current symptoms in cancer survivors across the Asia-Pacific region: results from the International STEP Study. *Ann Oncol.* 2017 Oct 1; 28(10):2552–2558.

Rowland JH. Cancer survivorship: new challenge in cancer medicine. In: Bast Jr RC. Croce CM, Hait WN, et al., (eds.). *Holland-Frei Cancer Medicine 9th Edition* (pp. 909 – 916). Hoboken, New Jersey: Wiley-Blackwell, 2017.

Rowland JH, Bellizzi KM. Cancer survivorship issues: life after treatment and implications for an aging population. *J Clin Oncol.* 2014;32(24): 2662–2668.

Rowland JH, Kent EE, Forsythe LP, et al. Cancer survivorship research in Europe and the United States: Where have we been, where are we going, and what can we learn from each other? *Cancer.* 2013;119 (Suppl 11):2094–2108.

Surbone A, Annunziata MA, Santoro A, Tirelli U, Tralongo P. Cancer patients and survivors: changing words or changing culture? *Ann Oncol.* 2013;24(10):2468–71.

Torre LA, Bray F, Siegel RL, Ferlay J, Lortet-Tieulent J, Jemal A. Global cancer statistics, 2012. *CA Cancer J Clin.* 2015;65(2):87–108.

Zheng Z, Han X, Guy GP Jr, Li C, Banegas MP, Ekwueme DU, Davidoff AJ, Jemal A, Yabroff KR. Medical financial hardship among cancer survivors in the US. *Cancer.* 2019; Jan 21. doi:10.1002/cncr.31913.

Map 1:
Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

Map 2:
Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualization. Seattle, WA: IHME, University of Washington, 2018. Available from http://vizhub.healthdata.org/gbd-compare.

Figure 1:
Poor physical health is physical health score < 1 SD below U.S. population mean as assessed using the PROMIS Global Health Scale; Poor mental health is mental health score < 1 SD below U.S. population mean; Poor physical and mental health is physical and mental health-related quality of life < 1 SD below U.S. population mean.

Weaver KE, Forsythe LP, Reeve BB, et al. Mental and Physical Health–Related Quality of Life among U.S. Cancer Survivors: Population Estimates from the 2010 National Health Interview Survey. *Cancer Epidemiol Biomarkers Prev.* 2012;21(11):2108.

Figure 2:
Breast: https://www.nice.org.uk/guidance/ng101/chapter/Recommendations#followup

Colorectal: https://www.nice.org.uk/guidance/cg131/chapter/1-Recommendations#ongoing-care-and-support

Lung: https://www.nice.org.uk/guidance/cg121/chapter/1-Guidance#follow-up-and-patient-perspectives

TAKING ACTION

Section Divider:
Simms KT, Steinberg J, Caruana M, et al. Impact of scaled up human papillomavirus vaccination and cervical screening and the potential for global elimination of cervical cancer in 181 countries, 2020–99: a modelling study. Lancet Oncol. 2019;20:394–407.

The Cancer Continuum: An Overview of Interventions and Potential for Impact

The number of annual worldwide deaths the HPV vaccination can prevent:
Van Kriekinge G, Castellsague X, Cibula D, Demarteau N. Estimation of the potential overall impact of human papillomavirus vaccination on cervical cancer cases and deaths. *Vaccine.* 2014;32(6):733–739.

Text:
Bleich SN. A road map for sustaining healthy eating behavior. *N Engl J Med.* 2018;379(6):507–509.

Centers for Disease Control and Prevention. *Best Practices for Comprehensive Tobacco Control Programs—2014.* Atlanta: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2014.

Centers for Disease Control and Prevention. *Strategies to prevent obesity and other chronic diseases: The CDC guide to strategies to increase physical activity in the community.* Atlanta: U.S. Department of Health and Human Services; 2011.

Gelband H, Sankaranarayanan R, Gauvreau CL, et al. Costs, affordability, and feasibility of an essential package of cancer control interventions in low-income and middle-income countries: Key messages from Disease Control Priorities, 3rd edition. *Lancet.* 2016;387(10033):2133–2144.

Plummer M, de Martel C, Vignat J, Ferlay J, Bray F, Franceschi S. Global burden of cancers attributable to infections in 2012: a synthetic analysis. *Lancet Glob Health.* 2016;4(9):e609-616.

World Health Organization. *Reducing Global Health Risks Through Mitigation of Short-Lived Climate Pollutants: Scoping Report For Policy-makers.* Geneva: World Health Organization; 2015.

Wu YP, Aspinwall LG, Conn BM, Stump T, Grahmann B, Leachman SA. A systematic review of interventions to improve adherence to melanoma preventive behaviors for individuals at elevated risk. *Prev Med.* 2016;88:153–167.

Figure 1:
Romero Y, Trapani D, Johnson S, et al. National cancer control plans: a global analysis. *Lancet Oncol.* 2018;19(10):e546-e555.

Figure 2:
Thun MJ, Carter BD, Feskanich D, et al. 50-year trends in smoking-related mortality in the United States. *N Engl J Med.* 2013;368(4):351–64. Unpublished additional analyses.

Map 1:
Cervical Cancer Action, http://www.cervicalcanceraction.org/comments/maps.php

Figure 3:
WHO IARC Cancer Mortality Database, http://www-dep.iarc.fr/WHOdb/WHOdb.htm

Figure 4:
Adapted from Breast Health Global Initiative. Survivorship care after curative treatment for breast cancer. Available at https://www.fredhutch.org/en/labs/phs/projects/breast-cancer-initiative_2-5/knowledge-summaries/survivorship-care-survivorship-care-after-curative-treatment-for.html

Figure 5:
Global Atlas of Palliative Care at the End of Life. Available from: http://www.who.int/cancer/publications/palliative-care-atlas/en/

Health Promotion: A Population and Systems Approach

Access creates progress:
Fishman E, Schepers P, Kamphuis CBM. Dutch Cycling: Quantifying the Health and Related Economic Benefits. *Am J Public Health.* 2015;105(8):e13-e15.

Text and Figure 1:
World Cancer Research Fund/ American Institute for Cancer Research. Continuous Update Project Expert Report 2018. Recommendations and public health and policy implications. Available at dietandcancerreport.org.

Figure 2:
Briggs ADM, Mytton OT, Kehlbacher A, et al. Health impact assessment of the UK soft drinks industry levy: a comparative risk assessment modelling study. *Lancet Public Health.* 2017;2:e15-22.

Colchero MA, Popkin BM, Rivera JA, Ng SW. Beverage purchases from stores in Mexico under the excise tax on sugar sweetened beverages: observational study. *BMJ.* 2016;352:h6704.

Zhong Y, Auchincloss AH, Lee BK, Kanter GP. The Short-Term Impacts of the Philadelphia Beverage Tax on Beverage Consumption. *Am J Prev Med.* 2018;55(1):26–34.

Figure 3:
Used with permission from Healthy Caribbean Coalition. Campaign materials. Available from: https://www.toomuchjunk.org/campaign-materials.html

Figure 4:
Hamlin MJ, Yule E, Elliot CA, Stoner L, Kathiravel Y. Long-term effectiveness of the New Zealand Green Prescription primary health care exercise initiative. *Public Health.* 2016;140:102–108.

Tobacco Control

Image:
Cigarette pack photo courtesy of Robert Eckford, Campaign for Tobacco-Free Kids.

Text:
Drope J, Schluger N, Cahn Z, et al. *The Tobacco Atlas, 6th Edition.* Atlanta: American Cancer Society and Vital Strategies, 2018.

Map 1:
Framework Convention Alliance. Parties to the WHO FCTC (ratifications and accessions). https://www.fctc.org/parties-ratifications-and-accessions-latest/

Map 2:
World Health Organization. 2018. *Global Tobacco Control Report.* Geneva: World Health Organization.

Canadian Cancer Society. 2018. *Cigarette package Health Warnings: International Status Report.* Toronto: Canadian Cancer Society.

Figure 1:
Van Walbeek CP. *The Economics of Tobacco Control in South Africa.* School of Economics, University of Cape Town; 2005.

Figure 2
Kaiser K, Bredenkamp C, Iglesias RM. 2016. Sin tax reform in the Philippines : transforming public finance, health, and governance for more inclusive development (English). Directions in development. Washington, D.C. : World Bank Group. Available from: http://documents.worldbank.org/curated/en/638391468480878595/Sin-tax-reform-in-the-Philippines-transforming-public-finance-health-and-governance-for-more-inclusive-development

Vaccination

Liver cancer rates in Taiwan and China:
Chiang CJ, Yang YW, You SL, Lai MS, Chen CJ. Thirty-year outcomes of the national hepatitis B immunization program in Taiwan. *JAMA.* 2013;310(9):974–976.

Access creates progress:
Black E, Richmond R. Prevention of Cervical Cancer in Sub-Saharan Africa: The Advantages and Challenges of HPV Vaccination. *Vaccines.* 2018;6(3):61.

Text:
de Martel C, Plummer M, Vignat J, Franceschi S Worldwide burden of cancer attributable to HPV by site, country and HPV type. *Int J Cancer.* 2017;141:664–670.

Gallagher KE, LaMontagne DS, Watson-Jones D. Status of HPV vaccine introduction and barriers to country uptake. *Vaccine*. 2018;36:4761–4767.

Li X, Dumolard L, Patel M, et al. Implementation of hepatitis B birth dose vaccination- worldwide, 2016. *Weekly Epidemiologic Record.* 2018;93:61–72.

World Health Organization. *Global and Regional Immunization Profile: Data as of 21 September 2018*. Accessed at: http://www.who.int/immunization/monitoring_surveillance/data/gs_gloprofile.pdf?ua=1

World Health Organization. *Global hepatitis report 2017*. Geneva: World Health Organization, 2017. http://www.who.int/iris/handle/10665/255016. License: CC BY-NC-SA 3.0 IGO

World Health Organization. *Hepatitis B vaccines: WHO position paper- July 2017*. Weekly Epidemiologic Record: 2017;27:369–392

Map 1:
World Health Organization Global Health Observatory Data, https://www.who.int/gho/en/

Map 2:
World Health Organization Immunization, Vaccines, and Biologicals Database, https://www.who.int/immunization/monitoring_surveillance/data/en/

Figure 1:
de Martel C., Plummer M, Vignat J, et al. Worldwide burden of cancer attributable to HPV by site, country and HPV type. *International Journal of Cancer.* 2017;141(4):664–670.

Figure 2:
Simms KT, Steinberg J, Caruana M, Franceschi S. Impact of scaled up human papillomavirus vaccination and cervical screening and the potential for global elimination of cervical cancer in 181 countries, 2020–99: a modelling study. *Lancet Oncol.* 2019;20(3):394–407.

Early Detection

Cervical cancer death rates in high income countries:
International Agency for Research on Cancer. *IARC Handbooks of Cancer Prevention volume 10: Cervix Cancer Screening.* Lyon: IARC, 2005.

Access creates progress:
Denny L, de Sanjose S, Mutebi M, et al. Interventions to close the divide for women with breast and cervical cancer between low-income and middle-income countries and high-income countries. *Lancet*. 2017;389:861–870.

Text:
Arbyn M, Anttila A, Jordan J, Ronco G, Schenck U, Segnan N, Wiener HG, Herbert A, Daniel J, von Karsa L. *European guidelines for quality assurance in cervical cancer screening. Second edition.* Luxembourg: European Union, 2008.

Dobrow MJ, Hagens V, Chafe R, Sullivan T, Rabeneck L. Consolidated principles for screening based on a systematic review and consensus process. *CMAJ.* 2018;190(14):E422-E429.

Ferlay J, Colombet M and Bray F. Cancer Incidence in Five Continents, CI5plus: IARC CancerBase No. 9 [Internet]. Lyon, France: International Agency for Research on Cancer; 2018. Available from: http://ci5.iarc.fr.

IARC. *IARC Handbooks of Cancer Prevention Volume 15. Breast Cancer Screening.* Lyon: International Agency for Research on Cancer, 2016.

Marmot MG, Altman DG, Cameron DA, Dewar JA, Thompson SG, Wilcox M. The benefits and harms of breast cancer screening: an independent review. *Br J Cancer.* 2013;108(11):2205–40.

Moyer VA; U.S. Preventive Services Task Force. Screening for lung cancer: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med.* 2014;160(5):330–8.

Park S, Oh CM, Cho H, Lee JY, Jung KW, Jun JK, Won YJ, Kong HJ, Choi KS, Lee YJ, Lee JS. Association between screening and the thyroid cancer "epidemic" in South Korea: evidence from a nationwide study. *BMJ.* 2016;355:i5745.

Segnan N, Patnick J, von Karsa L. *European guidelines for quality assurance in colorectal cancer screening and diagnosis. First edition.* Luxembourg: European Union, 2010.

WHO. *Guide to cancer early diagnosis.* Geneva: World Health Organization, 2017.

Wilson JMG, Jungner G. *Principles and practice of screening for disease.* Geneva: World Health Organization, 1968.

World Health Organization. Department of Information. Evidence and Research. Mortality database. Available from: http://www-dep.iarc.fr/WHOdb/WHOdb.htm

Maps 1 and 2:
Used with permission under copyright from John Wiley and Sons: Basu P, Ponti A, Anttila A, et al. Status of implementation and organization of cancer screening in The European Union Member States-Summary results from the second European screening report. *Int J Cancer.* 2018;142:44–56.

Map 3:
Cervical Cancer Action. Global progress in cervical cancer prevention. http://www.cervicalcanceraction.org/comments/maps.php

Figure 1:
Cancer Control Knowledge into Action: WHO Guide for Effective Programs. Early Detection. 2007. https://www.who.int/cancer/modules/Early%20Detection%20Module%203.pdf

Figure 2:
Danckert B, Ferlay J, Engholm G , et al. NORDCAN: Cancer Incidence, Mortality, Prevalence and Survival in the Nordic Countries, Version 8.2 (26.03.2019).

Surveillance, Epidemiology, and End Results (SEER) Program (www.seer.cancer.gov) SEER*Stat Database: Incidence - SEER 9 Regs Research Data, Nov 2018 Sub (1975–2016) <Katrina/Rita Population Adjustment> - Linked To County Attributes - Total U.S., 1969–2017 Counties, National Cancer Institute, DCCPS, Surveillance Research Program, released April 2019, based on the November 2018 submission.

Management and Treatment

Quote:
Knaul FM, Gralow JR, Atun R, Bhadelia A (Eds.) for the Global Task Force on Expanded Access to Cancer Care and Control in Developing Countries. *Closing the Cancer Divide: An Equity Imperative.* Boston, MA: Harvard Global Equity Initiative, 2012.

Text:
Abdel-Wahab M, Fidarova E, Polo A. Global Access to Radiotherapy in Low- and Middle-income Countries. *Clinical Oncology.* 2017;29(2):99–104.

Adesina A, Chumba D, Nelson AM, Orem J, Roberts DJ, Wabinga H, et al. Improvement of pathology in sub-Saharan Africa. *Lancet Oncol.* 2013;14(4):e152-7.

African Strategies for Advancing Pathology: ASAP. Available from: URL: https://www.pathologyinafrica.org/.

Davies C, Godwin J, Gray R, et al. Relevance of breast cancer hormone receptors and other factors to the efficacy of adjuvant tamoxifen: patient-level meta-analysis of randomised trials. *Lancet.* 2011;378(9793):771–84.

Haider A, Scott JW, Gause CD, et al. Development of a Unifying Target and Consensus Indicators for Global Surgical Systems Strengthening: Proposed by the Global Alliance for Surgery, Obstetric, Trauma, and Anaesthesia Care (The G4 Alliance). *World J Surgery*. 2017;41(10):2426–34.

Hanna TP, Shafiq J, Delaney GP, Barton MB. The population benefit of radiotherapy for cervical cancer: local control and survival estimates for optimally utilized radiotherapy and chemoradiation. *Radiother Oncol.* 2015;114:389e394.

Horton S, Sullivan R, Flanigan J, et al. Delivering modern, high-quality, affordable pathology and laboratory medicine to low-income and middle-income countries: a call to action. *Lancet.* 2018;391(10133):1953–64.

International Atomic Energy Agency. Directory of Radiotherapy Centres Countries report. 2019. Available from: https://dirac.iaea.org/Query/Countries.

Jaffray DA, Knaul FM, Atun R, et al. Global Task Force on Radiotherapy for Cancer Control. *Lancet Oncol.* 2015;16(10):1144–6.

Knaul FM, Gralow JR, Atun R, Bhadelia A (Eds.) for the Global Task Force on Expanded Access to Cancer Care and Control in Developing Countries. *Closing the Cancer Divide: An Equity Imperative.* Boston, MA: Harvard Global Equity Initiative, 2012.

Kruk ME, Gage AD, Arsenault C, et al. High-quality health systems in the Sustainable Development Goals era: time for a revolution. *Lancet Global Health.* 2018;6(11):e1196-e1252.

Meara JG, Leather, Andrew JM, et al. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *Int J Obstet Anesthesia.* 2016;25:75–8.

Nelson AM, Milner DA, Rebbeck TR, Iliyasu Y. Oncologic Care and Pathology Resources in Africa: Survey and Recommendations. *J Clin Oncol.* 2016;34(1):20–6.

Robertson J, Barr R, Shulman LN, Forte GB, Magrini N. Essential medicines for cancer: WHO recommendations and national priorities. *Bull World Health Org.* 2016;94(10):735–42.

Shulman LN, Wagner CM, Barr R, et al. Proposing Essential Medicines to Treat Cancer: Methodologies, Processes, and Outcomes. *J Clin Oncol.* 2016;34(1):69–75.

Sullivan R, Alatise OI, Anderson BO, et al. Global cancer surgery: delivering safe, affordable, and timely cancer surgery. *Lancet Oncol.* 2015;16(11):1193–224.

Wilson ML, Atun R, DeStigter K, et al. The Lancet Commission on diagnostics: advancing equitable access to diagnostics. *Lancet.* 2019;393(10185):2018–20.

Zubizarreta E, van Dyk J, Lievens Y. Analysis of Global Radiotherapy Needs and Costs by Geographic Region and Income Level. *Clinical Oncology.* 2017;29(2):84–92.

Map:
Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

International Atomic Energy Agency Directory of Radiotherapy Centres, https://dirac.iaea.org/.

Figure 1:
African Strategies for Advancing Pathology: ASAP [cited 2019 Apr 11]. Available from: URL: https://www.pathologyinafrica.org/.

Figure 2:
Davies C, Godwin J, Gray R, et al. Relevance of breast cancer hormone receptors and other factors to the efficacy of adjuvant tamoxifen: patient-level meta-analysis of randomised trials. *Lancet.* 2011;378(9793):771–84.

Figure 3:
Robertson J, Barr R, Shulman LN, Forte GB, Magrini N. *Essential medicines for cancer: WHO recommendations and national priorities.* Bulletin of the World Health Organization. 2016;94:735–742.

Pain Control

Deaths in pain:
World Health Organization (12 Sept 2018) http://www.who.int/news-room/fact-sheets/detail/cancer

Access creates progress:
O'Brien M, Schwartz A, Plattner L. Treat the Pain Program. *J Pain Symptom Manage.* 2018;55(2):S135-S139.

Text:
United Nations International Narcotics Control Board. *Narcotic Drugs: Estimated World Requirements for 2018 - Statistics for 2016.* 2017. Report No.: E/INCB/2017/2. Available from: https://www.incb.org/documents/Narcotic-Drugs/Technical-Publications/2017/Narcotic_drugs_technical_publication_2017.pdf

United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: *The 2017 Revision, custom data acquired via website.* 2017. Available from: https://population.un.org/wpp/DataQuery/

World Health Organization. Global Health Observatory Data Repository. 2018. Available from: http://apps.who.int/gho/athena/data

World Bank. World Bank country and lending groups. 2018. Available from: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

International Agency for Research on Cancer. Globocan 2018: Estimated Cancer *Incidence, Mortality and Prevalence Worldwide in 2018* [Internet]. [cited 2018 Oct 25]. Available from: http://gco.iarc.fr/today/home

Map and all figures:
Population: World Health Organization, http://apps.who.int/gho/data/

World Bank regions and income levels: World Bank, https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

Deaths from HIV: UNAIDS, http://aidsinfo.unaids.org/

Deaths from cancer: World Health Organization International Agency for Research on Cancer GLOBOCAN 2018, http://gco.iarc.fr/today/home

Consumption of narcotics: International Narcotics Control Board, unpublished data

Cancer Surveillance

Changes in number of high-quality population-based cancer registries:
Cancer Incidence in Five Continents. http://ci5.iarc.fr.

Text:
Bray F, Znaor A, Cueva P, et al. *Planning and developing population-based cancer registration in low- and middle-income settings: IARC Technical Publication No. 43.* Lyon: International Agency for Research on Cancer, 2015. Available at: https://publications.iarc.fr/Book-And-Report-Series/Iarc-Technical-Publications/Planning-And-Developing-Population-Based-Cancer-Registration-In-Low--And-Middle-Income-Settings-2014.2.

World Health Organization. World health statistics 2018: Monitoring health for the SDGs, sustainable development goals. Geneva: WHO, 2018.

Sankaranarayanan R, Swaminathan R, Lucas E, eds. *Cancer survival in Africa, Asia, the Caribbean and Central America. IARC Scientific Publication No. 162.* Lyon: International Agency for Research on Cancer, 2011. Available at: https://publications.iarc.fr/Book-And-Report-Series/Iarc-Scientific-Publications/Cancer-Survival-In-Africa-Asia-The-Caribbean-And-Central-America-2011.

Map 1:
Data provided by the Global Initiative for Cancer Registry Development.

Map 2:
World health statistics 2018: monitoring health for the SDGs, sustainable development goals. Geneva: World Health Organization; 2018. Licence: CC BY-NC-SA 3.0 IGO.

Figure 1:
Cancer Incidence in Five Continents. http://ci5.iarc.fr.

Research

Quote:
Dye C, Boerma T, Evans D, et al. *The World Health Report 2013: Research for universal health coverage.* Geneva: World Health Organization, 2013.

Access creates progress:
Fischer SE, Alatise OI, Komolafe AO, et al. Establishing a Cancer Research Consortium in Low- and Middle-Income Countries: Challenges Faced and Lessons Learned. *Annals of Surgical Oncology.* 2017;24: 627–631.

Anderson BO. Cancer Research in Low- and Middle-Income Countries: Consortiums, Implementation Science and Healthcare Delivery. *Annals of Surgical Oncology.* 2017;24: 624–626.

Text:
Begum M, Lewison G, Lawler M, Sullivan R. Mapping the European cancer research landscape: An evidence base for national and Pan-European research and funding. *Eur J Cancer.* 2018 Sep;100:75–84. Licence CC BY-NC-ND 4.0

Beran D, Byass P, Gbakima A, et al. Research capacity building-obligations for global health partners. *Lancet Glob Health.* 2017 Jun;5(6):e567-e568.

Buxton M, Hanney S, Jones T. Estimating the economic value to societies of the impact of health research: a critical review. *Bull World Health Organ.* 2004 Oct;82(10):733–9.

Carter AJ, Nguyen CN. A comparison of cancer burden and research spending reveals discrepancies in the distribution of research funding. *BMC Public Health.* 2012 Jul 17;12:526.

Digital Science. (2018-) Dimensions [Software] available from https://app.dimensions.ai. Accessed on 10/25/2018, under licence agreement. For more information see www.dimensions.ai or Hook et al. 2018 - "Dimensions: Building Context for Search and Evaluation", https://doi.org/10.3389/frma.2018.00023.

Eckhouse S, Lewison G, Sullivan R. Trends in the global funding and activity of cancer research. *Mol Oncol.* 2008;2(1):20–32.

Franzen SRP, Chandler C, Siribaddana S, Atashili J, Angus B, Lang T. Strategies for developing sustainable health research capacity in low and middle-income countries: a prospective, qualitative study investigating the barriers and enablers to locally led clinical trial conduct in Ethiopia, Cameroon and Sri Lanka. *BMJ Open.* 2017 Oct 13;7(10):e017246.

Frech S, Muha CA, Stevens LM, et al. Perspectives on strengthening cancer research and control in Latin America through partnerships and diplomacy: Experience of the National Cancer Institute's Center for Global Health. *J Glob Oncol.* 2018 Sep;(4):1–11.

Lakdawalla DN, Sun EC, Jena AB, Reyes CM, Goldman DP, Philipson TJ. An economic evaluation of the war on cancer. *J Health Econ.* 2010 May;29(3):333–46.

Peipert JF. The economic value of medical research: is it worth the investment? *Obstet Gynecol.* 2002 May;99(5 Pt 1):835–40.

Phipps W, Kansiime R, Stevenson P, Orem J, Casper C, Morrow RA. Peer mentoring at the Uganda Cancer Institute: A novel model for career development of clinician-scientists in resource-limited settings. *J Glob Oncol.* 2018 Sep;(4):1–11.

Rosenberg LE. Exceptional economic returns on investments in medical research. *Med J Aust.* 2002 Oct 7;177(7):368–71.

Seruga B, Sadikov A, Cazap EL, et al. Barriers and challenges to global clinical cancer research. *Oncologist.* 2014 Jan;19(1):61–7.

Unesco Institute for Statistics. Available at: http://data.uis.unesco.org/Index.aspx?DataSetCode=SCN_DS&lang=en. Accessed April 1, 2019.

Figure 1:
Digital Science. (2018-) Dimensions [Software] available from https://app.dimensions.ai. Accessed on 10/25/2018, under licence agreement. For more information see www.dimensions.ai or Hook et al. 2018 - "Dimensions: Building Context for Search and Evaluation", https://doi.org/10.3389/frma.2018.00023. Accessed October 21, 2018.

Figure 2:
Begum M, Lewison G, Lawler M, et al. Mapping the European cancer research landscape: An evidence base for national and Pan-European research and funding. *Eur J Cancer.* 2018;100:75–84.

Figure 3:
Unesco Institute for Statistics. Available at: http://data.uis.unesco.org/Index.aspx?DataSetCode=SCN_DS&lang=en. Accessed April 1, 2019.

Figure 4:
Lortet-Tieulent J, Soerjomataram I, Lin CC, et al. US Burden of Cancer by Race and Ethnicity According to Disability-Adjusted Life Years. *Am J Prev Med.* 2016; 51(5):673–681.

Digital Science. (2018-) Dimensions [Software] available from https://app.dimensions.ai. Accessed on 10/25/2018, under licence agreement. For more information see www.dimensions.ai or Hook et al. 2018 - "Dimensions: Building Context for Search and Evaluation", https://doi.org/10.3389/frma.2018.00023. Accessed October 21, 2018.

[United States] National Cancer Institute. Funding for Research Area. Available at https://www.cancer.gov/about-nci/budget/fact-book/data/research-funding. Accessed June 28, 2019.

The Economic Burden of Cancer

Text:
Estimates for the US are in 2017 US Dollars.

Estimates for the EU are for 27 countries in 2009 adjust to 2017 Euros.

Estimates for HPV vaccination savings from treatment costs and productivity losses are in 2017 US Dollars.

Estimates for the cost of smoking globally are in 2017 US Dollars.

Bradley CJ, Yabroff KR, Dahman B, Feuer EJ, Mariotto A, Brown ML. Productivity costs of cancer mortality in the United States: 2000–2020. *J Natl Cancer Inst.* 2008;100(24):1763–1770.

CPI inflation calculator. https://www.bls.gov/data/inflation_calculator.htm Accessed Oct 11, 2018.

Guy GP, Jr., Ekwueme DU, Yabroff KR, et al. Economic burden of cancer survivorship among adults in the United States. *J Clin Oncol.* 2013;31(30):3749–3757.

HICP Index. https://ec.europa.eu/eurostat/web/hicp/methodology/reference-year-2015 Accessed Oct 11, 2018.

Lansdorp-Vogelaar I, van Ballegooijen M, Zauber AG, Habbema JD, Kuipers EJ. Effect of rising chemotherapy costs on the cost savings of colorectal cancer screening. *J Natl Cancer Inst.* 2009;101(20):1412–1422.

Luengo-Fernandez R, Leal J, Gray A, Sullivan R. Economic burden of cancer across the European Union: a population-based cost analysis. *Lancet Oncol.* 2013;14(12):1165–1174.

Mariotto AB, Yabroff KR, Shao Y, Feuer EJ, Brown ML. Projections of the cost of cancer care in the United States: 2010–2020. *J Natl Cancer Inst.* 2011;103(2):117–128.

Pearce A, Sharp L, Hanly P, et al. Productivity losses due to premature mortality from cancer in Brazil, Russia, India, China, and South Africa (BRICS): A population-based comparison. *Cancer Epidemiol.* 2018;53:27–34.

The Tobacco Atlas, 6th Edition. https://tobaccoatlasorg/topic/societal-harms/. Atlanta: American Cancer Society, 2018.

Figure 1:
Estimates in 2009 prices with adjustments based on purchasing power parity exchange rates and inflated to 2017 Euros.

Luengo-Fernandez R, Leal J, Gray A, Sullivan R. Economic burden of cancer across the European Union: a population-based cost analysis. *Lancet Oncol.* 2013;14(12):1165–1174.

Figure 2:
Estimates are in 2012 US Dollars with adjustments based on purchasing power parity exchange rates and inflated to 2017 US Dollars.

Pearce A, Sharp L, Hanly P, et al. Productivity losses due to premature mortality from cancer in Brazil, Russia, India, China, and South Africa (BRICS): A population-based comparison. *Cancer Epidemiol.* 2018;53:27–34.

Figure 3:
Estimates are in 2016 US Dollars based on PPP exchange rates and inflated to 2017 US Dollars.

The Tobacco Atlas, 6th Edition. https://tobaccoatlasorg/topic/societal-harms/. Atlanta: American Cancer Society, 2018.

Building Synergies

Quote:
El-Sadr WM, Goosby E. Building on the HIV platform: tackling the challenge of noncommunicable diseases among persons living with HIV. *AIDS.* 2018;32 Suppl 1:S1-S3.

Cervical cancer in women with HIV:
Patel P, Rose CE, Collins PY, et al. Noncommunicable diseases among HIV-infected persons in low-income and middle-income countries: a systematic review and meta-analysis. AIDS. 2018;32 Suppl 1:S5-S20.

Text:
Tangcharoensathien V, Chandrasiri O, Waleewonga O, Rajatanavin N. Overcoming internal challenges and external threats to noncommunicable disease control. *Bull World Health Organ.* 2019;97:74–74A. Available at: https://www.who.int/bulletin/volumes/97/2/18-228809.pdf.

Binagwaho A, Ngabo F, Wagner CM, et al.. Integration of comprehensive women's health programmes into health systems: cervical cancer prevention, care and control in Rwanda. *Bull World Health Organ.* 2013;91:697–703. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3790215/pdf/BLT.12.116087.pdf.

Menon S, Rossi R, Harmon SG, Mabey H, Callens S. Public health approach to prevent cervical cancer in HIV-infected women in Kenya: Issues to consider in the design of prevention programs. *Gynecol Oncol Rep.* 2017;22:82–88. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5678735/.

Map:
Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today.* Lyon, France: IARC. Available from: https://gco.iarc.fr/today.

World Health Organization Global Health Observatory Data Repository, https://www.who.int/gho/en/.

Figure 1:
Saving lives, spending less: a strategic response to noncommunicable diseases. Geneva, Switzerland. World Health Organization; 2018 (WHO/NMH/NVI/18.8). Licence: CC BY-NC-SA 3.0 IGO.

World Health Organization and World Economic Forum. From Burden to "Best Buys": Reducing the Economic Impact of Non-Communicable Diseases in Low- and Middle-Income Countries. https://www.who.int/nmh/publications/best_buys_summary.pdf

Figure 2:
Romero Y, Trapani D, Johnson S, et al. Global Analysis of National Cancer Control Plans. *Lancet Oncol.* 2018;19(10):e546-e555.

Uniting Organizations

Text:
Union for International Cancer Control. Advocacy. Available from https://www.uicc.org/what-we-do/advocacy, accessed September 7, 2018.

Map:
Data provided by the Union for International Cancer Control, 2018

Figure 1:
Union for International Cancer Control. Treatment for All. Available from https://www.uicc.org/what-we-do/advocacy/treatment-all, accessed September 7, 2018.

Figure 3:
Union for International Cancer Control. Convening. Available from: https://www.uicc.org/what-we-do/convening, accessed September 7, 2018.

Global Relay For Life

Unpublished data from the Relay For Life program

Policies and Legislation

Text:
Australia – Certain Measures Concerning Trademarks, Geographical Indications and Other Plain Packaging Requirements Applicable to Tobacco Products and Packaging, WT/DS435/R, WT/DS441/R, WT/DS458/R, WT/DS467/R (28 June 2018).

Philip Morris Asia Ltd v. Australia (Award on Jurisdiction and Admissibility), PCA Case No. 2012–12, 17 December 2015.

Philip Morris Brands Sàrl (Switzerland), Philip Morris Products S.A. (Switzerland) and Abal Hermanos S.A. (Uruguay) v Oriental Republic of Uruguay (Award) (ICSID Arbitral Tribunal, Case No. ARB 10/7, 8 July 2016).

Liberman, J. Building a law and NCDs workforce: a necessity for global cancer and NCD prevention and control. J Cancer Policy. 2017;12, 72–74.

World Health Organization. *Updated Appendix 3 of the Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013–2020.* Geneva: WHO, 2017.

Image:
Cigarette pack photo used with license under copyright from the Commonwealth of Australia.

Figure 1:
World Health Organization. Noncommunicable diseases and mental health: about 9 voluntary targets. https://www.who.int/nmh/ncd-tools/definition-targets/en/

Figure 2:
United Nations Sustainable Development Goals Knowledge Platform. https://sustainabledevelopment.un.org/sdgs

Figure 3:
Australia – Certain Measures Concerning Trademarks, Geographical Indications and Other Plain Packaging Requirements Applicable to Tobacco Products and Packaging, WT/DS435/R, WT/DS441/R, WT/DS458/R, WT/DS467/R (28 June 2018).

Liberman, J. Building a law and NCDs workforce: a necessity for global cancer and NCD prevention and control. *J Cancer Policy.* 2017;12, 72–74.

Philip Morris Asia Ltd v. Australia (Award on Jurisdiction and Admissibility), PCA Case No. 2012–12, 17 December 2015.

Philip Morris Brands Sàrl (Switzerland), Philip Morris Products S.A. (Switzerland) and Abal Hermanos S.A. (Uruguay) v Oriental Republic of Uruguay (Award) (ICSID Arbitral Tribunal, Case No. ARB 10/7, 8 July 2016).

Universal Health Coverage

Quote:
Ghebreyesus TA. Achieving universal health coverage: from the past to the future. Prince Mahidol Award Conference, Bangkok, Thailand. 2 Feb 2018. https://www.who.int/dg/speeches/detail/achieving-universal-health-coverage-from-the-past-to-the-future-prince-mahidol-award-conference-bangkok-thailand

Text:
Jan S, Laba TL, Essue BM, et al. Action to address the household economic burden of non-communicable diseases. *Lancet.* 2018 May 19;391(10134):2047–2058.

Meheus F, Atun R, Ilbawi A. The Role of Health Systems in Addressing Inequalities in Access to Cancer Control. In: *IARC Social inequalities and cancer.* 2019.

Watkins D, Jamison D, Mills A, Atun R, Danforth K. Universal health coverage and essential packages of care. In: Jamison D, Gelband H, Horton S, Jha P, Laxminarayan R. (eds.), *Disease Control Priorities (third edition)*: Volume 9, Disease Control Priorities. Washington, DC: World Bank. 2017.

World Health Organization. *Assessing national capacity for the prevention and control of noncommunicable diseases: global survey.* Geneva: World Health Organization; 2017. https://apps.who.int/iris/bitstream/handle/10665/276609/9789241514781-eng.pdf.

Figure 1:
World Health Organization. Making fair choices on the path to universal health coverage. Final report of the WHO Consultative Group on Equity and Universal Health Coverage. 2014. https://www.who.int/choice/documents/making_fair_choices/en/

Figure 2:
Original figure by authors.

Figure 3:
Assessing national capacity for the prevention and control of noncommunicable diseases: global survey. Geneva: World Health Organization; 2017. https://apps.who.int/iris/bitstream/handle/10665/276609/9789241514781-eng.pdf

Figure 4:
With the exception of the following:
China: >40% of total household income
Iran: >40% of capacity to pay (household income remaining after basic needs have been met)

Jan S, Laba TL, Essue BM, et al. Action to address the household economic burden of non-communicable diseases. *Lancet.* 2018 May 19;391(10134):2047–2058.

Digital Science. (2018-) Dimensions [Software] available from https://app.dimensions.ai. Accessed on 10/25/2018, under licence agreement. For more information see www.dimensions.ai or Hook et al. 2018 - "Dimensions: Building Context for-Search and Evaluation", https://doi.org/10.3389/frma.2018.00023. Accessed October 21, 2018.

United States National Cancer Institute. Funding for Research Area. Available at https://www.cancer.gov/about-nci/budget/fact-book/data/research-funding. Accessed June 28, 2019.

APPENDIX

History of Cancer

Jemal A, Vineis P, Bray F, Torre L, Forman D, eds. The Cancer Atlas, 2nd edition. Atlanta: American Cancer Society; 2014.

US Food and Drug Administration. FDA approves Sovaldi for chronic hepatitis C: Drug is third with breakthrough therapy designation to receive FDA approval. Available from: https://wayback.archive-it.org/7993/20170111161004/http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm377888.htm, accessed May 8, 2019.

US Food and Drug Administration. FDA approval brings first gene therapy to the United States Available from: https://www.fda.gov/news-events/press-announcements/fda-approval-brings-first-gene-therapy-united-states, accessed May 8, 2019.

Photos:
American Cancer Society courtesy of the American Cancer Society

Glossary

Ferlay J, Colombet M and Bray F. *Cancer Incidence in Five Continents, CI5plus: IARC CancerBase No. 9 [Internet].* Lyon, France: International Agency for Research on Cancer; 2018. Available from: http://ci5.iarc.fr.

Ferlay J, Ervik M, Lam F, et al. Global Cancer *Observatory: Cancer Today. Lyon, France:* IARC, 2018. Available from: https://gco.iarc.fr/today.

Jemal A, Vineis P, Bray F, Torre L, Forman D, eds. *The Cancer Atlas,* 2nd edition. Atlanta: American Cancer Society; 2014.

National Cancer Institute (US). *NCI Dictionary of Cancer Terms. Available from:* https://www.cancer.gov/publications/dictionaries/cancer-terms, accessed July 31, 2019.

INDEX

While we face great challenges in this work, we also have the proven interventions, dedicated global partners, and momentum we need to truly address the global cancer burden. This *Cancer Atlas, Third Edition* is an important source of information to help the global cancer community achieve our shared goal of a world without cancer.

— Gary Reedy, CEO, American Cancer Society

The Cancer Atlas, Third Edition has brought together cancer control experts from around the world to present useful and comprehensible information to aid in the fight against cancer. This all-new edition is a comprehensive global overview that equally highlights the distinct patterns and inequities in the present cancer burden, the associated risk factors, and the prospects for cancer prevention and control. This edition unites these topics under the theme of "Access Creates Progress," drawing attention not only to the problem at hand, but also the means of tackling the cancer burden through access to information and services. It provides basic information on the global burden of cancer in a user-friendly and accessible form for cancer control advocates, government and public health agencies, and policymakers as well as patients, survivors, and the general public.

Topics Include

Risks of tobacco

Body weight, physical activity, diet, and alcohol as cancer risk factors

Infection-related cancers

Childhood cancers

Cancer in indigenous populations

The burden of cancer by world region

Cancer survival and survivorship issues

Vaccines

Early detection

Pain control

Universal health coverage

CANCER.ORG/BOOKSTORE
$29.95 (CAN $32.95)
ISBN 9781604432657