CANCER IN MASSACHUSETTS: A CALL TO ACTION

For more information or to download the report: www.CancerInMass.org

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To the many people, across multiple institutions, who contributed to the development of this report

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Dana-Farber/Harvard Cancer Center (DF/HCC) is one of the nation’s 49 Comprehensive Cancer Centers designated by the National Cancer Institute. We are proud to be the sole Comprehensive Cancer Center in Massachusetts, where our mission is to focus the collective efforts of Harvard’s cancer research community on translational research and speed our ability to convert new discoveries into better ways of preventing, diagnosing, and treating cancer.

We fulfill our mission through an unwavering commitment to high-impact cancer research carried out by collaborating groups of investigators who, collectively, span the three canonical forms of cancer science: laboratory, clinical, and population-based research.

Cancer kills about 13,000 Massachusetts residents per year, and current cancer control activities are not optimally effective or equitably applied. We are committed to understanding the impact of cancer in our local population and to addressing the particular needs of Massachusetts residents, who constitute 78% of our patients. We recognize that there are extraordinary opportunities for DF/HCC scientists to undertake translational research that will reduce the cancer burden in Massachusetts.

In this document, we provide a report of local cancer rates, risk factors, and disparities to serve as a blueprint for engaging scientists, clinicians, public health officials, policy makers, and communities in Massachusetts. Through understanding the cancer burdens in Massachusetts’ populations, we seek to set priorities for our research agenda.

Together we hope to define the optimal strategies to impact all aspects of cancer control in the Commonwealth and activate partnerships to achieve broader, deeper, and faster impacts on cancer outcomes in Massachusetts.

Sincerely,

Laurie H. Glimcher, M.D.
Director, Dana-Farber/Harvard Cancer Center
President and CEO, Dana-Farber Cancer Institute
Harvard Catalyst is committed to harnessing the talent and resources dispersed across the University’s 10 schools and 16 academic healthcare centers to promote a collaborative, innovative model of clinical and translational (C/T) research. As one of approximately 60 Clinical and Translational centers across the U.S., we are dedicated to creating an environment where novel discoveries are efficiently translated to effect the greatest impact on human health.

Harvard Catalyst’s mission is twofold. First, we are committed to training and sustaining the next generations of C/T researchers and leaders across all disciplines and institutions. Second, we’re committed to “One Harvard.” When opportunities arise to translate innovations from the laboratory, bedside, or community, Harvard Catalyst convenes teams of multidisciplinary, cross-institutional investigators, forges connections, and then leverages Harvard Catalyst resources to catalyze success. Harvard Catalyst has also been a national leader in developing transformative approaches and infrastructure to improve collaboration and education. These include SMART IRB, Accrual to Clinical Trials, and N-Lighten Network.

We’re proud to partner on this effort with the DF/HCC as we collaborate to train the next generation of clinical and translational cancer investigators. We will leverage Harvard Catalyst’s wide reach to bring innovation from across Harvard to the Cancer Center. Through collaboration across disciplines, the three Massachusetts Clinical and Translational Science Centers, and our communities across the state, we will work together to address the important findings from this report.

We see this as the beginning of a new, collaborative effort to provide policymakers, clinicians, advocates, and patient/family support groups with a comprehensive overview of cancer in Massachusetts, and we will seek their guidance and expertise as we navigate the most effective path forward.

Sincerely,

Lee M. Nadler, M.D.
Virginia and D. K. Ludwig Professor for Cancer Research and Teaching
Dean for Clinical and Translational Research
Principal Investigator, Harvard Catalyst
Harvard Medical School

WHAT IS HARVARD CATALYST?

Established in 2008, Harvard Catalyst is the Clinical and Translational Science Center at Harvard, and is dedicated to improving human health by enabling collaboration and providing tools, training, and technologies to clinical and translational investigators.

Harvard Catalyst is funded by the National Institutes of Health Clinical and Translational Science Awards (CTSA) Program (grant UL1 TR001102), and by contributions from Harvard University, Harvard Medical School, Harvard T.H. Chan School of Public Health, Beth Israel Deaconess Medical Center, Boston Children’s Hospital, Brigham and Women’s Hospital, Dana-Farber Cancer Institute, and Massachusetts General Hospital. This center is part of a network of approximately 60 centers across the U.S. dedicated to advancing clinical and translational research.
The Centers for Disease Control and Prevention reports that cancer kills more Massachusetts residents than heart disease, accidents, stroke, infectious disease, or diabetes. Thus, cancer requires a critical mass of researchers, public health officials, communities, and other relevant groups to address this urgent public health concern.

This report is intended to identify priority needs for cancer research in Massachusetts. This summary covers cancer risk factors, incidence, and mortality in Massachusetts, and identifies disparities by race, ethnicity, and gender. Because of these disparities, there is an unequal cancer burden across specific groups.

In presenting these issues, the goal of this report is to begin a conversation about prioritizing cancer-related research activities in the Commonwealth. Further, by understanding the needs of populations affected by disparities, the research community and its partners are better equipped to help limit the impact of cancer in these groups.
A majority of Massachusetts residents have higher levels of income and education compared to the country, and more of them are covered by health insurance than any other state. As a result, residents of Massachusetts have better health overall than most people in the U.S.

But despite these relatively positive numbers, Massachusetts’ rates of cancer incidence and mortality are higher than the U.S. overall. Within the state, cancer rates vary by race/ethnicity, gender, age, and geographic region.

The Harvard cancer community brings together research, clinical care, and community outreach to address the burden of cancer on all Massachusetts residents. This report highlights some of the work we are doing to improve the health of Massachusetts residents by:

- Assessing cancer’s effects on our population and identifying priorities for action
- Engaging with communities and partners to address cancer in Massachusetts
- Researching and discovering the best approaches to reducing the effects of cancer
CANCER BURDEN  The number of cancer deaths and newly diagnosed cancers in a population is one measure of cancer burden. But the true burden of cancer goes beyond statistics. Cancer affects people in many ways:

- Financially (having trouble paying bills, skipping medication to save money)
- Emotionally (depression, anxiety)
- Long-term health effects (subsequent cancers, chronic diseases)
- Effects on parents, children, families, caretakers, and others around the person who has/had cancer
In 2018, more than 37,000 Massachusetts residents will be diagnosed with cancer and 12,620 people will die of cancer (American Cancer Society estimate).
INCIDENCE

As the graphic above shows, Massachusetts residents have a higher incidence rate than the U.S. overall for some cancers, while many common cancers in Massachusetts have a similar or lower incidence than the national rate.

INCIDENCE AND MORTALITY:
NEW CASES OF CANCER AND CANCER DEATHS IN MASSACHUSETTS, 2010–2014

MORTALITY

The number of cancer deaths per 100,000 people in the population. Mortality statistics provide important information about the need for treatment services and survivorship resources.

As the graphic above shows, Massachusetts residents have a higher incidence rate than the U.S. overall for some cancers, while many common cancers in Massachusetts have a similar or lower incidence than the national rate.

Higher rates of these new cancer cases in Massachusetts compared to the U.S.
represent priority targets for prevention and early detection, including:

- Brain
- Breast
- Esophagus
- Lung and bronchus
- Thyroid
- Urinary bladder
- Uterine corpus

**MORTALITY**

Most common cancers in Massachusetts have a similar or lower mortality rate than that of the U.S. overall. The Centers for Disease Control and Prevention estimates that Massachusetts had one of the lowest cancer death rates among U.S. states in 2014. However, Massachusetts residents have a higher mortality rate for the following cancers:

- Esophagus
- Liver and hepatic bile duct
- Urinary bladder

These cancers represent high-priority targets for prevention, early detection, and treatment.

**TRENDS IN INCIDENCE AND MORTALITY**

In recent decades, the number of cancer diagnoses and deaths has declined both in Massachusetts and throughout the U.S. This improvement is due, in part, to research advances in prevention, early detection, and treatment.

However, some cancers are increasing in incidence and/or mortality. To anticipate future needs in Massachusetts, it is important to recognize which cancers may be on the rise. Armed with this vital information, the research community can prioritize our efforts and mobilize outreach to strive to save as many lives as possible.

**LOCATION**

Cancer rates in Massachusetts vary by geographic location, as some parts of the state have a higher burden of cancer than others.

Compared to the U.S. overall:

- Eastern Massachusetts generally has higher cancer incidence rates
- Western Massachusetts generally has lower cancer incidence rates

Cancer death rates are highest in Sussex and Hampden Counties, with substantially elevated rates in Plymouth and Bristol Counties.

This information suggests that cancer control strategies in Massachusetts need to target areas of the Commonwealth that have higher rates.
CANCER INCIDENCE IN MASSACHUSETTS, 2010–2014, FOR ALL RACES (INCLUDING HISPANIC), ALL AGES, AND BOTH SEXES

AGE-ADJUSTED ANNUAL INCIDENCE RATE (CASES PER 100,000)

- 401.9 to 436.5
- >436.5 to 462.3
- >462.3 to 477.9
- >477.9 to 485.4
- >485.4 to 523.8

LOWEST RATE

HIGHEST RATE

CANCER MORTALITY IN MASSACHUSETTS, 2010–2014, FOR ALL RACES (INCLUDING HISPANIC), ALL AGES, AND BOTH SEXES

AGE-ADJUSTED ANNUAL DEATH RATE (CASES PER 100,000)

- 148.8 to 154.6
- >154.6 to 157.3
- >157.3 to 168.8
- >168.8 to 171.4
- >171.4 to 176.7

LOWEST RATE

HIGHEST RATE
The burden of cancer does not fall equally on all communities. Increased risk of cancer can be due to:
• Exposure to environmental toxins
• Genetic susceptibilities
• Inadequate access to cancer screening or care
• Unhealthy work or living conditions

If these risk factors are more common in some groups, disparities in cancer incidence or mortality may result. Disparities in cancer often affect the most vulnerable in our society.

**INCIDENCE BY RACE/ETHNICITY**

To address cancer disparities among specific race/ethnic groups, prevention and screening are essential. Among the consistently identified priorities for cancer control in Massachusetts are the high rates of many cancers in Black men and women, and high rates of liver cancer across many populations. However, each population defined by race/ethnicity experiences important cancer issues in Massachusetts.

**MEN**

As in the U.S. overall, the leading cancers in men in Massachusetts are prostate, lung, and colorectal cancer.
• Black and Hispanic men have substantially higher rates of prostate cancer than other groups.
• Black men also have an elevated incidence of colorectal cancer than other groups.
• White non-Hispanic men have higher rates of bladder and melanoma skin cancer than U.S. men as a whole.
Liver cancer is one of the top-five cancers in non-White men in Massachusetts, and liver cancer rates are substantially higher among men in Massachusetts than in U.S. men overall or among White non-Hispanic men in the state.

**WOMEN**
The leading cancers in Massachusetts women of all races/ethnicities are the same cancers affecting women overall in the U.S.:
- Breast
- Lung and bronchus
- Colorectal
- Uterine corpus
- Thyroid

However, there is substantial variability by race/ethnicity in these rates that defines important cancer health disparities in Massachusetts:
- White non-Hispanic women in Massachusetts have higher rates of breast, lung, and uterine cancers than women in the U.S.
- Black women in Massachusetts have elevated colorectal cancer rates than women of other races or in the U.S. overall.
- Women of all race/ethnic groups in Massachusetts have elevated thyroid cancer rates compared to the U.S. overall, with White non-Hispanic women having the highest rates in the Commonwealth.

Massachusetts was ranked the healthiest U.S. state in 2017. The state has extremely favorable cancer risk profiles and lower-than-average cancer death rates among U.S. states. However, Massachusetts has one of the poorest records for disparity in health status, ranking 41 out of 50. —Source: United Health Foundation, 2017
MORTALITY BY RACE/ETHNICITY

MEN
In Massachusetts, Black men have elevated rates of death from prostate and pancreatic cancer compared with men of other race/ethnic groups or U.S. men overall. While liver cancer is not one of the five most common causes of cancer death in White non-Hispanic men, liver cancer is substantially elevated in Black, Asian/Pacific Islander, and Hispanic men in Massachusetts.

WOMEN
White non-Hispanic women have an elevated rate of lung cancer mortality compared with other race/ethnic groups in Massachusetts and U.S. women overall. Black non-Hispanic women have elevated rates of colorectal, pancreatic, and uterine cancer death compared with all other groups. Finally, Asian/Pacific Islander and Hispanic women have increased liver cancer death rates compared to U.S. women overall.

AGE
The majority of cancers occur later in life, so it is critical to consider the aging of the population when planning for cancer control in the future. Massachusetts is a diverse state with respect to age. While the proportion of Massachusetts residents over age 65 (15%) is identical to that of the U.S., there is substantial variability in the proportion of people older than 65 across the state:
• City of Boston: 10.8%
• Barnstable County: 27.1%
• Berkshire County: 20.2%
• Dukes County: 19.0%

PROSTATE CANCER RISK AND QUALITY OF LIFE IN AFRICAN-AMERICAN MEN
AFRICAN-AMERICAN MEN WHO are newly diagnosed with localized prostate cancer are often faced with difficult treatment decisions, because there is no consensus among experts about how to manage the disease for this population. Studies have identified significant differences in clinical presentation and health-related quality of life between African-American and White men.

Understanding the potential outcomes of different treatment options for African-American men is critical for making treatment decisions and providing optimal care. However, data specific to African-American men are very limited.

To address the elevated risk and poorer outcomes in African-American men with a prostate cancer diagnosis, Dr. Anthony D’Amico is developing race-specific models of prostate cancer risk to help improve quality of life in African-American men who are diagnosed with prostate cancer.

Dr. D’Amico is a collaborator on a Health Disparity Research Award funded by the Department of Defense. The major objectives of this study are to:

• Collect comprehensive data for the entire prostate cancer course and for health-related quality of life at different stages of prostate cancer among African-Americans

• Develop the first calculator to provide individualized risk estimates for African-Americans

The goal of this research is help predict cancer events based on patients’ race, tumor characteristics, and health status. These new tools will help inform patients’ treatment decisions. They will also allow physicians to tailor disease management to African-American patients and identify patients who are likely to benefit from timely intervention, which will ultimately improve prostate cancer outcomes and quality of life among African-American patients.
DF/HCC HAS PARTNERED with the University of Massachusetts, Boston (UMass Boston) for nearly 15 years in a joint research collaboration addressing issues of cancer disparities in Massachusetts residents.

This partnership, which is led by Drs. Jill Macoska and Adán Colón-Carmona at UMass Boston and Dr. Vish Vishwanath at Dana-Farber Cancer Institute, is supported by the National Cancer Institute’s Center to Reduce Cancer Health Disparities through its Comprehensive Partnership to Advance Cancer Health Equity Program.

The DF/HCC–UMass Boston Partnership’s programs aim to improve research, training, and outreach opportunities for under-represented minority students, fellows, and scientists, and to develop information and resources toward closing the cancer disparities gap. Its programs encompass basic and population science research, student and investigator training, and community outreach.

To date, this partnership has funded 29 collaborative pilot and full projects, which have resulted in 130 publications and $36 million in external funding.

The DF/HCC–UMass Boston Partnership also has created a dedicated set of opportunities for UMass Boston trainees who seek careers in the biomedical field. More than 180 minority UMass Boston students have participated in this career-enabling program to date, and $15 million in new training grants has been secured.

Reflecting the success and the ongoing promise of this relationship, DF/HCC and UMass Boston successfully obtained a joint $10 million award from the Commonwealth of Massachusetts to fund a Center for Personalized Cancer Therapy (CPCT).
The Commonwealth of Massachusetts is home to a wide variety of communities and stakeholders who have an interest in reducing the burden of cancer in the population.

Countless communities thrive within Massachusetts’ 39 cities and 312 towns. Each one is complex and organic, faced with its own concerns and challenges and enriched by its own intrinsic strengths and resources.

Engaging communities is essential to ensuring that efforts to reduce the cancer burden are relevant and effective. We achieve this by forming and sustaining partnerships in which we listen to, learn from, and combine forces with diverse communities across the state, such as:

**MEMBER- AND DISEASE-BASED COMMUNITIES** of people and groups who have specific health-related needs, are medically under-served, or lack adequate healthcare access. These communities may be based on identity—racial, ethnic, or sexual/gender, for example—or they may be patient-powered networks that focus on specific health conditions.

**ACTIVITY-SPECIFIC COMMUNITIES** such as governmental and policy-making groups, professional societies, industry, nonprofit/non-governmental organizations, healthcare providers and networks, and academic institutions.

**GEOGRAPHICALLY DEFINED COMMUNITIES**—neighborhood, regional, and others—in which people live or work, and where they may be affected by adverse conditions, such as environmental challenges or limited healthcare access.
THE MASSACHUSETTS GENERAL Hospital (MGH) Breast Care Programs, funded by the Avon and Komen Foundations, reach out to medically underserved patients to provide breast health education, increase breast cancer screening, promote timely follow-up of abnormal clinical or mammography findings, and ensure early detection and comprehensive treatment for patients with breast cancer.

Since 2001, the Avon Breast Care Program has worked to ensure that women who have abnormal mammogram findings receive appropriate and timely diagnostic follow-up and care to improve their health outcomes.

There are five program sites: MGH Chelsea HealthCare Center, Mattapan Community Health Center, Geiger Gibson Community Health Center, Neponset Health Center, and Mid-Upper Cape Community Health Center.

The Komen Breast Care Program was established in 2008 to improve breast cancer screening in women refugees and immigrants from the former Yugoslavia, Somalia, and the Middle East who receive care at MGH Chelsea and/or reside in surrounding communities. Thousands of patients have benefited from these activities since the program’s initiation.

These Breast Care Programs:
- Assist with patient scheduling
- Help patients keep their appointments by providing reminder calls and accompanying patients when needed
- Facilitate communication between patients and their healthcare providers
- Assess and address individual barriers to care (e.g., limited English language skills; inadequate health insurance coverage; difficulties with transportation, child care, elder care, or work-related issues; cultural constraints; and unfamiliarity with the healthcare system) through improved communication with patients and by conducting home visits whenever necessary
- Provide emotional support
- Connect breast cancer patients in treatment to available resources and ensure efficient utilization of these resources
- Educate patients and the community on breast health and promote breast cancer awareness

HELPING BREAST CANCER PATIENTS NAVIGATE CANCER CARE

Photo © 2018 Danielle Coller/Massachusetts General Hospital—Center for Community Health Improvement
DANA-FARBER/HARVARD CANCER Center (DF/HCC) created the Initiative to Eliminate Cancer Disparities (IECD) in 2007 to maximize the acceptance and improve the perception of cancer research within and among communities that have historically experienced significant disparities of cancer care.

IECD focuses on four key programmatic areas:
- Community engagement
- Minority student training, recruitment, and faculty development in cancer-related science and its clinical application
- Increasing minority enrollment in cancer clinical trials
- Enhancing cultural competency throughout DF/HCC institutions and membership

The IECD partners with the Faith-Based Cancer Disparities Network to identify and address health-related concerns most relevant to their congregations. In 2016, the Health Ministry Assessment tool completed by the network churches identified several cancer-related topics of interest, including breast cancer, prostate cancer, nutrition, stress management, and physical activity, and created programming to address these areas.

The Patient Navigation Network (PNN) is a consortium of patient navigators and community health workers across Boston who help patients navigate cancer diagnoses. Navigators are empowered through education, including the sharing of best practices, resource information, and research trends, which allows them to better support the broader community of oncology navigators.

In 2016, the PNN was instrumental in providing data for a U01 grant submission, Translating Research into Practice, which was funded for implementation across six healthcare systems. Principal investigators from four Massachusetts Clinical and Translational Science Awards hubs (Boston University, Harvard University, Tufts University, and University of Massachusetts) partnered with the Boston Breast Cancer Equity Coalition to overcome barriers to widespread implementation and dissemination of evidence-based practices. These practices will improve the delivery of guideline-concordant care to vulnerable women. The members of the PNN will develop, test, and validate a coordinated and integrated model of patient navigation that will impact clinical outcomes for vulnerable breast cancer patients.

Creating and fostering pipeline programs to support the engagement and education of under-represented students interested in cancer-related research has been a centerpiece of the IECD. Since the program’s inception 17 years ago, IECD has placed almost 400 students in 221 research environments across basic, clinical, nursing, and population science. Science education training programming supports the next generation of cancer researchers from vulnerable populations who recognize the importance and added value that cultural diversity in research lends toward decreasing the unequal burden of cancer.
A person diagnosed with cancer often asks what may have caused the cancer to develop.

Usually there is not a clear explanation for the cause of a cancer in an individual, but Harvard cancer researchers are working to understand what causes cancer. This endeavor is particularly important if we can identify factors that, if modified, can help reduce cancer risk.

Many risk factors are known to cause specific cancers, including:
- Lifestyle factors like smoking, alcohol consumption, nutrition, and physical activity. Reducing these risk factors in the population is a major public health goal.
- Biological factors, including genetics. While an individual’s genes cannot be modified, genetic information helps identify at-risk individuals and may guide their screening or treatment choices.

MASSACHUSETTS HAS the fifth lowest rate of smoking and the second lowest obesity rate among all U.S. states.

—Source: United Health Foundation, 2017
An understanding of the factors that cause cancer can lead to interventions that reduce risk and improve outcomes. This information is valuable because it allows healthcare resources to be directed to those in greatest need (e.g., those who are identified as being at increased cancer risk), providing opportunities for individuals to take concrete steps to address their cancer needs and concerns.

A few major risk factors account for a large proportion of avoidable or modifiable cancer risks: tobacco use, obesity, diet, and physical inactivity. These factors are not only associated with cancer risk, but also with other diseases, such as heart disease and diabetes.

**RISK FACTORS IN MASSACHUSETTS**

Massachusetts residents have unique patterns of exposure to cancer risk factors. Understanding these patterns may allow us to better address cancer risk in our population. Across the board, Massachusetts residents have more favorable cancer risk-factor profiles than residents in the U.S. overall. Despite this, it is clear that the prevalence of cancer risk factors is still too high and needs to be lowered for better cancer outcomes in the Commonwealth.

**TOBACCO**

Tobacco exposures are a leading cause of preventable cancers, and tobacco use accounts for 30% of all cancer deaths. Exposures associated with tobacco-related cancer risk include:

- Cigarette and cigar smoking
- Secondhand smoke (breathing in smoke while not smoking yourself)
- Smokeless tobacco products, such as chewing tobacco or snuff

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**SMOKING RISK FACTORS AND PROTECTIONS**

<table>
<thead>
<tr>
<th>Description</th>
<th>MASS. 14.0%</th>
<th>U.S. 16.7%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current smoker (age 18+), 2015</td>
<td>14.0%</td>
<td>16.7%</td>
</tr>
<tr>
<td>Percent of people who answered that no one is allowed to smoke inside their home, 2014-2015</td>
<td>89.0%</td>
<td>86.5%</td>
</tr>
<tr>
<td>Percent of population with 100% smokefree workplace, Restaurant and Bar Laws, 2017</td>
<td>100%</td>
<td>58.0%</td>
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</table>
• E-cigarettes (also called “electronic nicotine delivery systems,” or ENDS), emerged as an alternative to cigarette smoking, but there is mounting evidence that the toxic and carcinogenic chemicals they contain are still associated with cancer risk (the long-term health risks of e-cigarettes remain unknown)

Cancers associated with tobacco use include:
• Bladder
• Cervix
• Colorectal
• Esophagus
• Kidney
• Larynx
• Lung
• Myeloid leukemia
• Oral cavity and pharynx
• Pancreas
• Stomach

GEOGRAPHIC VARIABILITY IN SMOKING ACROSS MASSACHUSETTS
In addition to risk-factor patterns statewide, there is variability across the Commonwealth that may identify areas that could be targeted for specific public health interventions. For example, rates of smoking are highest in Plymouth and Bristol Counties, while smoking rates are substantially lower in Hampshire, Norfolk, and Nantucket Counties. Thus, an understanding of the high rates of smoking in Plymouth and Bristol Counties may aid in developing interventions in these counties to reduce cigarette smoking.

OBESITY
Obesity is a rapidly increasing public health concern in the U.S. and has important implications for many health conditions, including cancer. A variety of cancers have been associated with elevated body mass index, a measure of obesity. Possible mechanisms of obesity-related cancer include low-level inflammation leading to DNA damage, production of estrogen and other hormones by fat cells that may fuel cancer cells, and increased levels of growth factors and other cellular growth regulators in obese individuals.

The association of diet and nutrition with cancer is complex and has evolved over time as better research studies and methods have been developed. Based on a review of the accumulated literature, the 2015-2020 Dietary Guidelines for Americans (health.gov/dietaryguidelines/2015/guidelines/) has developed key recommendations for healthy eating patterns that have the potential to minimize cancer risk, as well as other health outcomes.

A healthy lifestyle that includes balanced nutrition and adequate physical activity is among the best ways to maintain overall health, as well as lower cancer risk.

Cancers associated with obesity include:
• Breast (postmenopausal women)
• Colorectal
• Esophagus
• Gallbladder
• Stomach
• Kidney
• Liver
• Meningioma
• Multiple myeloma
• Ovary
• Pancreas
• Thyroid
• Uterine

<table>
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<tr>
<th>OBESITY RISK FACTORS AND PROTECTIONS, 2015</th>
<th>MASS.</th>
<th>U.S.</th>
</tr>
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<tbody>
<tr>
<td>Consumed one or more servings of fruit per day</td>
<td>66.0%</td>
<td>59.7%</td>
</tr>
<tr>
<td>Consumed one or more servings of vegetables per day</td>
<td>81.7%</td>
<td>77.9%</td>
</tr>
<tr>
<td>Healthy weight (Body Mass Index 18.5-25, age 20+)</td>
<td>37.0%</td>
<td>32.6%</td>
</tr>
<tr>
<td>Obese (Body Mass Index &gt;30, age 20+)</td>
<td>24.9%</td>
<td>29.5%</td>
</tr>
<tr>
<td>No leisure time physical activity (age 18+)</td>
<td>26.5%</td>
<td>26.1%</td>
</tr>
</tbody>
</table>
THE MAJORITY OF epidemiological studies on risk factors and cancers have focused on exposures in mid- to late life, thus etiologically relevant time periods may have been missed. Early-life exposures are likely to be critical because of the long subsequent lifetime at risk and because of enhanced susceptibility.

Supported by an investigator-initiated grant from the American Institute for Cancer Research, Harvard investigators developed and conducted novel projects to address the lack of data in this area.

ALCOHOL
Alcohol consumption is strongly associated with some cancers, perhaps because of the DNA damage that alcohol can cause. Cancers associated with alcohol exposure include:
- Breast (women)
- Colorectal
- Esophagus
- Larynx
- Liver
- Mouth
- Pancreas
- Pharynx
- Stomach

and study the role of early-life dietary and lifestyle factors in the development of colorectal adenomas, which are established precursors for colorectal cancers.

The investigators found that comparing women who were overweight to women who were most lean was associated with a 44% increase in colorectal adenomas. Adherence to a “Western” diet pattern (characterized by high intakes of red meat, processed meat, sugar-sweetened beverages, refined grains, desserts, and potatoes) during high school was significantly associated with colorectal and advanced adenomas later in life.

With funding from the National Cancer Institute, the investigators also found that, independent of adult intake, higher dairy intake during adolescence was associated with lower risk of advanced colorectal adenoma.

If confirmed, these projects can help to determine whether to shift the focus of some interventions from mid- to late adulthood to earlier stages of life, and help guide cancer prevention counseling.
THE HARVARD CANCER epidemiology cohorts have developed innovative approaches that have become a standard for the conduct of cancer research across the world.

In the 1970s, Dr. Frank Speizer launched the Nurses’ Health Study (NHS) cohort, enrolling 121,700 female nurses from 11 states. Follow-up was conducted by questionnaires mailed every two years. This same approach was used for the Health Professionals Follow-up Study (HPFS), which enrolled 51,529 men in 1986. The Nurses’ Health Study II (NHSII) began in 1989 with 116,430 additional women. Sons and daughters of NHS and NHSII participants were enrolled in the Growing Up Today Study, which was initiated in 1996. The Nurses’ Health Study 3 (NHS3) uses a rolling admission and currently has 43,000 participants.

In addition to dietary and activity assessments, the cohorts have evaluated hormone use, UV radiation, psychosocial measures, anti-inflammatory medications, and new pharmaceuticals, such as statins. More recently, subjects have been geocoded, which provides data on environmental exposures nationwide.

Outcomes that are followed include almost all cancer sites, colorectal adenoma, benign prostatic hyperplasia, Barrett’s esophagus, and benign breast disease. The incorporation of biomarkers into the cohorts has expanded the scope enormously; these now include toenails, plasma, red cells, buffy coat, cheek cells (for DNA), and urine.

Groundbreaking knowledge generated by the Harvard cohorts has identified cancer risk factors, including:

- Smoking and increased risk of colorectal and pancreatic cancer
- Physical activity and decreased risk of breast, colorectal, and prostate cancer
- Obesity and increased risk for numerous cancers
- Oral contraceptive use and higher risk of melanoma and breast cancer, but lower risk of ovarian cancer
- Hormone therapy and higher risks of breast and endometrial cancer
- Endogenous hormones and breast cancer
- Dietary factors and breast and pancreatic cancer
- Shift work, sleep duration, night light, and cancer
Many effective cancer prevention and early detection strategies exist. Recommendations on preventing cancer vary, depending on the organization that has reviewed the current data. For example, current recommendations by the American Cancer Society are based on a strong foundation of research and implementation in the general community, although they do change from time to time as new data become available. For some individuals, such as those with a genetic predisposition, screening recommendations may differ.

Goals of cancer prevention and early detection include reducing (or eliminating) the risk of cancer and finding cancers at an early stage to limit mortality.

Despite these recommendations, not all individuals in the population who may benefit take advantage of the opportunity to lower their cancer risks or detect their cancers early. In Massachusetts, more individuals take advantage of screening than in the U.S. overall. Nonetheless, the proportion of individuals who do not take advantage of these prevention and screening recommendations remains too high.
As with cancer rates, the use of prevention and early detection can also vary by geography. This variability may be related to access to information or to a clinical practice that promotes screening.

Rates of colorectal cancer screening in Massachusetts vary from lower rates in Berkshire, Bristol, and Nantucket Counties to much higher rates in Norfolk and Barnstable Counties. Similarly, mammography use is generally lower in western Massachusetts, while higher in southeastern and northeastern Massachusetts.

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**MASSACHUSETTS HAS ONE** of the highest rates of colorectal cancer screening in the U.S.
—*Source: United Health Foundation, 2017*

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**USE OF COLONOSCOPY/SIGMOIDOSCOPY IN MASSACHUSETTS FOR COLORECTAL CANCER EARLY DETECTION, 2010–2014, ALL RACES (INCLUDING HISPANIC), BOTH SEXES, AGES 50+**

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**CANCER PREVENTION AND SCREENING**

<table>
<thead>
<tr>
<th>Mass.</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever had a sigmoidoscopy or colonoscopy to detect colorectal cancer (age 50+), 2014</td>
<td>77.9%</td>
</tr>
<tr>
<td>Fecal occult blood test in the past year or fecal occult blood test in the last 3 years and/or colonoscopy in the last 10 years (age 50+), 2014</td>
<td>76.5%</td>
</tr>
<tr>
<td>Mammogram in the past 2 years (age 40+), 2014</td>
<td>82.1%</td>
</tr>
<tr>
<td>Mammogram in the past 2 years (ages 50–74), 2014</td>
<td>88.1%</td>
</tr>
<tr>
<td>Pap smear in the past 3 years (no hysterectomy, ages 21–65), 2014</td>
<td>88.0%</td>
</tr>
<tr>
<td>Received 3+ doses of HPV vaccine (females ages 13–17), 2015</td>
<td>52.8%</td>
</tr>
<tr>
<td>Received 3+ doses of HPV vaccine (males ages 13–17), 2015</td>
<td>35.2%</td>
</tr>
</tbody>
</table>
PANCREATIC CANCER IS THE third leading cause of cancer death in Massachusetts. More than 80% of patients present with incurable disease, and the vast majority live less than one year.

The high mortality of pancreatic ductal adenocarcinoma (PDAC), the most common form of pancreatic cancer, is largely because diagnosis occurs at an advanced stage, when it is not possible to remove the tumor through surgery. Symptoms rarely appear at earlier stages, and established risk factors for PDAC, such as smoking, obesity, chronic pancreatitis, diabetes, and family history of PDAC, are insufficient to identify people who might benefit from screening.

Experimental studies indicate that more than a decade elapses from the initiation of the tumor to a patient’s diagnosis, suggesting a window of opportunity for early detection.

To address the critical goal of PDAC early detection, Dr. Brian Wolpin formed the Pancreatic Cancer Circulating Biomarker (Pan-C2-Bio) Consortium. The Consortium has three primary goals:

- Generation of a large, unified, thoroughly annotated human and murine sample bank for testing of early detection markers
- Definitive evaluation of four highly promising PDAC early detection markers for near-term clinical utility, including circulating cell-free DNA mutations and methylation patterns, cancer-derived exosomes, and metabolism markers
- Identification of biomarker-based screening strategies to facilitate early cancer diagnosis in high-risk groups and the general population

The work of the Pan-C2-Bio Consortium is delivering much-needed biospecimen resources for early detection studies, providing evidence for (or against) the utility of highly promising PDAC early detection technologies, and demonstrating how new biomarkers can be integrated with previously characterized risk factors to identify individuals for disease screening.
Harvard is one of the world leaders in developing new cancer treatments. This groundbreaking research has changed the face of cancer treatment.

Between 2012-2017, Massachusetts had the second largest decrease in cancer deaths of any U.S. state. —Source: United Health Foundation, 2017

Between 2011 and 2015, more than 1,100 new cancer clinical trials opened in the Harvard system. Paradigm-changing discoveries at Harvard include new approaches to immunotherapy and personalized medicine that provide hope to many Massachusetts residents with a cancer diagnosis.

Harvard scientists provided significant leadership in preclinical discovery, clinical development, or definitive clinical testing for 41 of the 100 new cancer drugs that gained FDA approval in 2011-2017.
<table>
<thead>
<tr>
<th>YEAR APPROVED</th>
<th>DRUG</th>
<th>FOR THE TREATMENT OF</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>Rydapt (midostaurin)</td>
<td>FTL3+ acute myeloid leukemia and mastocytosis</td>
</tr>
<tr>
<td>2017</td>
<td>Nerlynx (neratinib)</td>
<td>HER2+ breast cancer</td>
</tr>
<tr>
<td>2017</td>
<td>IDHIFA (enasidenib)</td>
<td>relapsed or refractory acute myeloid leukemia with IDH2 mutation</td>
</tr>
<tr>
<td>2017</td>
<td>Alunbrig (brigatinib)</td>
<td>advanced ALK+ metastatic non-small cell lung cancer</td>
</tr>
<tr>
<td>2017</td>
<td>Xermelo (telotristat ethyl)</td>
<td>carcinoid syndrome diarrhea</td>
</tr>
<tr>
<td>2017</td>
<td>Vyxeos (daunorubicin and cytarabine)</td>
<td>newly diagnosed therapy-related acute myeloid leukemia (AML) or AML with myelodysplasia changes</td>
</tr>
<tr>
<td>2017</td>
<td>Kisqali (ribociclib)</td>
<td>breast cancer</td>
</tr>
<tr>
<td>2017</td>
<td>Besponsa (inotuzumab ozogamicin)</td>
<td>relapsed or refractory B-cell precursor acute lymphoblastic leukemia</td>
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<tr>
<td>2017</td>
<td>Zejula (niraparib)</td>
<td>recurrent epithelial ovarian, fallopian tube, or primary peritoneal cancer</td>
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<tr>
<td>2017</td>
<td>Verzenio (abemaciclib)</td>
<td>HR+, HER2- breast cancer</td>
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<tr>
<td>2016</td>
<td>Venclexta (venetoclax)</td>
<td>chronic lymphocytic leukemia with 17p deletion</td>
</tr>
<tr>
<td>2016</td>
<td>Opdivo (nivolumab)</td>
<td>classical Hodgkin lymphoma</td>
</tr>
<tr>
<td>2016</td>
<td>Cabometyx (cabozantinib)</td>
<td>advanced renal cell carcinoma</td>
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<tr>
<td>2016</td>
<td>Keytruda (pembrolizumab)</td>
<td>head and neck squamous cell cancer</td>
</tr>
<tr>
<td>2016</td>
<td>Rubraca (rucaparib)</td>
<td>advanced ovarian cancer in women with deleterious germline or somatic BRCA mutation</td>
</tr>
<tr>
<td>2015</td>
<td>Yondelis (trabectedin)</td>
<td>liposarcoma or leiomyosarcoma</td>
</tr>
<tr>
<td>2015</td>
<td>Tagrisso (osimertinib)</td>
<td>EGFR T790M mutation positive non-small cell lung cancer</td>
</tr>
<tr>
<td>2015</td>
<td>Lenvima (lenvatinib)</td>
<td>thyroid cancer</td>
</tr>
<tr>
<td>2015</td>
<td>Farydak (panobinostat)</td>
<td>multiple myeloma</td>
</tr>
<tr>
<td>2015</td>
<td>Darzalex (daratumumab)</td>
<td>multiple myeloma</td>
</tr>
<tr>
<td>2015</td>
<td>Empliciti (elotuzumab)</td>
<td>patients with multiple myeloma who have received prior therapies</td>
</tr>
<tr>
<td>2015</td>
<td>Alecensa (alectinib)</td>
<td>ALK+ metastatic non-small cell lung cancer</td>
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<tr>
<td>2014</td>
<td>Imbruvica (ibrutinib)</td>
<td>chronic lymphocytic leukemia and Waldenstrom macroglobulinemia</td>
</tr>
<tr>
<td>2014</td>
<td>Zykadia (ceritinib)</td>
<td>ALK+ metastatic non-small cell lung cancer</td>
</tr>
<tr>
<td>2014</td>
<td>Opdivo (nivolumab)</td>
<td>unresectable or metastatic melanoma</td>
</tr>
<tr>
<td>2014</td>
<td>Lynparza (olaparib)</td>
<td>previously treated BRCA mutated advanced ovarian cancer</td>
</tr>
<tr>
<td>2014</td>
<td>Cyramza (ramucirumab)</td>
<td>gastric cancer</td>
</tr>
<tr>
<td>2013</td>
<td>Xgeva (denosumab)</td>
<td>giant cell tumor of bone</td>
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</tbody>
</table>
IMMUNOTHERAPY IS A MEANS of treating cancer by using the body’s natural defenses. Cancer immunotherapy uses approaches that improve or restore immune system function.

Immunotherapy has become a central tool in the cancer treatment toolkit, and Harvard researchers have been key in the development of these treatments.

CANCER IMMUNOTHERAPY

YEAR APPROVED | DRUG | FOR THE TREATMENT OF
--- | --- | ---
2013 | Tafinlar (dabrafenib) | unresectable or metastatic melanoma with BRAF V600E mutation
2013 | Stivarga (regorafenib) | gastrointestinal stromal tumor
2013 | Revlimid (lenalidomide) | mantle cell lymphoma
2013 | Pomalyst (pomalidomide) | relapsed and refractory multiple myeloma
2013 | Mekinist (trametinib) | unresectable or metastatic melanoma with BRAF V600E or V600K mutations
2013 | Gilotrif (afatinib) | metastatic non-small cell lung cancer with EGFR mutations
2012 | Votrient (pazopanib) | soft tissue sarcoma
2012 | Inlyta (axitinib) | advanced renal cell carcinoma
2011 | Zytiga (abiraterone acetate) | prostate cancer
2011 | Zelboraf (vemurafenib) | BRAF+ melanoma
2011 | Yervoy (ipilimumab) | metastatic melanoma
2011 | Xalkori (crizotinib) | ALK+ non-small cell lung cancer
2011 | Sutent (sunitinib malate) | pancreatic neuroendocrine tumors

Center Watch. “FDA Approved Drugs for Oncology.” www.centerwatch.com/drug-information/fda-approved-drugs/therapeutic-area/12/oncology

Approvals are included on this list when DF/HCC scientists made the following contributions:
1. Significant preclinical involvement, including discovery, validation, and/or extensive testing that informed the translational and/or clinical development; or
2. Major involvement in the design and conduct of early phase testing (phase I/ Ib/II) that ultimately supported the clinical development; or
3. Major involvement in the design and conduct of the definitive clinical testing that led to FDA approval

A landmark study led by Dr. Steven Hodi in 2010 demonstrated that a subgroup of patients (~20%) treated with the drug Ipilimumab survived for five years compared to less than 10% in the placebo group.

This was a very important study because it demonstrated that immunotherapy can result in durable responses in patients with an advanced cancer. Also, this was the first study to demonstrate effectiveness of a drug in patients with advanced melanoma.

Ipilimumab became the first cancer immunotherapy drug to be approved by the FDA.
THE LEONARD P. ZAKIM CENTER for Integrative Therapies and Healthy Living at Dana-Farber Cancer Institute is dedicated to enhancing quality of life for cancer patients and their families by incorporating integrative therapies into traditional cancer care.

Through clinical services, education, and group programs led by physicians, therapists, nurses, and other healthcare professionals, the Center empowers patients to be active participants in their treatment plans. This integrative cancer care can help patients feel better by reducing the pain, stress, and anxiety caused by cancer and its treatment.

The Zakim Center also seeks to build knowledge about the effectiveness of these therapies through peer-reviewed, evidence-based research.

Research has shown that, when used in conjunction with traditional cancer care, integrative therapies can help ease cancer-related symptoms and improve quality of life. These therapies range from individual treatments, such as acupuncture, massage, and Reiki, to group programs for movement, meditation, and creative arts, as well as exercise and nutritional consultations.
The American Cancer Society estimates that in 2016 there were more than 15.5 million cancer survivors in the U.S. More than 400,000 of them live in Massachusetts. By 2026, there are predicted to be over 20 million cancer survivors in the U.S.

The vast majority of these survivors are over the age of 50, with a substantial proportion over the age of 70. Thus, many survivors contend not only with the challenges of aging, but also with the effects of their cancer and its treatment.

The impressive improvements in cancer treatment in recent years have had an important consequence: There are many more cancer survivors in the population than ever before.
On the other end of the age spectrum are more than 100,000 childhood and young adult cancer survivors in the U.S. Because many childhood cancers are highly treatable, many of these individuals will live for decades after a cancer diagnosis and may experience side effects and symptoms for many years. In particular, some survivors of childhood cancers have a substantially greater risk of developing subsequent cancers in their lifetimes.

Medical science has begun to address the needs of cancer survivors, including side effects or symptoms of the cancer or its treatment, as well as the ongoing monitoring that may be needed to identify potential cancer recurrences. Survivorship clinics are becoming more common, and research among these populations is increasing our understanding of how to manage their continued care. This care may involve management of physical and psychosocial symptoms, lifestyle (diet, physical activity, smoking cessation, etc.), and enhanced cancer screening efforts to ensure maximal health and quality of life.

Cancer survivors may experience disparities related to their clinical management as well as their psychosocial well-being. Groups that are in jeopardy of experiencing disparities as a result of their cancer diagnoses include race/ethnic groups, those who do not have adequate health or disability insurance, and those with inadequate access to health care.

Dr. Kelly Irwin has developed an innovative model of integrated psychiatry and cancer care for patients with serious mental illness to increase access and reduce cancer care disparities in this population. She is conducting the first randomized trial focused on this issue.

In 2017, Dr. Irwin and her colleagues organized a symposium, “Bridging the Divide: Mental Health and Cancer Care,” to break down the silos between cancer care and mental health care. The symposium brought together patients, families, oncologists, psychiatrists, community mental health physicians, advocates, and policy makers from 30 different institutions.
CRITICAL TO CANCER CONTROL in Massachusetts is not only the prevention of an initial cancer diagnosis, but ensuring that children who have been diagnosed with a cancer live long and healthy lives.

Improvements in treatment for childhood cancer over the past three decades have resulted in remarkable increases in survival rates, with approximately 80% of children diagnosed today expected to be cured of their primary cancer.

Despite this success, survivors of childhood cancer face very high risks for serious chronic illness and premature death as they age. These “late effects” include secondary cancers, cardiac disease, and other chronic illnesses, such as endocrine, pulmonary, and neurologic conditions.

Harvard researchers, led by Drs. Jennifer Yeh and Lisa Diller, are studying childhood cancer survivors who are at increased risk for secondary cancers due to childhood radiation exposure.

These researchers are evaluating the lifelong health consequences associated with late effects, including reduced quality of life and premature death. To address these challenges, they are developing effective, risk-tailored follow-up care for survivors of childhood cancer.

By developing a model of effective, risk-stratified follow-up care that can be applied directly to clinical care recommendations and policy, this research will contribute to long-term survival, fewer late-effects morbidity and mortality, and better quality of life for survivors of childhood cancer.
The information presented in this report is intended to identify high-priority areas for cancer research in Massachusetts.

These priorities include enhancing implementation and dissemination of optimal cancer prevention, early detection, treatment, and survivorship strategies.

It is also critical to study the cause of cancer disparities and to develop, implement, and disseminate strategies to groups affected by disparities.

The following categories summarize the priorities and areas of focus needed to address the cancer burden in Massachusetts.

The list does not imply that other areas are not of importance; all areas of cancer research should be adequately supported to optimally reduce the cancer burden in Massachusetts.

**PREVENTION AND DETECTION**

Priority cancers for prevention and early detection based on higher **INCIDENCE** rates in Massachusetts:

- **BLADDER**
- **BRAIN**
- **BREAST (FEMALE)**
- **ESOPHAGUS**
- **LUNG**
- **THYROID**
- **UTERINE CORPUS**

Priority cancers for prevention, early detection, and treatment based on higher **MORTALITY** rates in Massachusetts:

- **BLADDER**
- **ESOPHAGUS**
- **LIVER**

**INCREASING INCIDENCE AND MORTALITY**

Priority cancers with increasing **INCIDENCE** in Massachusetts:

- **BREAST**
- **ESOPHAGUS**
- **KIDNEY**
- **LIVER**
- **NON-HODGKIN LYMPHOMA**
- **ORAL**
- **PANCREAS**
- **STOMACH**
- **THYROID**

Priority cancers with increasing **MORTALITY** in Massachusetts:

- **ESOPHAGUS**
- **KIDNEY**
- **LIVER**
- **PANCREAS**
- **THYROID**
- **UTERUS**
### DISPARITIES

Priority cancers for disparities based on elevated rates of cancer in specific racial or ethnic groups in Massachusetts:

**BLACK MEN:** Prostate and colorectal cancer incidence; prostate and pancreatic cancer mortality  
**HISPANIC MEN:** Prostate cancer incidence  
**NON-HISPANIC WHITE MEN:** Bladder cancer and melanoma incidence  
**NON-WHITE MEN:** Liver cancer incidence and mortality  

**WOMEN OF ALL RACES AND ETHNICITIES:** Thyroid cancer incidence  
**ASIAN AND HISPANIC WOMEN:** Liver cancer mortality  
**BLACK WOMEN:** Colorectal cancer incidence; and colorectal, pancreatic, and uterine cancer mortality  
**NON-HISPANIC WHITE WOMEN:** Breast, lung, and uterine cancer incidence; lung cancer mortality

### RISK FACTORS

Priorities for risk-factor reduction, prevention, and early detection in Massachusetts:

**REDUCE** smoking, obesity, and alcohol consumption  
**INCREASE** healthy diet, physical activity, HPV vaccination, mammography, and colorectal cancer screening

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**Identifying high-priority areas for addressing cancer in Massachusetts will allow researchers and communities to limit the impact of this disease on Massachusetts residents.**