Epidemiology, Carcinogenesis and Prevention of Cancer

MAGGIE MOORE, MS, APRN
MT ASCUTNEY HOSPITAL/DH AFFILIATE

Objectives

Identify the three leading causes of cancer deaths world wide.
Describe the difference between primary, secondary and tertiary prevention strategies
Identify five lifestyle risk factors for the development of cancer
Develop a basic understanding of carcinogenesis
Describe the role of the oncology nurse in cancer prevention
Cancer epidemiology

Definition:
◦ The study of the factors determining and influencing the frequency and distribution of cancer in population groups.

Global Cancer Statistics

◦ Cancer is the leading cause of death worldwide accounting for 8.2 million deaths [around 13% of all deaths].
◦ The total number of cases globally is increasing
◦ The three leading cancer killers worldwide are lung (17.8% of all cancer deaths), stomach (10.4%), and liver (8.8%).
◦ According to the WHO, the following will occur;
  • Cancer rates will increase by 50% to 15 million new cases in 2020 primarily because of steadily aging population, increases in smoking and worldwide adoption of unhealthy lifestyles
  • Annual death toll from tobacco alone will climb to 10 million people in 2020, double what it is now
### Cancer rates relative to select demographic variables

**Age**
- Incidence of most cancers increases with age

**Gender**
- Cancer is more common in males than females

**Geography**
- Major incidence and mortality differences exist in different locations

**Socioeconomic status**
- Lower SES associated with increased risk of lung, cervical, stomach, head & neck cancers
- Higher SES associated with breast, prostate and colon cancer
- Economic, social and cultural factors can create barriers to accessing information and preventative services

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#### Leading Sites of New Cancer Cases and Deaths = 2016 Estimates

<table>
<thead>
<tr>
<th>Male Estimated New Cases</th>
<th>Female Estimated New Cases</th>
<th>Male Estimated Deaths</th>
<th>Female Estimated Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prostate 180,890 (21%)</td>
<td>Breast 246,660 (29%)</td>
<td>Lung &amp; bronchus 85,920 (27%)</td>
<td>Lung &amp; bronchus 72,160 (26%)</td>
</tr>
<tr>
<td>Lung &amp; bronchus 117,920 (14%)</td>
<td>Lung &amp; bronchus 108,470 (13%)</td>
<td>Prostate 26,120 (8%)</td>
<td>Breast 40,650 (14%)</td>
</tr>
<tr>
<td>Colon &amp; rectum 70,820 (8%)</td>
<td>Colon &amp; rectum 63,670 (8%)</td>
<td>Colon &amp; rectum 26,020 (8%)</td>
<td>Colon &amp; rectum 23,170 (8%)</td>
</tr>
<tr>
<td>Urinary bladder 58,950 (7%)</td>
<td>Uterine corpus 60,050 (7%)</td>
<td>Pancreas 21,450 (7%)</td>
<td>Pancreas 20,330 (7%)</td>
</tr>
<tr>
<td>Melanoma of the skin 46,670 (6%)</td>
<td>Thyroid 49,350 (6%)</td>
<td>Liver &amp; intrahepatic bile duct 18,280 (6%)</td>
<td>Ovary 14,240 (5%)</td>
</tr>
<tr>
<td>Non-Hodgkin lymphoma 10,410 (5%)</td>
<td>Non-Hodgkin lymphoma 32,410 (4%)</td>
<td>Leukemia 14,130 (4%)</td>
<td>Uterine corpus 10,470 (4%)</td>
</tr>
<tr>
<td>Kidney &amp; renal pelvis 39,650 (5%)</td>
<td>Melanoma of the skin 29,510 (3%)</td>
<td>Esophagus 12,720 (4%)</td>
<td>Leukemia 10,270 (4%)</td>
</tr>
<tr>
<td>Oral cavity &amp; pharynx 34,780 (4%)</td>
<td>Leukemia 26,050 (3%)</td>
<td>Urinary bladder 11,820 (4%)</td>
<td>Liver &amp; intrahepatic bile duct 8,890 (3%)</td>
</tr>
<tr>
<td>Leukemia 34,900 (4%)</td>
<td>Pancreas 25,400 (3%)</td>
<td>Non-Hodgkin lymphoma 11,520 (4%)</td>
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<tr>
<td>&amp; intrahepatic bile duct 28,410 (3%)</td>
<td>Kidney &amp; renal pelvis 23,050 (3%)</td>
<td>Brain &amp; other nervous system 9,440 (3%)</td>
<td>Brain &amp; other nervous system 6,610 (2%)</td>
</tr>
<tr>
<td>All sites 841,390 (100%)</td>
<td>All sites 843,820 (100%)</td>
<td>All sites 314,290 (100%)</td>
<td>All sites 281,400 (100%)</td>
</tr>
</tbody>
</table>

*Note: Rounding and omission of small values.*

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Cancer Statistics in U.S.

**Prevalence:** number or percent of people alive on a certain date in a population who previously had a diagnosis of cancer [includes new incidence and pre-existing cases]
- Information is used for health planning, resource allocation, estimation of cancer survivorship

**Fatality:** number of persons among all those who have a form of cancer who die during a specified period of time
- Provides a measure of aggressiveness of cancer or the success of medical intervention

**Cancer Incidence by Race/Ethnicity**
- For all cancer sites combined;
  - African American men have a 14% higher incidence rate and a 33% higher death rates than white men
  - African American women have a 6% lower incidence rate but a 16% higher death rate than white women
  - Incidence and death rates for cancers related to infectious agents [cervix, stomach, liver] are generally higher in minority populations than whites
  - Twice as high in Asian Americans/Pacific Islanders due to chronic infections with *Helicobacter pylori* and Hepatitis B virus.
  - Kidney cancer incidence and death rates are highest among American Indians/Alaskan Natives which may reflect higher prevalence of obesity and smoking.
Minority populations are more likely than whites to be diagnosed at advanced stage disease for all 4 major cancer sites.

- African Americans are less likely to survive cancer than whites

  - Disparities related to inequalities in access to and receipt of quality healthcare as well as co-morbidities
  - Less likely to be diagnosed at localized stages when treatment is less extensive and more successful

All minority males had a greater probability than whites of dying from cancer within 5 years of diagnosis although the difference was smaller for Hispanic men.

Among women, Asian Americans/Pacific Islanders (69%) and Hispanics (67%) have a higher 5-year survival followed by whites (66%), American Indians/Alaskan Native (60%) and African Americans (58%).

Recent statistics for four most common cancers

- Lung
- Breast
- Prostate
- Colorectal
Recent statistics for four most common cancers: **Lung**

**WOMEN**
- 2nd most common cancer
- Accounts for 13% all female cancers; rates declining
- 106,470 new cases expected in US in 2016
- Rates [per 100,000 population] vary by ethnicity
  - Caucasian 59.3
  - African American 51.7
  - American Indian and Alaska native 52.5
  - Asian African and Pacific Islander 28
  - Hispanic 26.3

**MEN**
- 2nd most common cancer
- Accounts for 14% all male cancers; rates declining
- 115,610 new cases expected in US in 2016
- Incidence rates [per 100,000 population] vary by ethnicity
  - African American 95.4
  - Caucasian 81.3
  - American Indian and Alaska native 68.5
  - Asian African and Pacific Islander 48
  - Hispanic 45

Recent statistics for four most common cancers: **Breast**

**WOMEN**
- Most common cancer amongst women
- Accounts for 32% all female cancers and 15% all female cancer deaths
- Risk of lifetime development: 1 in 8
- Estimated 246,660 new cases and 40,450 deaths expected in US in 2016
- Highest mortality occurs among African American woman followed by Caucasians and Hawaiian women.
- 5-year survival rates for Caucasians (92%) exceeds African Americans (80%)

**MEN**
- Rare disease accounting for <1% of all male cancers and <1% of all breast cancers
- Estimated 2,360 new cases and ~440 deaths expected in US in 2016
  - Unlike in women where rates have stabilized, incidence in men < 40 yrs seems to be substantially increasing
  - Men's survival is lower than women's
Recent statistics for four most common cancers: **Prostate**

- Lifetime risk of developing prostate cancer is 1 in 5; fortunately only 3% will die from disease
- Estimated 180,890 new cases expected in US in 2016
- Number of new cases expected to reach 380,000 by 2025 because of aging male population
- Estimated 26,120 deaths expected in US in 2016
- 2nd leading cause of cancer deaths among US men

* Risk factors: increasing age, family history, African American heritage, high fat diet

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**Colo-rectal Cancer**

3rd most common neoplasm worldwide; 2nd leading cause of cancer death in US

Estimated that 93,090 Americans will be diagnosed with colorectal cancer in 2016

Estimated deaths 49,700 in 2016

6% Americans are expected to develop the illness during their lifetime

Over the past 15 years, the mortality rate has decreased by 1.7% yearly

5 year overall survival rate is 62.1%. Despite advances in surgical technique and adjuvant therapy, only a modest improvement in survival in those diagnosed with advanced stage disease.

9 of 10 vases could be prevented if people >50 years led a healthy lifestyle and had regular screenings
Pancreatic Cancer:

53,070 estimated new cases in the US in 2016
12th most common type of cancer overall but highest in age group 65-74
3rd leading cause of deaths from cancer
African Americans have appreciable higher rates than Caucasians
Survival rates are dismal; majority diagnosed at advanced stage
  - Five year survival rate is 7.2%

Cancer Prevention

According to the Institute of Medicine’s report “Fulfilling the Potential of Cancer Prevention and Early Detection”, the US is failing to take advantage of proven methods to prevent cancer

If sustained efforts were made to help people change their behaviors and were in place to take advantage of cancer detection procedures, 60,000 cancer deaths and about 100,000 new cases annually could be prevented by 2016

For many health problems, a combination of primary, secondary and tertiary interventions are needed to achieve a meaningful degree of prevention and protection.
Cancer defined:

An abnormal growth of cells which tend to proliferate in an uncontrolled way and, in some cases, to metastasize (spread). **Cancer** is not one disease. It is a group of more than 100 different and distinctive diseases.

Carcinogenesis: the process by which cancer arises – Three-Stage Theory

**Initiation** – an initiating agent may be chemical, physical or biologic, causing damage to DNA by changing a specific gene.

The gene may then:
- Undergo repair
- Become permanently damaged but not cause cancer unless subsequent exposures.
- Become mutated and produce a cancer cell line if the initiator is a complete carcinogen (both and initiator and promoter)
Carcinogenesis – three-stage theory

**Promotion** – process of subsequent exposure to carcinogens.
May alter genetic structure of cell or inhibit apoptosis of the cell.
Results in
- Reversible damage to proliferation mechanism of the cell.
- Irreversible damage to the proliferation mechanism of the cell, resulting in cell transformation.

Carcinogenesis

**Progression** – increasing genetic instability (mutations) providing tumors a growth advantage.

Invasion

Angiogenesis – (a target for therapy)

Metastasis –
- direct invasion into local organ.
- Seeding in a body cavity eg. peritoneal cavity.
- Dissemination via lymphatic system – entrapment in first LN, or skip to more distant sites.
- Dissemination via the bloodstream – most common.
Carcinogenesis: Causative Factors

Physical

- Ionizing radiation
diagnostic sources
- cosmic radiation
radioactive ground minerals, e.g., radon
- Ultraviolet radiation
sunlight
tanning salon
industrial sources, e.g., welding
Carcinogenesis

What are the steps leading to the development of cancer?

- Carcinogen
- Mutation: oncogene
- Oncogenes are switched on
- Tumour suppressors are switched off
- Do not respond to intracellular signals
- No apoptosis
- Immune system doesn’t recognise cells as foreign
- Mitosis
- Mitosis

Characteristics of Cancer Cells
Structural Changes
Abnormal Chromosome Arrangements

- Translocation
- Deletion
- Gene Amplification
Translocation of Genes and Cancer Development

- Certain cancers
  - Are caused by translocations of chromosomes

Deletion of a chromosome and Cancer.

Image of typical chromosome #13 deletion
Gene Overexpression or Amplification and Cancer

Regulatory Mutations

- Normal expression
  - Her2 protein
  - Messenger RNA
  - Chromosome 17
- Overexpression
  - Her2 protein

Found something? Now what?

Lab

Imaging

Invasive Procedures
- Biopsies – tumor, bone marrow
- Colo – endoscopies
- Bronchoscopies
Detection

**Physical exam** and **history**: An exam of the body to check general signs of health, including checking for signs of disease, such as lumps or anything else that seems unusual. A history of the patient’s health habits and past illnesses and treatments will also be taken.

**Laboratory tests**: Medical procedures that test samples of tissue, blood, urine, or other substances in the body.

**Imaging procedures**: Procedures that make pictures of areas inside the body.

**Genetic tests**: Tests that look for certain **gene mutations** (changes) that are linked to some types of cancer.
PET Scan

Initial Diagnosis

After 2 cycles ABVD chemotherapy

CT Scan

cigarettes in shirt pocket

lung cancer

emphysema
Bone Survey – Multiple Myeloma

Brain tumor cell using FISH
Staging

Solid Tumors

Heme Malignancies

Lymphoma Staging

Ann Arbor Staging
Staging – Heme Malignancies

Recurrent chromosomal abnormalities in Hematological malignancies

Abnormalities important for classification

CML  t(9;22)
AML  t(8;21), t(15;17), inv(16), t(9;11), inv(3), t(6;9), t(1;22), -5/5q, -7/7q
ALL  t(4;11), t(1;19), t(v;11q23), t(12;21)\(^a\)
MDS  -Y, del(11q); del(5q), del(12p), del(20q); del(7q), +8, +19, t(17q); -7, inv(3)
Lymphoma
DLBCL  t(3q27)
Burkitt  t(8;14) and variant
Follicular  t(14;18)
Mantle cell  t(11;14)
Marginal zone  t(11;18), t(1;14), t(14;18)

Grading of Tumors

GX: Grade cannot be assessed (undetermined grade)
G1: Well differentiated (low grade)
G2: Moderately differentiated (intermediate grade)
G3: Poorly differentiated (high grade)
G4: Undifferentiated (high grade)
Metastases

Most common sites: Bone, Lung, Liver, CNS

They have to be able to break away from the original tumor and enter the bloodstream or lymph system, which can carry them to another part of the body.

They need to attach to the wall of a blood or lymph vessel and move through it into a new organ.

They need to be able to grow and thrive in their new location.

They need to be able to avoid attacks from the body’s immune system.

CANCER RISK FACTORS

Lifestyle
Occupational
Environmental
Biologic
Iatrogenic
NICOTINE

- Accounts for 30% all cancer deaths
- Accounts for 90% lung cancer cases [30% from secondhand smoke]

Lifestyle Risk Factors- Alcohol Consumption

Contributes to 3% of cancer mortality

Associated with cancer of the esophagus, liver, pharynx, stomach, colon, breast
- As few as 2 drinks per day may contribute to breast, colon and rectal cancer

Synergistic effect with tobacco
Lifestyle Risk Factors - Diet

Accounts for 20-42% cancer deaths

Overweight and obesity accounts for 20% of all cancer deaths in women and 12% in men

Diets high in total fat, protein, calories, alcohol and meat and diets low in calcium and folate are associated with increased risk of colorectal cancer

High fiber diet appears protective for cancers of the lung, colorectal, bladder, oral cavity.

Occupational Risk Factors

Account for 4% of cancers

- Asbestos is the single most important known occupational carcinogen [lung cancer, mesothelioma]

Effective regulation of workplace exposures has reduced risks tremendously

Special populations of concern;

- Blue collar workers – increase smoking
- African Americans - more hazardous jobs
- Steel workers – increase lung CA
- Rubber workers - increase prostate CA
- Chemical workers - increased bladder CA
- Miners - increased exposure to uranium and radon with a subsequent increase in gastric CA and birth defects
• Accounts for 2% cancer deaths
• Sun exposure
• Electromagnetic field exposure
• Radon gas
• Contribution of cellular phone, microwaves and other wireless systems remains unclear

Environmental Risk Factors

• Viral exposures
  ◦ associated with 15% of all cancers worldwide
  ◦ Implicated viruses include:
    ◦ HIV
    ◦ EBV
    ◦ HPV
    ◦ HTLV

• Familial and genetic contributions
  ◦ Autosomal dominant
  ◦ Inherited genetic mutations [5-20%]
  ◦ Gene-gene or gene-environment interactions
  ◦ Inherited cancer

Biologic Risk Factors
Iatrogenic risks

- Hormonal agents
- Anabolic steroids
- Certain fertility drugs (Pergonal)
- Growth hormones given to children
- Immunosuppressive agents [for organ transplant recipients]
- Antineoplastic agents (alkylating agents, anthracyclines)

Review Questions
What are the 3 stages in the process of Carcinogenesis?

A. INITIATION, TRANSLOCATION, PROGRESSION
B. PROMOTION, INITIATION, AMPLIFICATION
C. INITIATION, PROMOTION, PROGRESSION
D. INITIATION, PROMOTION, AMPLIFICATION

Colon cancer prevention strategies include which of the following?

A. Reduction of red meat in diet
B. Modification of dietary fat intake
C. Pursuit of a diet rich in vegetables
D. Pursuit of a diet rich in fiber and vegetables
The three leading sites of cancer deaths worldwide are?
A. Lung, stomach and liver
B. Lung, breast and prostate
C. Lung, colorectal and pancreatic
D. Lung, skin and colorectal

From a client’s history, the nurse discerns that the client does not practice breast self-exam regularly, is a heavy coffee drinker, is infected with HPV and follows a diet that is high in fat, low in fiber, fruits and vegetables. Of these risk factors, which has been specifically linked to a type of cancer?
A. Lack of practice of monthly breast self-exam
B. Caffeine consumption
C. Infection with HPV
D. A diet high in fat, low in fiber, fruits & veggies
Risk factors associated with pancreatic cancer include?

A. Cigarette smoking, consumption of smoked or processed meat, helico-bacter pylori and a history of diabetes and heavy alcohol consumption.
B. Age, diet high in fat and calories and low I fiber and a history of ulcerative colitis.
C. Increasing age and history of radiation exposure.
D. Cigarette smoking and a history of radon exposure.

What Risk Factor is the most important cause of death in the United States?

A. Sun Exposure
B. Alcohol
C. Tobacco
D. Viral exposures
According to a recent report by the Institute of Medicine, the United States could decrease cancer deaths and new cancer cases if the following were done?

A. Ban the use of alcohol
B. People stopped eating red meat
C. People changed their behaviors and a system was in place to allow people to take advantage of cancer detection procedures
D. Prophylactic surgery was performed on patients at risk for developing cancer

The director of your state’s environmental health program has asked you to consult on the development of a new public health services grant proposal. The purpose of this grant is to significantly reduce the number of cancer deaths related to a select environmental cause. A focus on which of the following would potentially have the greatest public health impact?

A. Electromagnetic field exposure and childhood cancer
B. Cellular telephone use and cancer of the brain
C. Ultraviolet exposure and skin cancer
D. Hazardous waste dump exposure and leukemia
Ann Arbor Staging is used in what type of malignancy?

A. Lung Cancer
B. Colon Cancer
C. Breast Cancer
D. Lymphoma

THANK YOU!