Careers in Cancer

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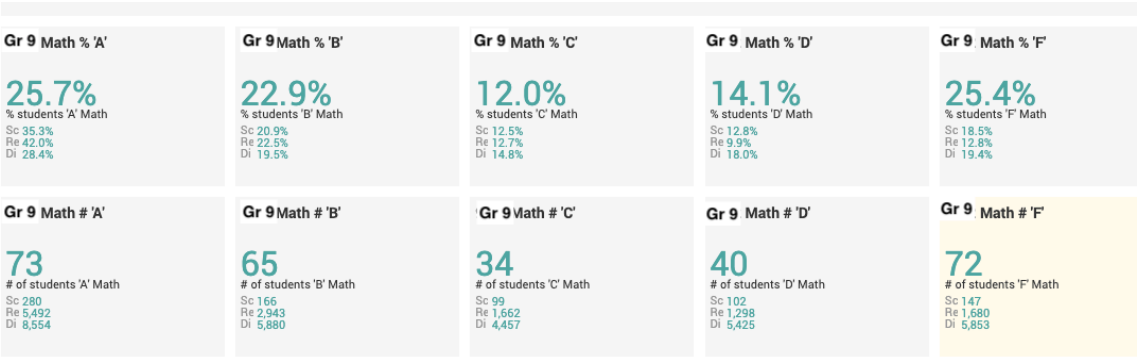
Content Objectives

Many high school students are not interested or invested in their math or science education. At the Philadelphia High School for Girls, we had record numbers of first quarter failures in math classes in the 2020-2021 academic year. Although the pandemic likely contributed to this low academic performance, I believe that low interest, investment and confidence in their ability is also a significant factor. For ninth graders alone, twice as many failed math than failed English so far this year. 25.4% of our new ninth graders failed their math class while 25% of the class also received A's. Half of the failures in math are among freshmen. Since the number of students who failed math increased from the first marking period to the second, this is not simply a case of newly transitioning to high school.

Science has an equally abysmal number of failures. 33% of our freshmen failed their Biology course. This represents almost twice the number of failures for students in grades 10-12. One difference between the math and science data for ninth graders is that science does not have an equal number of students earning A's – only 13% of freshmen earned an A is Biology. This could mean that the subject matter is more difficult or less engaging than 9th grade math.

What does this say about the 9th grade's experience with math and science at the Philadelphia High School for Girls? Are we unique or is this a trend across the country? I do not have specific 9th grade data for our network (a cluster of non-comprehensive schools who can select their student body) or the School District of Philadelphia as a whole. Our statistics for grades 9-12 is 6% lower than the network average and 1 % lower than all Philadelphia public high schools.



9-12 Math % 'A'

35.3%
% students 'A' Math
Sc 35.3%
Re 42.0%
Di 28.4%

9-12 Math % 'B'

20.9%
% students 'B' Math
Sc 20.9%
Re 22.5%
Di 19.5%

9-12 Math % 'C'

12.5%
% students 'C' Math
Sc 12.5%
Re 12.7%
Di 14.8%

9-12 Math % 'D'

12.8%
% students 'D' Math
Sc 12.8%
Re 9.9%
Di 18.0%

9-12 Math % 'F'

18.5%
% students 'F' Math
Sc 18.5%
Re 12.8%
Di 19.4%

9-12 Math # 'A'

280
# of students 'A' Math
Sc 280
Re 5,492
Di 8,554

9-12 Math # 'B'

166
# of students 'B' Math
Sc 166
Re 2,943
Di 5,880

9-12 Math # 'C'

99
# of students 'C' Math
Sc 99
Re 1,662
Di 4,457

9-12 Math # 'D'

102
# of students 'D' Math
Sc 102
Re 1,298
Di 5,425

9-12 Math # 'F'

147
# of students 'F' Math
Sc 147
Re 1,680
Di 5,853

Year-Over-Year (Through Q1) | End-of-Year

Course Marks Detail: Selected Schools/Networks, All Grades, All Courses
Through 1st Quarter in all years, selected schools or networks. Use drop-down boxes at top of page to modify view.Course

School Year	Subject Area	Course Name	Total number of grades assigned	# of As	% of As	# of Bs	% of Bs	# of Cs	% of Cs	# of Ds	% of Ds	# of Fs	% of Fs
2020-2021	Science	Biology	253	35	13.8%	54	21.3%	47	18.6%	32	12.6%	85	33.6%
2020-2021	Science	Chemistry	138	37	26.8%	24	17.4%	40	29.0%	20	14.5%	17	12.3%
2020-2021	Science	Environmental Science	89	23	25.8%	20	22.5%	14	15.7%	19	21.3%	13	14.6%
2020-2021	Science	Physics	164	49	29.9%	57	34.8%	27	16.5%	20	12.2%	11	6.7%
2020-2021	Science	Ap Biology	16	9	56.3%	4	25.0%	1	6.3%	0	0.0%	2	12.5%
2020-2021	Science	Ap Chemistry	15	9	60.0%	5	33.3%	0	0.0%	1	6.7%	0	0.0%
2020-2021	Science	Ap Environmental Science	17	10	58.8%	3	17.6%	2	11.8%	2	11.8%	0	0.0%
2020-2021	Science	Biology Honors	64	35	54.7%	17	26.6%	7	10.9%	3	4.7%	2	3.1%
2020-2021	Science	Chemistry Honors	61	31	50.8%	15	24.6%	12	19.7%	2	3.3%	1	1.6%
2020-2021	Science	Ib Biology - Sl	20	13	65.0%	3	15.0%	2	10.0%	1	5.0%	1	5.0%
2020-2021	Science	Physics Honors	31	25	80.6%	3	9.7%	2	6.5%	0	0.0%	1	3.2%

Gr 9 ELA % 'A'

40.1%
% students 'A' ELA
Sc 41.5%
Re 42.9%
Di 31.4%

Gr 9 ELA % 'B'

17.6%
% students 'B' ELA
Sc 23.4%
Re 22.7%
Di 20.3%

Gr 9 ELA % 'C'

15.2%
% students 'C' ELA
Sc 15.1%
Re 12.1%
Di 14.1%

Gr 9 ELA % 'D'

14.2%
% students 'D' ELA
Sc 11.9%
Re 9.9%
Di 15.8%

Gr 9 ELA % 'F'

12.8%
% students 'F' ELA
Sc 8.1%
Re 12.4%
Di 18.5%

Gr 9 ELA # 'A'

116
# of students 'A' ELA
Sc 338
Re 6,172
Di 10,521

Gr 9 ELA # 'B'

51
# of students 'B' ELA
Sc 191
Re 3,270
Di 6,794

Gr 9 ELA # 'C'

44
# of students 'C' ELA
Sc 123
Re 1,740
Di 4,745

Gr 9 ELA # 'D'

41
# of students 'D' ELA
Sc 97
Re 1,431
Di 5,294

Gr 9 ELA # 'F'

37
# of students 'F' ELA
Sc 66
Re 1,780
Di 6,189

9-12 ELA % 'A'

41.5%
% students 'A' ELA
Sc 41.5%
Re 42.9%
Di 31.4%

9-12 ELA % 'B'

23.4%
% students 'B' ELA
Sc 23.4%
Re 22.7%
Di 20.3%

9-12 ELA % 'C'

15.1%
% students 'C' ELA
Sc 15.1%
Re 12.1%
Di 14.1%

9-12 ELA % 'D'

11.9%
% students 'D' ELA
Sc 11.9%
Re 9.9%
Di 15.8%

9-12 ELA % 'F'

8.1%
% students 'F' ELA
Sc 8.1%
Re 12.4%
Di 18.5%

9-12 ELA # 'A'

338
# of students 'A' ELA
Sc 338
Re 6,172
Di 10,521

9-12 ELA # 'B'

191
# of students 'B' ELA
Sc 191
Re 3,270
Di 6,794

9-12 ELA # 'C'

123
# of students 'C' ELA
Sc 123
Re 1,740
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9-12 ELA # 'D'

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Sc 97
Re 1,431
Di 5,294

9-12 ELA # 'F'

66
# of students 'F' ELA
Sc 66
Re 1,780
Di 6,189

The Center for American Progress (CAP), an independent nonpartisan policy institute, published a High School STEM report in October of 2020. Their premise is that in order for students to do well in math, they must have a growth mindset. (Images et al., n.d.) A growth mindset in math class is known as a mathematical mindset. This is the idea that the harder you work, the more you learn; that it is possible to become smarter in math by making mistakes, persevering in tasks and believing yourself capable. Jo Boaler notes in her book *Mathematical Mindsets* that math, more than any other subject, has endured

decades of negative stereotypes and confessions by many that they are incapable of understanding. One traumatic event in elementary school can close the door to learning mathematics and create a fixed mindset towards it. (Boaler, 2016)

The findings reported in the CAP report, Early High School STEM Perceptions Associated with Postsecondary Outcomes, are that a new educational strategy is necessary to ignite a student's interest in available careers. Students need to see the purpose or utility in what they are learning before they invest in the work. (Images et al., n.d.)

CAP's analysis of the data found a correlation between a ninth grader's attitude or mindset in their math and science classes to enrollment in four-year colleges and pursuing a STEM major. This is especially important for young women who are typically under-represented in math and science careers. In high school, females achieve similarly to males in math and science classes, yet if they do major in science, technology, engineering or math, they are more likely than men to leave that STEM pipeline because of fear or lack of confidence in their ability.(Images et al., n.d.)

I would like to excite my students at Girls High and foster a mathematical growth mindset by offering tangible short- and long-term goals to motivate them to master mathematical concepts.

Through the University of Pennsylvania Teacher's Institute class Cancer Biology and Technology, I have learned about cancer biology and the many career opportunities in the broad area of cancer and will expose my students to these career opportunities linking them to their mastery of math and science in high school. There is a vast range of cancer-related jobs and professions with some only requiring a two-year degree or training in specific equipment but offering a career with long-term stability, high wages, health insurance and other benefits inclusive of an excellent standard of living.

According to The International Agency for Research on Cancer, in the year 2040, there will be a 30.2 million new cases of cancer. (*Cancer Tomorrow*, n.d.) Cancer is a disease of the aging and, as our society lives longer, the incidence of cancer will increase. Other factors that contribute to an increased incidence in cancer are diet and lifestyle with rates of obesity and inactivity also on the rise in the US.

According to the World Economic Forum's "The Future of Jobs Report 2020", "The top skills and skill groups which employers see as rising in prominence in the lead up to 2025 include groups such as critical thinking and analysis as well as problem-solving, and skills in self-management such as active learning, resilience, stress tolerance and flexibility."(*The Future of Jobs Report 2020 O C T O B E R 2 0 2 0*, 2020, p. 5)

The Pennsylvania Common Core Standards lists as the last of its four Key Points in Mathematics that "high school standards emphasize practicing applying mathematical ways of thinking to real world issues and challenges. One way of including this mode of utilizing the standards is to include rich tasks in classroom routines. Jennifer Piggot identifies a rich task in her 2018 article in NRICH by the environment in which a problem is posed. She describes this as "an environment in which learners are not passive recipients of knowledge, accepting what is given, but independent assertive constructors of their own understanding who challenge and reflect."(*Rich Tasks and Contexts*, n.d.)

The Common Core State Standards, released in 2010 by the National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO) emphasized that understanding mathematics is key to success in mastering mathematics. They state: Mathematical understanding and procedural skill are equally important, and both are assessable using mathematical tasks of sufficient richness. (*Mathematics Standards | Common Core State Standards Initiative*, n.d.)

The School District of Philadelphia refers to rich tasks as formative tasks. In the Comprehensive Guide for Mathematics Instruction Grades K-12, the math team recommends approximately 10 minutes of every 45 minute math period be spent posing a formative task to student teams.

My goal in this curriculum unit is to introduce students to careers in the cancer field. The need is there! Using techniques and strategies that support a mathematical mindset, I will present real world tasks that a professional cancer health care worker may encounter. The application of the content and reasoning students are learning in math class will hopefully spark interest in the career offerings and present a purpose for learning.

Teaching Strategies

In this curriculum unit, I will present rich/formative/performance tasks that are based on mathematics involved in various careers in cancer. Teachers can use these tasks when teaching lessons on the listed content or lessons that are specifically career focused. The very first lesson is an introduction to cancer and careers in cancer.

This unit uses the following strategies:

- Which one doesn't belong – an engagement strategy
- Cooperative team work

- Checklist using computer science principles
- Flowchart using computer science sorting principles
- Student reflection questions
- Real world math tasks
- Career exploration opportunities

Classroom Activities

Lesson 1: Introduction to Careers in Cancer (1 – 3 days)

Learning Objective: At the end of this lesson, students will be able to consider questions about careers in the health sciences, with a focus on cancer care. Students will research specific cancer related careers and will have access to compiled data from their classmates. Students will be familiar with cancer and one woman's cancer journey. Students will reflect on their learning and process in choosing a possible career or career pathway.

Materials:

- Which One Doesn't Belong (WODB) Picture (appendix1)
- Video Links: What is Cancer? from Macmillan Cancer Support, from TPT PBS Originals, from Teenage Cancer Trust, (appendix 2)
- C-Change *Consider a Career in Cancer: Speaker Kit* (appendix 3)
- Careers in Cancer Job Title Checklist (appendix 4)
- Cancer Careers Education Pathway Flowchart (appendix 5)
- A Cancer Journey (appendix 6)
- Student Reflection Questions (appendix 7)

Procedures:

1. Use the WODB picture as a Do Now. Students will use their observation skills to notice differences and similarities in the images (they do not have to be career related.) In WODB activities, there are no right or wrong answers; each image has at least one reason why it doesn't belong. (For instance, in the image in quadrant I, there are pouches, the woman is facing right; in quadrant II, the image contains a stool, the woman is facing front; in quadrant III's image, the woman is wearing rubber gloves, she is in a laboratory; in quadrant IV's image, there are two women, one machine, there is a patient, etc.)
2. After the Do Now, but still referring to the WODB picture, ask the students if they can guess the careers represented by each image.

3. Have students working in teams and ask "What questions should one consider when thinking about a career?" Each team should discuss the topic and make a list of 4 questions to consider when choosing a career path.
4. The teams should share their questions with the class and together, the class should agree on 5-7 most important questions.
5. Show one of the three videos: What is Cancer? Make sure to include time for questions or comments.
6. Show the C-Change slides *Consider a Career in Cancer* to the class. Encourage discussion and answer questions students may have. These slides are from 2013, so some things may be outdated, however emphasize that the job opportunities in the field are increasing.
7. Introduce/distribute the Cancer Career Pathways Checklist and the Education Flowchart to the student teams. (I suggest you distribute electronic versions in order to create a completed checklist and education pathway documents.)
8. Assign each team 3-5 careers from the list to research and answer the 5 questions.
9. Have teams share out verbally or by posting their career path checklists.
10. Use the Careers in Cancer flowchart to list the careers by education. If you could have the flowchart blown up to keep posted.
11. Assign *A Cancer Journey* as a reading assignment (perhaps for homework.)
12. Have students complete the reflection questions (perhaps also for homework.)

Mathematical Tasks

The remainder of the "lessons" are rich/formative and or performance tasks that ask the students to perform mathematical operations and reasoning with problems that are similar to those a professional cancer healthcare worker would perform. Each task contains an introduction to the career and the task, the task itself, a description of the careers, and an answer sheet.

I would recommend these tasks be completed in teams. It would be ideal if at least one team is able to share their work, their reasoning and their answer. Much will depend on how much time the teacher wishes to spend on each activity.

It will also be up to the teacher to decide when to introduce each task. The tasks can be introduced after a particular content is taught or during a career focused time (i.e. before a school-wide career day, etc.), or any day you want the students working in teams and/or on a task.

How the teacher decides to introduce each task to the class is also variable. Perhaps the teacher will want to start with the job descriptions or video (when available). Perhaps the teacher wants to spend time on making sure the students understand the context or content of the task. There are multiple discussions the teacher can begin or have students

begin before or after the task is introduced. These discussions can be based on the careers and/or the content.
The tasks included are only a sampling of the possibilities of the career focused mathematics that can be posed to students. A teacher can take requests from students on different careers to include for future tasks. A teacher could also assign the students to create their own tasks on specific careers or careers of the student's choice.
For years and years, math teachers have been told to use real world problems. These career focused tasks do that and hopefully inspire students to examine their career choices. They also answer the age old question "When are we ever going to use this?"

Lessons 2-7: Tasks for professions

Nurse's Task – Lesson 2

Lesson Objectives: At the end of this task, students will be able to apply proportions in order to find missing values. Students will convert between the metric and English system of measurement. Students will interpret medical language. Students will be familiar with the career pathway to become a nurse.

Materials: Nurse's Task (appendix 8)

Procedures:

1. Introduce the task to students in the context of the content (proportions, units and arithmetic) or the career.
2. I recommend solving the problem in teams to encourage discussion, justifying and being exposed to multiple solution methods. However, if desired, this task could be assigned individually as classwork or homework.
3. Teams can post their work and/or share their answers with the class.
4. Teacher can choose to elaborate on a career in nursing. Students can watch the 2.5 minute video if there is interest.

T-Cell Task – Lesson 3

Lesson Objectives: At the end of this task, students will be able to work with scientific notation and different metric units to solve a multi-step problem. Students will be introduced to T-cells and the genetic engineering process to create CAR T cells, a form of immunotherapy. Students will be introduced to careers in biomanufacturing.

Materials: T-Cell Task (appendix 9)

Procedures:

1. Introduce the task to students in the context of the content (working with small units in the metric system, scientific notation and percent) or the careers.
2. I recommend solving the problem in teams to encourage discussion, justifying and being exposed to multiple solution methods. However, if desired, this task could be assigned individually as classwork or homework.
3. Teams can post their work and/or share their answers with the class.
4. Teacher can choose to elaborate on a careers in biomanufacturing technology, immunology and oncology. Students can watch the any of the videos if there is interest.

Infusion Tasks 1,2,3 – Lessons 4-6

Lesson Objectives:
Tasks1-3: At the end of task, students will be able to use a formula (using square root) to find a patient's body surface area, BSA. Students will be introduced to careers in pharmacy, oncology and immunology.
Task 1: Students will be able to apply the patient's BSA to a protocol dose of 3 drugs to find the exact dose.
Task 2: Students will be able to apply the patient's BSA to a protocol dose and apply percent reduction to find the exact dose.
Task 3: Students will be able to apply the patient's BSA using 2 different formulas to find the exact dose and then compare the outcomes.

Materials:
- Infusion Task 1 (appendix 10)
- Infusion Task 2 (appendix 11)
- Infusion Task 3 (appendix 12)

Procedures:
1. Introduce the tasks to students in the context of the content (using formula with square roots and rational exponents and percent) or the careers. The tasks can be completed in succession, or 3 different occasions, or select only 1 or 2.
2. I recommend solving the problems in teams to encourage discussion, justifying and being exposed to multiple solution methods. However, if desired, these tasks could be assigned individually as classwork or homework.
3. Teams can post their work and/or share their answers with the class.
4. Teacher can choose to elaborate on a careers in pharmacy, nephrology, nursing and oncology. Students can watch the any of the videos if there is interest.

Performance Measures Task – Lesson 7

Lesson Objectives: At the end of this task, students will be able to complete, use and analyze a two-way table to answer questions about diagnostic screening. Students will find sensitivity, specificity, positive predictive value, and negative predictive value. Students will be introduced to careers in epidemiology and healthcare data science.

Materials: Performance Measures Tasks (appendix 13)

Procedures:

1. Introduce the tasks to students in the context of the content (two-way tables) or the careers. You could introduce the tasks together or separately. Task 2 requires the completion of task 2.
2. I recommend solving the problem in teams to encourage discussion, justifying and being exposed to multiple solution methods. However, if desired, this task could be assigned individually as classwork or homework.
3. Teams can post their work and/or share their answers with the class.
4. Teacher can choose to elaborate on a careers in data science. Students can read further about the careers if interested.

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Appendix

The Standard for Mathematical Practice (from the Common Core State Standards for Mathematics, CCSS)

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

Also from CCSS

- Reason quantitatively and use units to solve problems.
- Understand solving equations as a process of reasoning and explain the reasoning.
- Create equations that describe numbers or relationships.
- Interpret functions that arise in applications in terms of the context.
- Build a function that models a relationship between two quantities.
- Apply geometric concepts in modeling situations
- Summarize, represent, and interpret data on a single count or measurement variable.
- Understand and evaluate random processes underlying statistical experiments.
- Make inferences and justify conclusions from sample surveys, experiments and observational studies.

Which One Doesn't Belong

Video Links : What is Cancer?

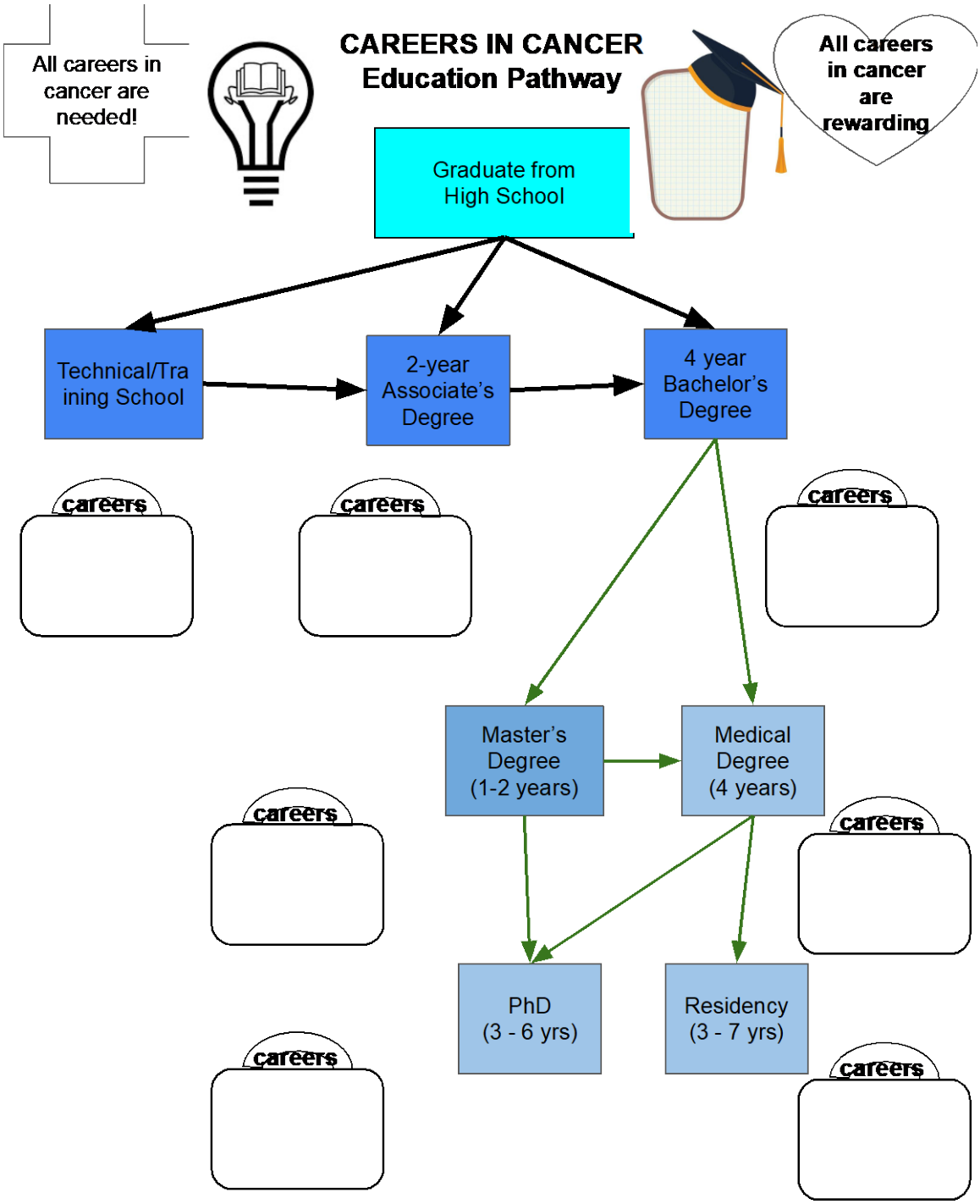
From MacMillan Cancer Support: https://www.youtube.com/watch?v=5MEYFgVnlb4

From TPT PBS Originals: https://www.tptoriginals.org/cancer-101/

From Teenage Cancer Trust: https://www.youtube.com/watch?v=2g5nJfKoIqE

Click on link to access pdf slides:
https://www.ceoroundtableoncancer.org/sites/default/files/careers_cancer_speaker_kit.pdf

Cancer Career Pathways


All careers in cancer are needed!
CAREERS IN CANCER
Education Pathway
All careers in cancer are rewarding
Graduate from High School
Technical/Training School
2-year Associate's Degree
4 year Bachelor's Degree
careers
careers
careers
Master's Degree (1-2 years)
Medical Degree (4 years)
careers
careers
PhD (3 - 6 yrs)
Residency (3 - 7 yrs)
careers
careers

A Cancer Journey

A hypothetical story of the people who touch the life of a woman with cancer

David Mankoff, MD, PhD, 2021

A woman, who we'll call Ms. X., visited her doctor because she has found a lump in her breast.
Her **General Practitioner** performed a Clinical Breast Exam and confirmed the existence of the lump. The GP ordered a *mammogram* and a 3-D x-ray of her breast. A mammogram is a low-energy x-ray that produces images used for screening and detecting breast cancer. A 3-D x-ray moves in an arc to produce multiple images from multiple angles. The **mammography technician** set Ms. X up and performed the tests. A **radiologist** read Ms. X's images and found a 2.5 centimeter mass in her left breast.

Ms. X's next step was a procedure called a *needle biopsy*, performed by a **radiologist**. This removes a tissue sample from the mass in patient's breast. Ms. X's tissue sample was prepared for viewing by a **medical radiologist technician** or a **pathologist technician.** The technician must first put the tissue sample into a formula for 6-12 hours before they can begin the processing of the sample. The preparation of the slides that are put under a microscope to be read, involves embedding, sectioning and staining, all performed by the technician. Once the slides are ready, a **pathologist** reads the slides. The pathologist found cancer cells in Ms. X's tissue slides and staged or categorized the her cancer according to the size of the mass. Ms. X's tumor size of 2.5cm was labeled with a pT (primary tumor) of T_2. It can often take a week or so for the pathologist to prepare their report, so this was a very tense time for Ms. X.

Ms. X was then referred to a **surgeon**, specifically a **surgical oncologist**. After examining Ms. X, and reading the reports from the pathologist and radiologist, her surgeon recommended a *lumpectomy*. A lumpectomy removes the tumor and a small area around the tumor to make sure those cells are normal, meaning the cancer hasn't spread. Because the surgeon found suspicious *lymph nodes*, a sampling of the lymph nodes was part of her surgery regiment. Lymph nodes are all over your body and often when a surgeon removes a primary tumor (Ms. X's breast tumor), they will also remove one or more of the nearby regional lymph nodes to check for the presence of cancer.(*Lymph Nodes and Cancer What Is the Lymph System?*, n.d.)

Ms. X has her lumpectomy and lymph node biopsy surgery. The surgeon removed the tumor from her breast and 5 lymph nodes from the area under her left armpit. The tumor and the lymph node samples were sent to pathology. The pathologist found cancer cells in 3 of the 5 lymph nodes that were removed.

Ms. X returned to her surgeon to hear the results of her latest pathology report. The news was bad, but the quick appointment of a care team, helped Ms. X feel supported. In her team was a radiologist who was to perform a PET scan to see if the cancer had spread to

other sites. She also was assigned a **medical oncologist** who would be in charge of her treatment plan. She was schedule to see a **genetic counselor** to explore her family's medical history, especially incidences of breast cancer. Ms. X was assigned a **patient navigator**, who identified an **oncological social worker** as part of her patient and family services, because Ms. X was concerned about how her illness and treatment would affect her young children.

Ms. X first had her *PET/CT scan*. A Positron Emission Tomography and Computed Tomography Scan uses radioactive material to track cancer cells in your body. A staff member injected her with radioactive glucose that was quickly absorbed by cancer cells. Ms. X went through the donut like machine while the **nuclear medical technologist** operated the scan to get the correct images. The **radiologist** who read the images was pleased to report to her oncologist, that the cancer had not spread to any other parts of her body. The radiology report included the good news that the surgeon had removed most of the cancer!

Her medical oncologist used all of the radiology and pathology reports as well as the results of the blood tests the genetic counselor ordered to create a treatment plan for Ms. X. The first phase of treatment was *chemotherapy* for 3-6 months. Adjuvant chemotherapy drugs are given to patients after surgery to kill any cancer cells in the body that may have been too small for any scans to see. Ms. X's specific chemotherapy drugs were prepared by a **pharmacologist**; a **pharmacy technologist** actually did the physical labor. The drugs themselves were designed by a **biomedical scientist**. A **nurse** or **nurse practitioner** managed Ms. X's infusions (how the chemotherapy drugs are delivered). Ms. X also spoke with a **nutritionist** to make sure she was able to eat healthily even though she often doesn't feel well after her chemotherapy treatments.

After a few months, Ms. X's medical oncologist announced that she had finished with her chemotherapy treatment. The oncologist had monitored her scans and declared she was cancer free! Ms. X then had to see a **radiation oncologist**. This oncologist recommends *radiation therapy* to sterilize the sites where the cancer was, in order to avoid a recurrence. During radiation therapy high-energy particles or waves are delivered to specific areas of the body. The planning session to pinpoint the exact sites for Ms. X's radiation therapy was called a simulation, or a sim. At this point a **radiation oncology medical physicist** and a **dosimetrist**, made calculations and measurements to determine the radiation dosage and delivery are correct. During radiation treatments, a **radiation oncology nurse, nurse practitioner or physician assistant** were present to answer questions and help Ms. X manage her health. A **radiation therapist** actually operated the equipment and administered her treatments.

Ms. X's cancer journey has been an ordeal for her and her family. Her story has a happy ending; she is living a cancer free life and trying to appreciating every minute of it!

Careers in Cancer Introduction
Reflection Questions

Answer the questions with as much detail as you can provide.

1. Had you previously considered a career in cancer?

2. Has cancer affected your life or the lives of family members or others you are close to? (If this question is to personal or emotional, please don't feel the need to expound.)

3. Which career(s) in cancer most align with your interests, personality and plans for the future? Explain.

4. How do you think success in math is aligned with a career in the cancer field?

5. What have you learned about yourself and your future from working on this lesson.

Career: Nurse

A **nurse** is caring for a young cancer patient with leukemia, who is running a fever. The cancer cells keep the bone marrow from making enough normal blood cells so the patient is often susceptible to infections. (*The Immune System and Cancer | Cancer Research UK*, n.d.)

Task

The doctor orders Amoxicillin 25mg PO TID for the child who weighs 26 pounds. The supply you have from the pharmacy is 50 mg/5ML oral suspension. The safe dosage range for the drug is 15mg/kg/day in divided doses.

Calculate the maximum dosage a child of this weight can receive each day, and how much that would be for each dose if given 3 doses.
Also calculate how many mL of Amoxicillin this child will receive each dose and explain if that dosage is safe for this child.

Some specific details you need to know:
PO TID means by mouth three times a day
1 kg = 2.2 pounds.

The minimum post high school education required to be a **nurse** is an associate's degree in nursing (ADN). Most employers look for nurses to have earned a bachelor's degree in nursing BSN. All U.S. nurses must take and pass a national exam. Many states also require a license. To receive an Advance Practice Registered Nursing Degree (APRN), post graduate work is required.

The median salary for a RN is $73,300. Of course, this varies based on your work and geographical locations.

Short video: 10 signs that you were born to become a nurse (*10 Signs That You Were Born to Become a Nurse || EveryNurse.Org*, n.d.)

Answer:

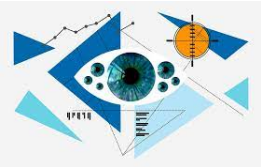
Safe Dosage:

First find the patient's weight in kilograms $\frac{1\ kg}{2.2\ lbs} = \frac{x}{26}$ => $x \approx 11.8\ kg$

(15mg/kg)(11.8 kg) = 177 mg/day is safe

(25mg)(3) = 75 mg, so dosage is safe

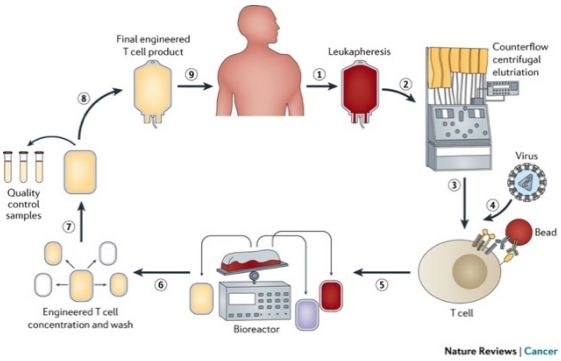
Dose: $\frac{50mg}{5mL} = \frac{25mg}{x}$ => x = 2.5 mL per dose.



Career: Biomanufacturing Technician

A **biomanufacturing technician** works in a lab with cells. In our task, the technician has to calculate many steps in the cell making process.

Our body makes & uses T cells to fight bacteria & viruses; they are part of our immune system. New cancer research is using synthetic (made in a lab) T-cells to target specific cancer cells to destroy them. The cells they make are called chimeric antigen receptor T cells or CAR T cells.
This treatment is called Immunotherapy.



Task

The cell concentration is 1.5 x 10^6 cells/mL. This means in a mL container, there are 1.5 million cells. A mL of water weights 1 gram. One milliliter is about 20 drops of water and a teaspoon contains 5 mL. Does this give you an idea of the size of a cell?

The culture bag where the cells grow, contains media and cells. This culture bag weighs 212g. 212 grams is the weight of a 80 pennies, 4 pop tarts or an adult hamster.

Flow cytometry is a technique used to detect the characteristics of cells. **When the manufactured cells go through the flow cytometry process, 22.7% of them are the actual desired CAR T cells.**

How many CAR T cells are there in a culture bag?(Fesnak, 2021)

To be a **biomanufacturing technician**, you need an associate's degree. In 2020, the national average salary was $46,340/year. short video(*What Is Biomanufacturing? | Biotech Careers*, n.d.)
More details about becoming a biotech careers(*Biotech Careers | The Best Source of Information about Biotech Careers and Companies*, n.d.)

A doctor who specializes in the immune system is called an **immunologist**. After medical school and residency (7 years), a doctor must complete an immunology fellowship. Licensing is required and board certification is highly recommended. The average salary of an immunologist is $200,900.
short video(*How To Become An Immunologist - Career Igniter*, n.d.)
More details about becoming an immunologist(*How to Become an Immunologist*, n.d.)

A doctor who specializes in cancer is called an **oncologist**. After medical school and residency (7 years), a doctor must complete an oncology fellowship in various sub-specialty such as **pediatric oncology**, **gynecological oncology**, etc. Licensing is required and board certification is highly recommended. short video(*How to Become an Oncologist*, n.d.-a)
More details on how to become an oncologist(*How to Become an Oncologist*, n.d.-b)

The answer:

1.5×10^6 cells in 1 mL = 1.5×10^6 cells in 1 gram.

The culture bag contains 212 grams, so
(1.5×10^6 cell/g)(212g) = $318 \times 10^6 = 3.18 \times 10^8$ cells in a culture bag.

22.7% of these cells are CAR T cells, so
(3.18×10^8 cells)(22.7%) = $.72186 \times 10^8 = 7.2186 \times 10^7$ = 72,186,000 CAR T cells

Or without scientific notation

(1,500,000cells/g)(212g) = 318,000,000 cells
22.7% of 318,000,000 cells= 72,186,000 CAR T cells

Career: Pharmacist & Pharmacy Technicians

Task 1

Often times, patients who receive chemotherapy have their medicine infused or delivered intravenously (IV). The drugs are prepared in a chemo transport bag on an individual basis after the patient has arrived and their height, weight and sometimes a blood sample have been collected and analyzed. A **pharmacy technician** gathers all of the supplies needed to prepare each dose. Another pharmacy technician mixes the items in a sterile environment. The **pharmacist** checks the technician's work before the drugs are administered by an **oncology nurse**.

The amount of drug or *dose* a patient receives is based upon their height and weight. A formula is used to find their Body Surface Area (BSA). This number is then used with the protocol dose to find the patient's exact dose. While there are many formulas to find a patient's BSA, the Mosteller formula is the most straight forward mathematically. Your task will be that of the pharmacist, finding the patient's correct dose of each of their chemotherapy drugs.

Your patient weighs 70kg and is 155cm tall and has breast cancer. Her oncologist orders 500mg/m^2 of fluorouracil with 100mg/m^2 of epirubicin and 500mg/m^2 of cyclophosphamide. Calculate the dose of each drug in mg, for the patient. Use the Mosteller formula to calculate her BSA and round to the nearest hundredth.(*Dosage Calculations Based on Body Surface Area - YouTube*, n.d.)

Mosteller formula: BSA $= \sqrt{\frac{\boldsymbol{height(cm) \times weight(kg)}}{\mathbf{3600}}}$

A **pharmacist technician** needs to be certified by taking the Pharmacy Technician Certification Exam (PTCE). You can attend a training program or get an associate's degree to help you prepare for the exam. A pharmacy technician can make an average of $35,100 annually. short video(*Pharmacy Technician - Explore Health Care Careers - Mayo Clinic College of Medicine & Science*, n.d.)

A **pharmacist** usually attends between 6-8 years in post-secondary education to receive a Doctor of Pharmacy degree. Some of the 4-year programs accept students with an associate's degree, but many require a bachelor's degree. There are also some 6-year programs you can enter after high school. Details on how to become a pharmacist(*Pharmacists : Occupational Outlook Handbook: : U.S. Bureau of Labor Statistics*, n.d.)

A nurse who specializes in cancer care is called an **oncology nurse**. After earning a bachelor's degree in Nursing (BSN), a nurse will need to learn specific cancer care skills through coursework, clinical practice or continuing education. After that, an exam is necessary to earn a certification as an OCN. The median annual salary for a certified oncology nurse is $77,460. In order to become an **oncology nurse practitioner**, a nurse must have a master's degree and become an advanced practice registered nurse, APRN. More information on becoming a certified oncology nurse or nurse practitioner(*Oncology Nurse Careers and Education | All Nursing Schools*, n.d.)

A doctor who specializes in cancer is called an **oncologist**. After medical school and residency (7 years), a doctor must complete an oncology fellowship in various sub-specialty such as **pediatric oncology**, **gynecological oncology**, etc. Licensing is required and board certification is highly recommended. The average salary for an oncologist is $263,000 annually. short video (*How to Become an Oncologist*, n.d.-a) More details on how to become an oncologist(*How to Become an Oncologist*, n.d.-b)

Answer

BSA = $\sqrt{\frac{(155)(70)}{3600}} = \sqrt{\frac{10{,}850}{3600}} = \sqrt{3.01} \approx 1.74\ m^2$

Fluorouracil: (500 mg/m^2)(1.74 m^2) = 870 mg

Epirubicin: (100 mg/m^2)(1.74 m^2) = 174 mg

Cyclophosphamide: (500 mg/m^2)(1.74 m^2) = 870 mg

Career: Pharmacist & Pharmacy Technicians

Task 2

Often times, patients who receive chemotherapy have their medicine infused or delivered intravenously (IV). The drugs are prepared and delivered in a chemo transport bag on an individual basis after the patient has arrived and their height, weight and sometimes a blood sample have been collected and analyzed. A **pharmacy technician** gathers all of the supplies needed to prepare each dose. Another pharmacy technician mixes the items in a sterile environment. The **pharmacist** checks the technician's work before the drugs are administered by an **oncology nurse**.

The amount of drug or *dose* a patient receives is based upon their height and weight. A formula is used to find their Body Surface Area (BSA). This number is then used with the doctor's prescribed dose to find the patient's exact dose. While there are many formulas to find a patient's BSA, the Mosteller formula is the most straight forward mathematically. Your task will be that of the pharmacist, finding the patient's correct dose of each of their chemotherapy drugs.

The drug carboplatin for ovarian carcinoma is administered intravenously at a dose of 360mg/m^2, except in patients with impaired kidney function. If this is the case, the dose is reduced by 30%. (When a patient's kidneys are diseased or impaired, the effect of any drug can be altered by patient susceptibility, pharmacodynamic changes or pharmacokinetic changes.) Your patient is 5ft. 2in. and weighs 110lbs. She is renally (kidney) impaired. Calculate the dose of carboplatin for the patient. Use the Mosteller formula to calculate her BSA and round to the nearest hundredth. (*Dosage Calculations Based on Body Surface Area - YouTube*, n.d.)

Mosteller formula: BSA $= \sqrt{\frac{\boldsymbol{height(in) \times weight(lb)}}{\mathbf{3131}}}$

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A **pharmacist** usually attends between 6-8 years in post-secondary education to receive a Doctor of Pharmacy degree. Some of the 4-year graduate programs accept students with an associate's degree, but most require a bachelor's degree. There are also some 6-year Pharm.D. programs you can enter after high school. A pharmacist earns on average $129,000 annually. Details on how to become a pharmacist(*Pharmacists : Occupational Outlook Handbook: : U.S. Bureau of Labor Statistics*, n.d.)

A nurse who specializes in cancer care is called an **oncology nurse**. After earning a bachelor's degree in Nursing (BSN), a nurse will need to learn specific cancer care skills through coursework, clinical practice or continuing education. After that, an exam is necessary to earn a certification as an OCN. The median annual salary for a certified oncology nurse is $77,460. In order to become an **oncology nurse practitioner**, a nurse must have a master's degree and become an advanced practice registered nurse, APRN. More information on becoming a certified oncology nurse or nurse practitioner(*Oncology Nurse Careers and Education | All Nursing Schools*, n.d.)

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A doctor who specializes in kidney problems is called a **nephrologist**. After medical school and residency (7 years), a doctor must complete a nephrology fellowship for another 2-3 years and then pass a certification exam. In 2019, a newly certified nephrologist earned $200,000 annually. More details on becoming a nephrologist(*Starting a Career in Nephrology | FMCNA*, n.d.)

Answer

5ft. 2in. = 5(12) + 2 = 62 inches

BSA = $\sqrt{\frac{(62)(110)}{3131}} = \sqrt{\frac{6{,}820}{3131}} = \sqrt{2.18} \approx 1.48\, m^2$

If patient's dose is reduced by 30%, patient will receive 100% - 30% = 70% of the drug. You can take this reduction with the recommended dose or with the calculated exact dose.

(360 mg/m^2)(70%) = 252 mg/m^2

(252 mg/m^2)(1.48 m^2) = 372.96 mg of carboplatin

OR

(360 mg/m^2)(1.48 m^2) = 532.8 mg

(532.8 mg)(70%) = 372.96 mg of carboplatin

Career: Pharmacist & Pharmacy Technicians

Task 3

Often times, patients who receive chemotherapy have their medicine infused or delivered intravenously (IV). The drugs are prepared in a chemo transport bag on an individual basis after the patient has arrived and their height, weight and sometimes a blood sample have been collected and analyzed. A **pharmacy technician** gathers all of the supplies needed to prepare each dose. Another pharmacy technician mixes the items in a sterile environment. The **pharmacist** checks the technician's work before the drugs are administered by an **oncology nurse**.

The amount of drug or *dose* a patient receives is based upon their height and weight. A formula is used to find their Body Surface Area (BSA). This number is then used with the doctor's prescribed dose to find the patient's exact dose. The most widely used formula to calculate BSA is the Dubois & Dubois formula which was presented in 1916. Many healthcare professionals are instead using the Mosteller formula, presented in 1987. Miscalculations in finding a patient's BSA can have many negative consequences. Studies show that up to 30% of patients have received inadequate treatment because of these errors. *Insert citation* Your task will be to calculate the patient's dose using each formula to find BSA and then compare the actual amounts of the drug the patient has received.

Your patient weighs 85kg and is 190cm tall and has non-Hodgkins lymphoma. His medication is dosed at 420 mg/m^2 over 4 hours. How much of the drug in milligrams is the patient getting in his infusion? How much is he getting every hour? Use both the Mosteller formula and the DuBois & DuBois formula to find his BSA (so you will do the dose calculations twice.) Find the difference in milligrams between the total doses from each BSA calculation.

Mosteller formula: BSA $= \sqrt{\frac{height(cm) \times weight(kg)}{3600}}$

Dubois formula: BSA = $(.007184 \times weight(kg)^{0.425})(height(cm)^{0.725})$

A **pharmacist technician** needs to be certified by taking the Pharmacy Technician Certification Exam (PTCE). You can attend a training program or get an associate's degree to help you prepare for the exam. A pharmacy technician can make an average of $35,100 annually. short video(*Pharmacy Technician - Explore Health Care Careers - Mayo Clinic College of Medicine & Science*, n.d.)

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Answer

BSA Mosteller = $\sqrt{\frac{(190)(85)}{3600}} = \sqrt{\frac{16,150}{3600}} = \sqrt{4.49} \approx 2.12\ m^2$

BSA Dubois = $(.\mathbf{007184} \times \boldsymbol{weight}(\boldsymbol{kg})^{\mathbf{0.425}})(\boldsymbol{height}(\boldsymbol{cm})^{\mathbf{0.725}})$

= $(.\mathbf{007184} \times \mathbf{190}^{\mathbf{0.425}})(\mathbf{85}^{\mathbf{0.725}})$

= $(.\mathbf{007184} \times \mathbf{9.30})(\mathbf{25.05})$ = $(.\mathbf{067})(\mathbf{25.05}) \approx \mathbf{1.67}\ \boldsymbol{m}^{\mathbf{2}}$

Total Dose Mosteller: (420 mg/m^2)(2.12 m^2) = 890.4 mg
Hourly Dose Mosteller: 890.4 mg/4 hours = 222.6 mg/hr

Total Dose Dubois: (420 mg/m^2)(1.67 m^2) = 701.4 mg
Hourly Dose Dubois: 701.4 mg/4 hours = 175.35 mg/hr

Difference in totals: 890.4mg – 701.4mg = 189 mg

Career: Healthcare Data Scientist

As we have learned from COVID 19, testing or **screening** is an important part of our healthcare system. Likewise, screening plays a vital part in cancer care. Screenings for many cancers are done on a regular basis, when a person does NOT have symptoms of the disease. The purpose is to find disease, in this case, cancer, in its early stage. Screenings for cancer can be varied, mostly in how and when. The debate over when cancer screenings are offered is often a theme in health disparities; that is not part of our task today.

Screening for cancer can be done with **imaging**, like mammography or an MRI, **clinical**, like a breast exam or skin check, or **pathology/biospecimen**, like a biopsy or blood test. While some tests have definite quantitative definitions, others are more open to interpretation. Think of when you take a test based on a grade of 100. 30-40% of your possible results could be passing, while 60-70% could be considered failing. That leaves a lot of gray area. When interpreting test results, ***physicians*** who have to provide care for the patient, tend to err on the side of a positive diagnosis because the longer cancer is present, the more damage it does to one's body and the less likely to respond favorably to treatment, in other words, better safe than sorry. **Data scientists**, on the other hand, might want more definitive proof of the presence of disease and might err on the side of assuming no cancer is present in their analyses, but will look for further proof.

Task 1

Complete the value of the cells in the two-way table and interpret their meaning. Use the abbreviations T for Test, C for Cancer and + & – for positive and negative.

	Cancer Positive	Cancer Negative
Test Positive		
Test Negative		

Interpretation:

Upper left: _____ Upper right: _____

Lower left: _____ Lower right: _____

Which cells represent the truth?

Abstract & Keywords

Physicians, healthcare data scientists, and epidemiologists measure the validity of medical tests and screenings using probability and percentages. In order to find the percentages/probabilities, we'll need to find and use totals from the table.

Task 2

The two-way table below has been populated with data from screening mammogram classification among women ages 50 to 59 at the time of screening. Breast Cancer Surveillance Consortium Data Explorer, 1994-2009 (BCSC Data Explorer [Internet]. Seattle: Breast Cancer Surveillance Consortium. 2011- [cited 2019 Oct 20]. Available from: http://tools.bcsc-scc.org/dataexplorer/.).
Calculate the cells that represent Totals.

	Cancer Positive	Cancer Negative	Total
Test Positive	7,044	165,115	
Test Negative	1,534	1,623,399	
Total			

Next, we'll define the probabilities and percentages. **Sensitivity, S_e**, $(\frac{C+/T+}{Total\ C+} * 100)$, measures the probability that a person who has cancer gets a test result of positive. **Specificity, S_p**, $(\frac{C-/T-}{Total\ C-} * 100)$, measures the probability that a person who does not have cancer gets a test result of negative. **Positive predictive value, PPV**, $(\frac{C+/T+}{Total\ T+} * 100)$, measures the percentage of people with a positive result who actually have cancer while **negative predictive value, NPV**, $(\frac{C-/T-}{Total\ T-} * 100)$, measures the percentage of people with a negative result who actually do not have cancer. (*Performance Measures - Assessment of Cancer Screening: A Primer - NCBI Bookshelf*, n.d.)

Find the probabilities and percentages for the table of values above. Discuss your results and their ramifications.

Sensitivity: _____

Specificity: _____

PPV: _____

NPV: _____

Abstract & Keywords

An **epidemiologist** is often called a disease detective. They use statistical analysis to study characteristics of a disease including how a contagious disease is spread. They also use statistics to analyze screenings and disease testing methods. (*Who Are Epidemiologists? | Teacher Roadmap | Career Paths to Public Health | CDC*, n.d.) To be an epidemiologist you need a master's degree in public health, with a concentration in epidemiology. The average annual salary is $74,560.(*Epidemiologists : Occupational Outlook Handbook: : U.S. Bureau of Labor Statistics*, n.d.) More details and a short video

A **healthcare data scientist** uses data to improve the healthcare system through analysis and mathematical modeling. This could mean helping hospitals operate more efficiently, influencing diagnostic and treatment processes, or developing artificial intelligence to diagnose and predict disease. To become a healthcare data scientist, you earn and bachelor's degree in a mathematical or computer science based major, and then pursue a master's degree in health data science. The average entry level salary of a healthcare data scientist is $93,202. (*What Does a Data Scientist in Healthcare Do?*, n.d.) More information about healthcare data science

Answers

	Cancer Positive	Cancer Negative
Test Positive	C+/T+	C+/T-
Test Negative	C-/T+	C-/T-

Interpretation:

Upper left: Has Cancer/Tested Positive

Upper right: No Cancer/Tested Positive

Lower left: Has Cancer/Tested Negative

Lower right: No Cancer/Tested Negative

Which cells represent the truth:

UL: C+/T+ and LR: C-/T-

	Cancer Positive	Cancer Negative	Total
Test Positive	7,044	165,115	172,159
Test Negative	1,534	1,623,399	1,624,933
Total	8,578	1,788,514	**1,797,092**

Sensitivity: 7,044/8,578 = 82%

Specificity: 1,623,399/1,788,514 = 91%

PPV: 7,044/172,159 = 4%

NPV: 1,623,399/1,624.933 = 99.9%

Sensitivity and specificity characterize the accuracy of the test. Our testing process would be ideal if our sensitivity was higher than 82%. This means 18% of the people tested who have cancer, received a negative test result, called **false negative**. With frequent enough screenings, or if symptoms exist, more testing will take place and cancer will be detected if it is there.

The specificity rate of 91% means that, out of the tested patients who don't have cancer, 9% were told (falsely) that they have cancer, called **false positive**. Further testing is always done, often times a clinical exam or biopsy to rule out cancer.

The positive and negative predictive values (PPV and NPV) provide guidance on how to treat a positive and negative test respectively. PPV & NPV are different than sensitivity, specificity, false positives and false negatives, because those values are measured out of patients with or without cancer. Positive and negative predictive probabilities use patients' test results as the base value for finding the percent.

A PPV of 4% means that of those women who tested positive, only 4% of them actually have cancer. So, after receiving the results of a positive mammogram screening, often enough, there is no cause for alarm. Note, that this data represents screenings of women with no symptoms, and that will keep the PPV low. The prevalence of cancer in this data is 8578/1797092, which is about 0.5%.

An NPV of 99.9% means when a woman gets a negative test result, she can be 99.9% sure she does not have cancer.

Abstract & Keywords

Careers in Cancer

Catherine Michini
Philadelphia High School for Girls

Abstract

This curriculum unit introduces high school math students to health profession careers, specifically in the field of cancer. There are numerous careers at many entry levels requiring varied levels of education. After an introduction lesson to cancer itself and the various careers, students will complete mathematical tasks in teams. The tasks feature mathematical problems from specific fields of cancer, that represent procedures and processes people in those jobs actually do. Not only will students be doing real world problems, they will be learning a little about who would be doing those problems in their line of work. It is predicted that in the year 2040, there will be over 30 million new cases of cancer. Not only are careers in cancer available, they are needed! The hope is that by completing these career based mathematical tasks, students will be engaged and interested and think about career pathways for their future.

Keywords

Careers, cancer, oncology, pharmacy, biomanufacturing, nursing, CAR T cells, Body surface area, chemotherapy infusion dosing, career investigation, immunology, two-way tables.