Instructor Resources Sample

This is a sample of the instructor resources for *Managerial Epidemiology: Cases and Concepts, Fourth Edition*, edited by Steven T. Fleming.

The complete instructor resources include the following:

- Test bank
- Presentation PowerPoint slides for each chapter and capstone case
- Answer guides to the end-of-book capstone cases

This sample includes the PowerPoint slides for chapter 4.

If you adopt this text, you will be given access to the complete materials. To obtain access, e-mail your request to hapbooks@ache.org and include the following information in your message:

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CHAPTER 4
Measuring and Interpreting Morbidity

Colonoscopy song

What is disease?

"An interruption, cessation or disorder of body functions, systems or organs" (Merrill 2016)

"Almost any departure from perfect health" (Weiss and Koepsell 2014)

"Any departure, subjective or objective, from a state of physiological or psychological well-being" (Porta 2014)—a definition that includes disease and illness

EXHIBIT 4.1
Natural History of Disease
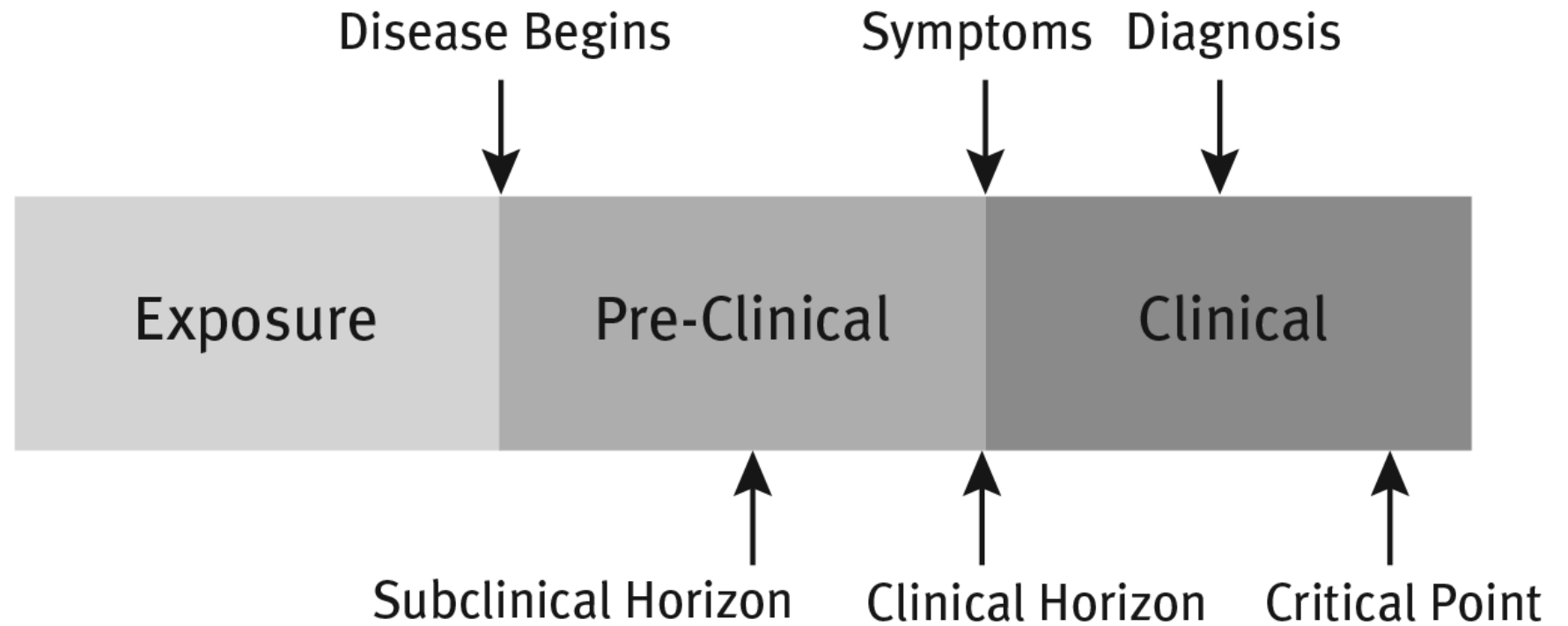
Two aspects of natural history

- Definition: Course of a disease over time from onset to resolution
- Process by which disease occurs
- Process of disease progression—movement from one stage to another

Course of disease: Two points

- Critical point: The moment in the progression of a disease before which treatment is more effective and after which major or severe consequences occur

- Clinical horizon: The point at which signs and symptoms make a disease detectable

- What happens if the critical point is before the clinical horizon? After?

Incidence versus prevalence

- Incidence: New cases of disease over a defined period

- Prevalence: Existing cases of disease over a defined period
  - Point prevalence: Cases at a particular point in time
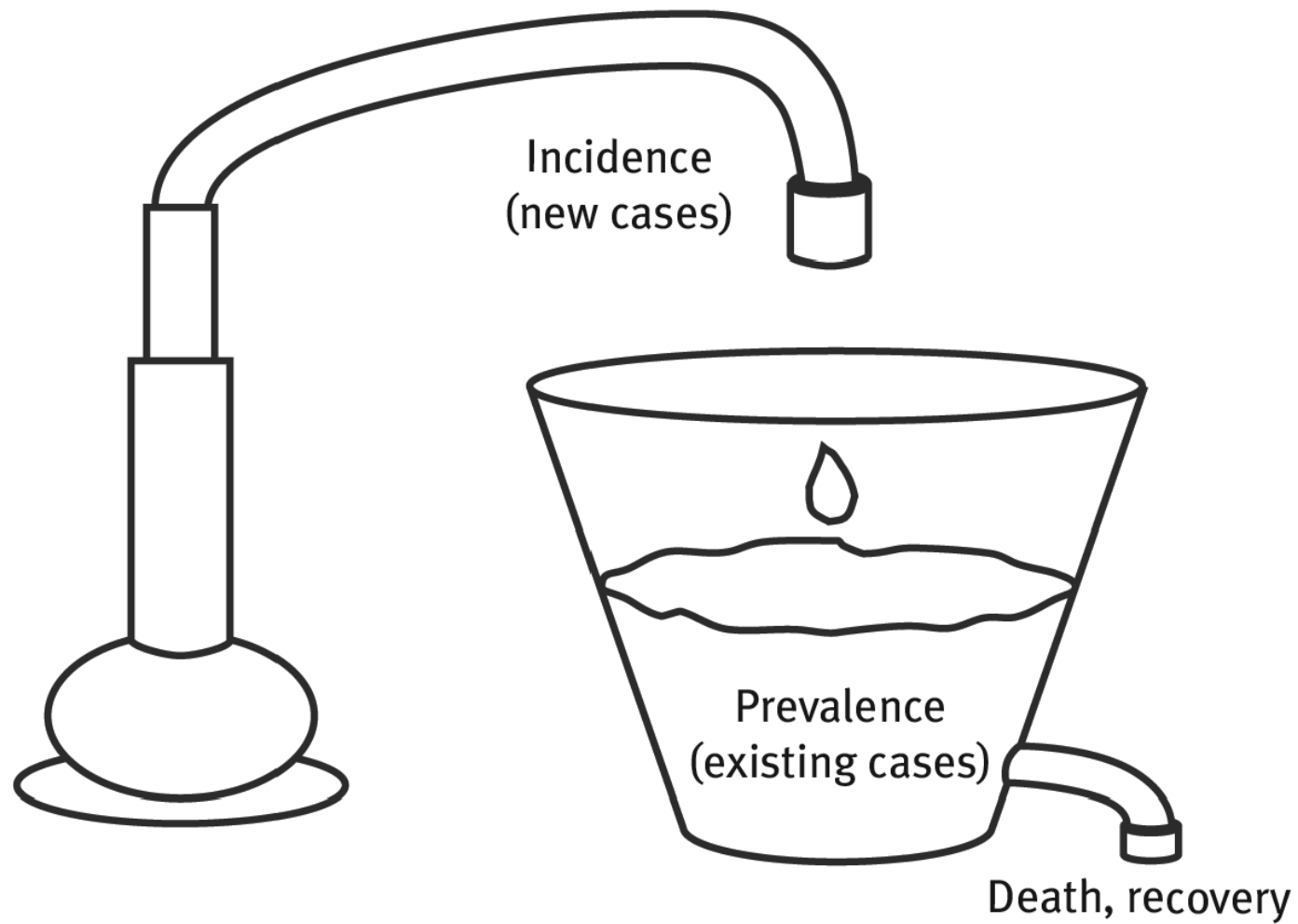 - Period prevalence: Cases over a period

EXHIBIT 4.2
Relationship Between Incidence and Prevalence

What is morbidity?

- Morbidity is disease
- Acute versus chronic disease
- Morbidity is measured by incidence/prevalence
- Morbidity is described by ICD-10 coding system

Sources of morbidity statistics

- Communicable disease reports
  - CDC's *Morbidity and Mortality Weekly Report*
  - Physicians/labs→ public health departments → CDC
  - Some notifiable diseases/life-threatening diseases reported directly to CDC
  - Notifiable diseases
    - Botulism/cholera/rabies, etc.: report by phone immediately
    - Hepatitis A/malaria/measles: report within one day
    - AIDS/mumps/Lyme disease: report within seven days
- Clinical records/hospital records
  - Viewed by some as biased because tied to reimbursement
  - Is it representative of the community? Not all sick people go to the hospital, there are access problems, and some conditions occur only in hospital
- Managed care organization records
- Morbidity registries (e.g., cancer registry)
- Record linkage of two or more sources
  - SEER data links cancer registry with Medicare claims

Surveys of disease and health

- National Health Interview Survey

- Health and Nutrition Survey

- National Hospital Discharge Survey

- National Notifiable Disease Surveillance System

- National Nursing Home Survey

- National Ambulatory Medicare Care Survey

Patterns of morbidity

- **Childhood and adolescence**
  - o Acute conditions—head colds, flu, injuries
  - o Chronic conditions—acne, asthma, hay fever, chronic sinusitis, accidents
- **Young and middle adulthood**
  - o Acute conditions—colds, flu, injuries, AIDS
  - o Chronic conditions—hypertension, heart disease, diabetes, arthritis
- **Elderly**
  - o Cancer, heart conditions, hypertension, arthritis, diabetes, hearing impairments
  - o Issues—loss of function, nursing home use

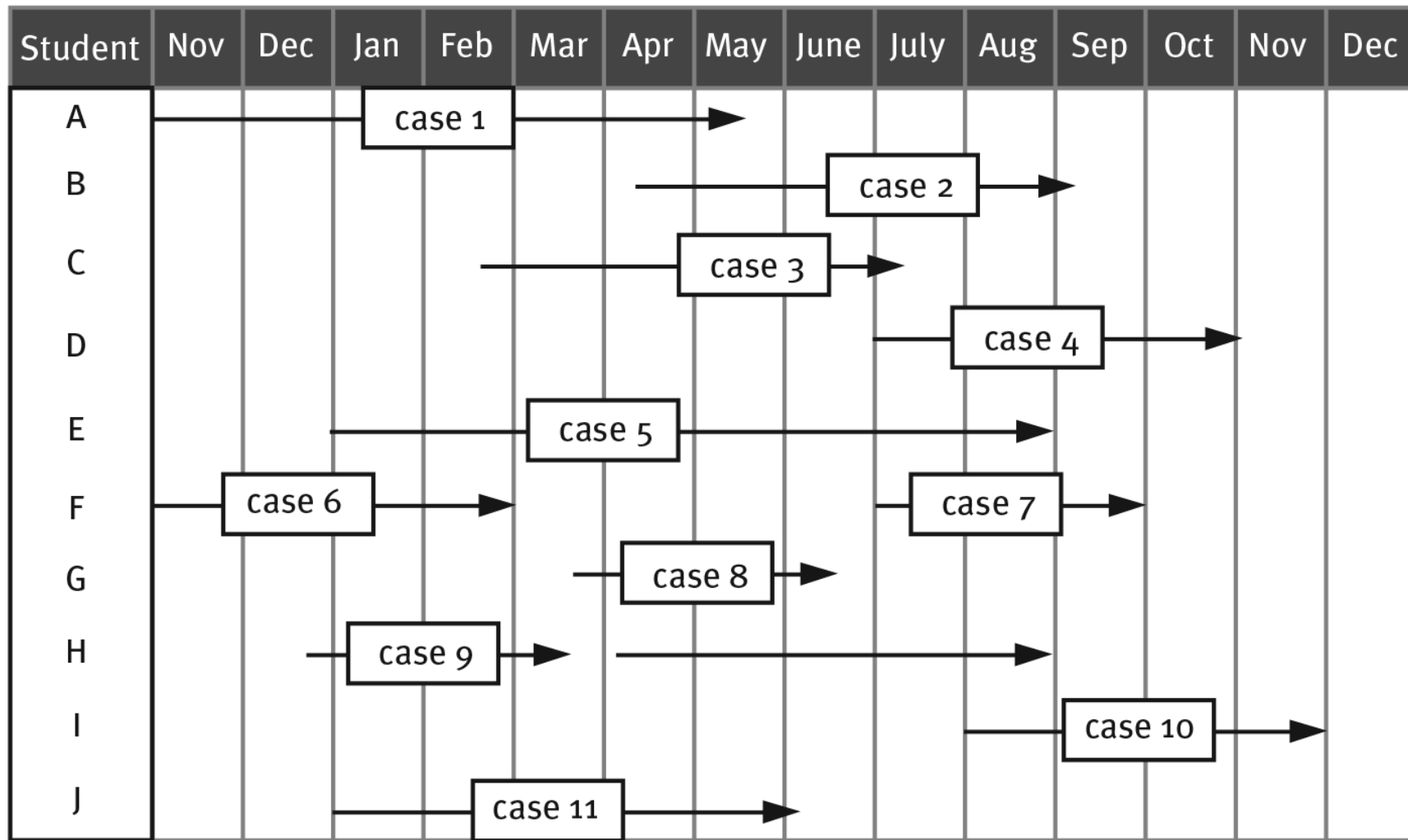*Source:* Valanis (1999).

EXHIBIT 4.3
Prevalence and Incidence Rates Among 1,000 College Students, November 2019–December 2020

Incidence and prevalence example

EXHIBIT 4.4
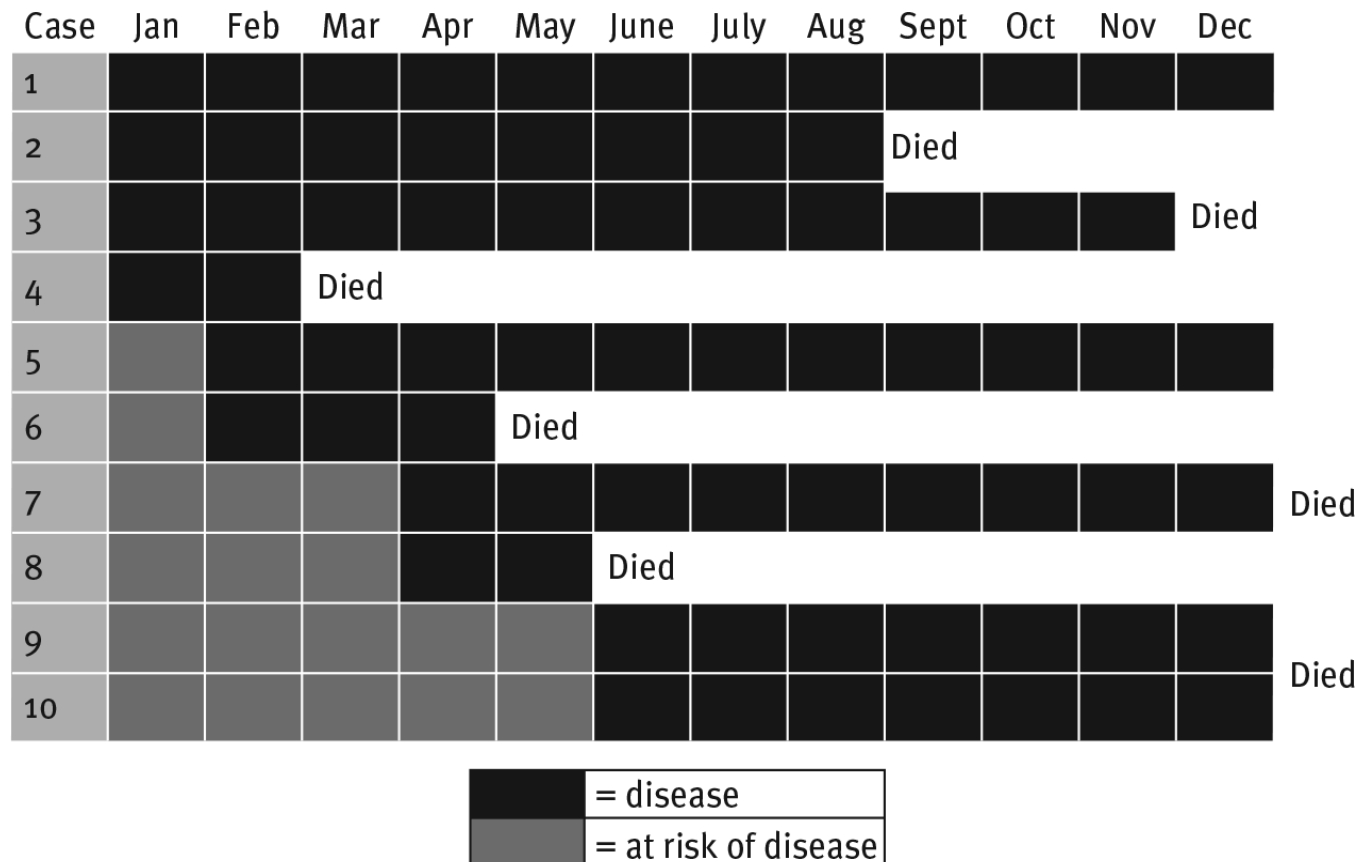Epidemiologic Investigation of Congestive Heart Failure 2020

Questions

1. What was the point prevalence on January 1, 2020?
2. What was the point prevalence on July 31, 2020?
3. What was the point prevalence on October 31, 2020?
4. What was the incidence rate during 2020?
5. What was the incidence density during 2020?
6. What was the mortality rate during 2020?
7. What was the case fatality rate during 2020?

Answers

1. Cases 1, 2, 3, and 4 = 4/1,000 or 4 per 1,000.

2. Cases 1, 2, 3, 4 (died), 5, 6 (died), 7, 8 (died), 9, 10 = 7/(1,000 – 3) = (7/997)*1,000 = 7.02 per 1,000. Note that 3 deaths need to be subtracted from the denominator since those people were not alive and present on this date.

3. 1, 2 (died), 3, 4 (died), 5, 6 (died), 7, 8 (died), 9, 10 = 6/(1,000 – 4) = (6/996)*1,000 = 6.02 per 1,000. Note that 4 deaths need to be subtracted from the denominator since those people were not alive and present on this date.

4. There are 6 new cases in denominator. The population at risk = 1,000 – 4 – (1/2)* 7, [6/(996 – 3.5)]* 1,000 = 6.05 per 1,000. Note that in the denominator we subtracted from the 1,000 cases the 4 prevalent cases at the beginning of the year, and one-half of the deaths that occurred during the year.

5. For incidence density (ID), the numerator is the same: 6 new cases. There were 990 people who did not get CHF or die during the year, so they were at risk for a total of 990 * 1 = 990 person-years. Cases 1–4 were not at risk for any time during the year. Cases 5–10 were at risk for a total of 18 months, or 1.5 person-years. ID = [6/(990+1.5)] *1,000 = 6.05 per 1,000 person-years.

6. For the mortality rate, there would be 7 deaths in the numerator and 1,000 people at risk of dying in the denominator = 7 per 1,000.

7. Case fatality measures the percentage of all cases who die within a period of time = 7/10 or 70%.

Testing for a Disease: Discrimination and Classification

EXHIBIT 4.5
Screening for
Disease

	Reality	
	Yes	No
Test Yes	(a) True positives	(b) False positives
No	(c) False negatives	(d) True negatives

"Appearances to the mind are of four kinds. Things either are what they appear to be [   ]; or they neither are, nor appear to be [   ]; or they are, and do not appear to be [   ]; or they are not, and yet appear to be [   ]. Rightly to aim in all these cases is the wise man's task." Epictetus (c. 50-120 AD) Discourses, Bk I, Chap 27

Four options with testing

- **True Negatives:** Peace of mind and sigh of relief

- **True Positives:** Benefit from detection if:
  - test detected disease before symptoms appear
  - earlier detection → improved prognosis
  - available treatment acceptable to patient

- **False Positives:**
  - Worry for a period of time
  - Discomforting/risky/costly diagnostic tests

- **False Negatives:** False sense of security

Sensitivity

- Ability of the test to correctly identify those with disease
- Probability of testing positive given the presence of disease
- True positives/(true positives + false negatives)
- Want high-sensitivity test if disease is relatively serious and cure is relatively inexpensive and available
  - Don't want many false negatives
- Tests with high sensitivity often used to "screen" for disease

Suitable Disease

o Disease serious enough
  o Severe health consequences and/or progressive
  o Is prevalent in population to be screened
  o Breast cancer, cervical cancer, hypertension, diabetes

o Treatment more effective at an earlier stage
  o Treatment available and acceptable
  o Treatment will alter outcome
    o Less severity
    o Prevent symptomatic phase
    o Prevent spread of disease

o Disease has a detectable preclinical phase (DPCP)

o DPCP is fairly long and of high prevalence in the target population

Suitable Test

o Affordable, relatively inexpensive, non- or minimally invasive

o Available

o Valid, sensitive, specific

Specificity

- Ability of the test to correctly identify those without disease

- Probability of testing negative given the absence of disease

- True negatives/(true negatives + false positives)

- Want high-specificity test if disease is not so serious and cure is relatively expensive or there are other significant costs, e.g. side effects of treatment etc.
  - Don't want many false positives

- Tests with high specificity often used to "confirm" results of highly sensitive but less specific tests
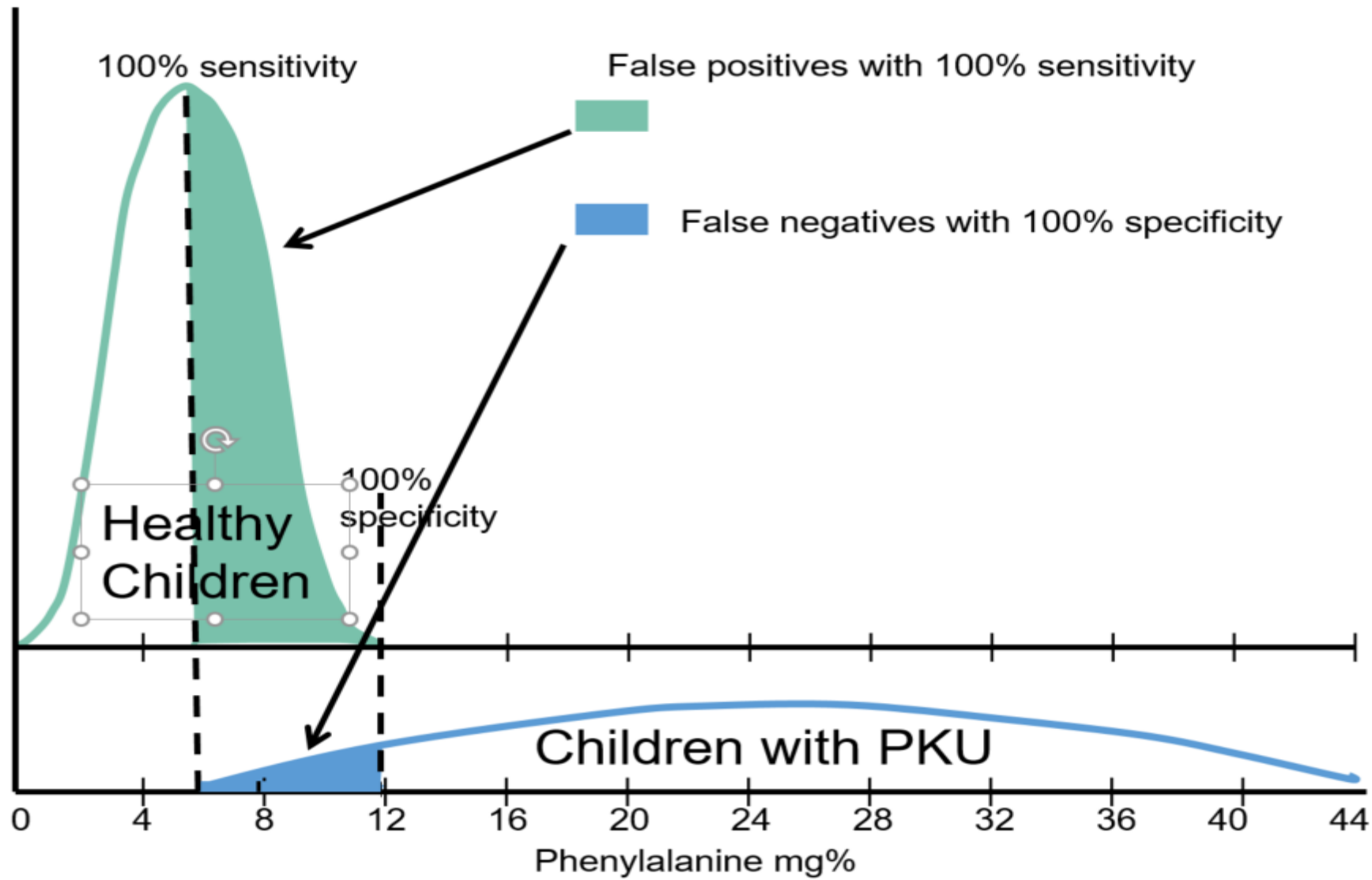
Validity: Sensitivity and specificity

Sensitivity and specificity

- Inherent characteristics of the test
- Stable over different populations with different disease prevalence
- Useful for comparing performance of two tests
    - e.g., digital versus film mammography (Pisano, *NEJM* 2005)
- Have a **reciprocal relationship** with one another

Validity: Sensitivity and specificity

Assume a population of 1,000 people of whom 100 have a disease. Of these 100 people, the test correctly identifies 80. Of the 900 disease-free people, the test correctly identifies 800.

DISEASE

		Yes	No
TEST	Positive	80 (a)	100 (b)
	Negative	20 (c)	800 (d)

Sensitivity = $a/(a + c) = 80/100 = 80\%$
Specificity = $d/(b + d) = 800/900 = 89\%$

Gordis, 2009, Table 5-1

Positive predictive value

- True positives/true positives + false positives
- True positives/all those with a positive test result

Negative predictive value

- True negatives/true negatives + false negatives
- True negatives/all those with a negative test result

Validity: Positive and negative predictive values

Assume a population of 1,000 people of whom 100 have a disease. Of these 100 people, the test correctly identifies 80. Of the 900 disease-free people, the test correctly identifies 800.

DISEASE

		Yes	No
TEST	Positive	80 (a)	100 (b)
	Negative	20 (c)	800 (d)

Positive PV = $a/(a + b) = 80/180 = 44\%$
Negative PV = $d/(c + d) = 800/820 = 98\%$

Gordis, 2009, Table 5-7

EXHIBIT 4.6

Sensitivity, Specificity, PPV, NPV by Disease Prevalence

	Disease (50%)		Disease (10%)		Disease (1%)	
Test	Yes	No	Yes	No	Yes	No
Yes	800	100	160	180	16	198
No	200	900	40	1,620	4	1,782
Totals	1,000	1,000	200	1,800	20	1,980

Disease (50%)	Disease (10%)	Disease (1%)
Sensitivity = 80%	Sensitivity = 80%	Sensitivity = 80%
Specificity = 90%	Specificity = 90%	Specificity = 90%
PPV = 0.89	PPV = 0.47	PPV = 0.07
NPV = 0.82	NPV = 0.98	NPV = 0.998

Accuracy of tests

- **Reliability:** Consistency of results
  - o Inter-rater reliability
  - o Intra-rater reliability

- **Validity**: Test represents reality?

- **Sensitivity:** Proportion with disease who test positive

- **Specificity:** Proportion without disease who test negative

- **Positive predictive value:** Proportion who test positive with disease

- **Negative predictive value:** Proportion who test negative without disease

Sequential (2 stage) testing

"believe the negative"

Stage 1 (Blood Cholesterol Test)

Sensitivity = 60%
Specificity = 70%
Population = 15,000
Prevalence = 10%

Heart Disease

|	Yes	No	
Positive	900	4050	4,950
Negative	600	9450	10,050
	1,500	13,500	15,000

Test Results

SEQUENTIAL (2 STAGE) TESTING

Stage 1 (Blood Cholesterol Test)

Sensitivity = 60%
Specificity = 70%
Population = 15,000
Prevalence = 10%

Stage 2 (Cardiac Cath)

Sensitivity = 95%
Specificity = 90%

Heart Disease

	Yes	No	
+	900	4050	4,950
−	600	9450	10,050
	1,500	13,500	15,000

Heart Disease

	Yes	No	
	855	405	1260
	45	3645	3690
	900	4,050	4,950
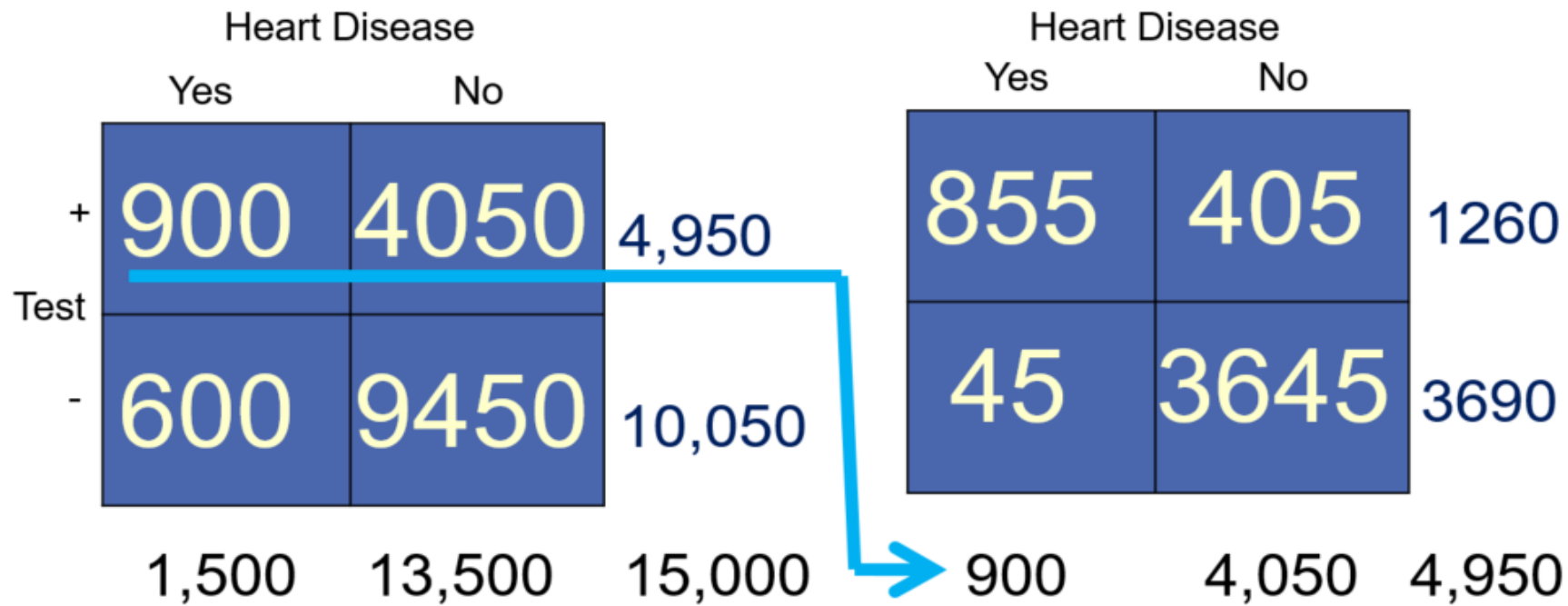
Test

If use two stage testing …   "believe the negative"

Only 405 false positives

Net sensitivity = 855/1500 = 57%

Net specificity = (3645 + 9450)/13,500 = 97%

Net PPV = 855/1260 = 68%

Net NPV = (9450 + 3645)/(10,050 + 3,690) = 95%

Note: This is a "believe the negative" (BN) rule since only those who test positive are tested again. Could also use a "believe the positive"(BP) rule where only those who test negative are tested again.

BP rule→sensitivity↑ specificity↓
BN rule→sensitivity↓ specificity↑

Case Study 4.2. Breast Cancer Screening

This case study evaluates the changes in test characteristics for breast cancer screening, with the first stage being magnetic resonance imaging (MRI) and the second stage being core needle biopsy (CNB). Assume sensitivity of 92 percent and specificity of 70 percent for MRI and sensitivity of 87 percent and specificity of 98 percent for CNB. Assume that the prevalence of breast cancer among women aged 20–40 is 0.2 percent, among all women aged 20 and older is 2 percent, and among women with symptoms is 10 percent.

	Cancer	No Cancer	Total
MRI+	1,840	29,400	31,240
MRI-	160	68,600	68,760
	2,000	98,000	100,000

EXHIBIT 4.7
MRI: Women Aged 20 and Older, 2 × 2 Table

	Cancer	No Cancer	Total
MRI+	184	29,940	30,124
MRI-	16	69,860	69,876
Total	200	99,800	100,000

EXHIBIT 4.8
MRI: Women Aged 20–40, 2 × 2 Table

EXHIBIT 4.9
MRI: Women with Symptoms, 2×2 Table

	Cancer	No Cancer	Total
MRI+	9,200	27,000	36,200
MRI-	800	63,000	63,800
Total	10,000	90,000	100,000

EXHIBIT 4.10
MRI and CNB Sequential Testing

	Cancer	No Cancer	Total
MRI+	1,840	29,400	31,240
MRI-	160	68,600	68,760
Total	2,000	98,000	100,000

	Cancer	No Cancer	Total
CNB+	1,601	588	2,189
CNB-	239	28,812	29,051
Total	1,840	29,400	31,240

Net sensitivity with simultaneous testing

"believe the positive" ....so A+, B+ or A+B+

Suppose that in a population of 10,000
people, 1,000 have the asthma.
Clinical test (A) sensitivity = 80%
Lab test (B)   sensitivity = 85%
Net sensitivity = A+, B+, or both

Step 1: 0.8 x 1000 = 800 who are A+
Step 2: 0.85 x 1000 = 850 who are B+
Step 2: 0.85 x 800 = 680 who are A+B+
Step 3: 800 – 680 = 120 who are A+ only
Step 4: 850 – 680 = 170 who are B+ only
Step 5: 680 + 120 + 170 = 970 A+, B+, or both
Step 6: 970/1000 = 97%
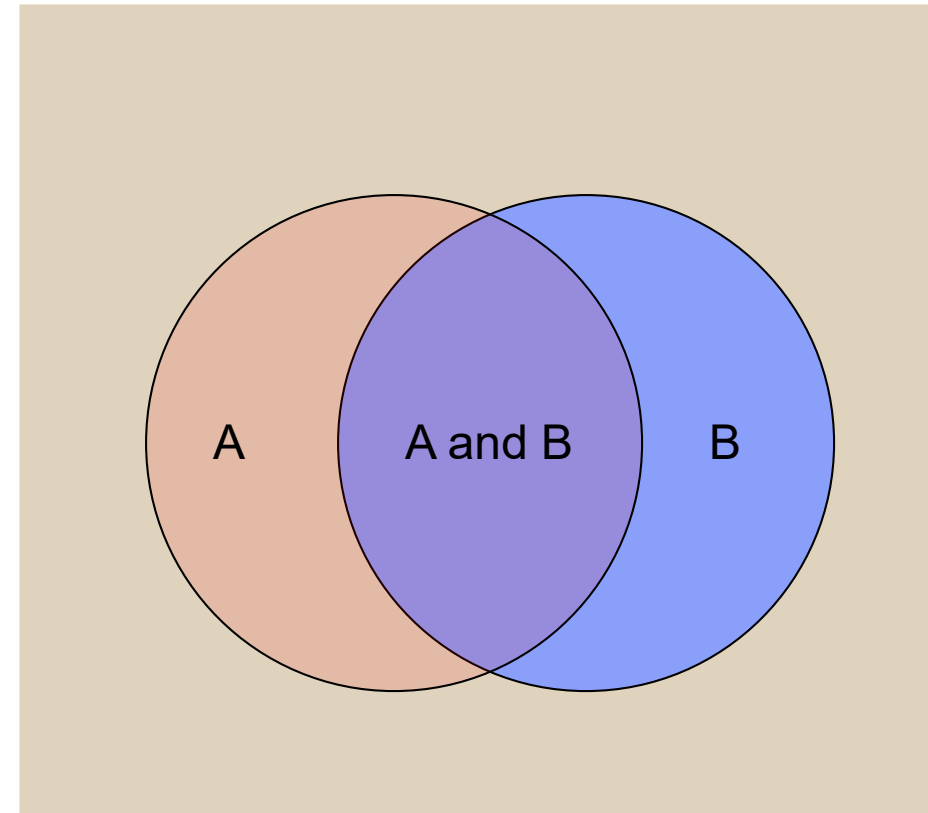
FOBT for colorectal cancer: Simultaneous testing

With the FOBT test, three stool samples are collected on consecutive days but evaluated simultaneously for the presence of blood. If we "believe the positive," it means a person would test positive if blood was found in one or more of the three samples. The concept of simultaneous testing is best illustrated by a Venn diagram. If three tests (A,B,C) are run simultaneously, patients can test positive on one or more of these tests, and we would expect some overlap of patients who test positive on two or three tests. For "believe the positive" simultaneous testing, the challenge is to calculate the total area of the overlapping circles.

Net sensitivity FOBT simultaneous testing

"believe the positive" ….so A+, B+, C+, A+B+, A+C+,B+C+,A+B+C+

Suppose that in a population of 100,000 people, 1,240
have the CRC.

FOBT #1 sensitivity = 60%
FOBT #2 sensitivity = 60%
FOBT #3 sensitivity = 60%
Net sensitivity = A+, B+, C+, or more than one

Step 1: 0.6 x 1,240 = 744 who are A+
Step 2: 0.6 x 1,240 = 744 who are B+
Step 3: 0.6 x 1,240 = 744 who are C+
Step 4: 0.6*744 = 446 who are   A+B+
                                  A+C+
                                  B+C+
Step 5: 0.6 x 446 = 268   a+b+c+
Step 6: 446 -268 = 178 who are a+b+
                               a+c+
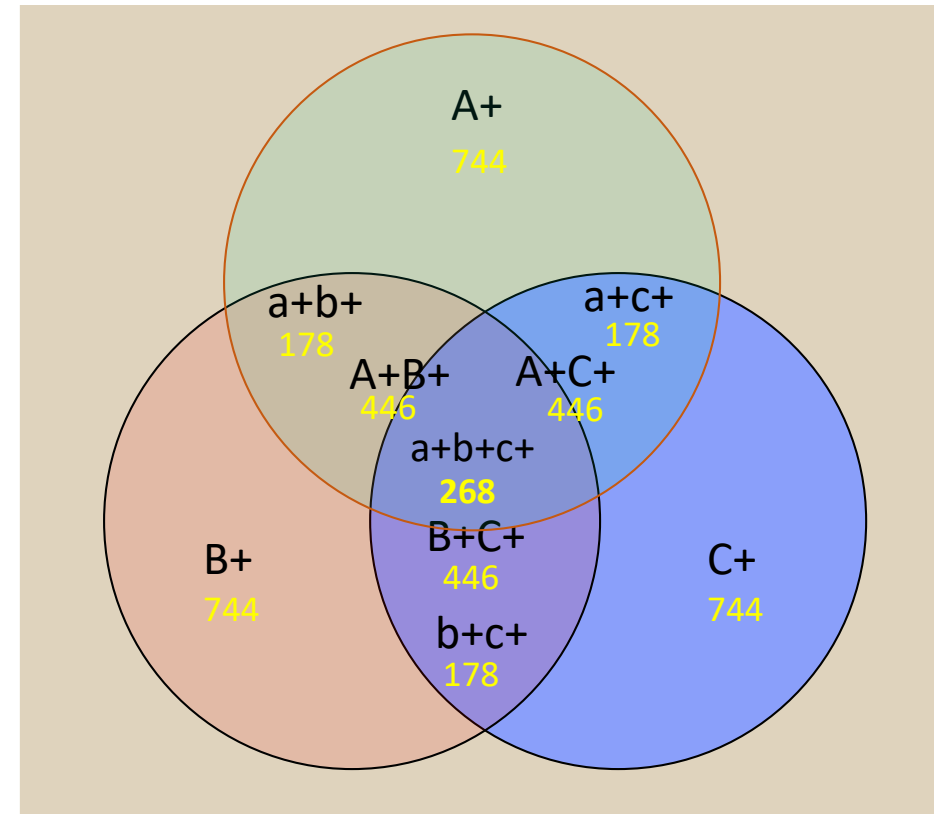   b+c+
Step 7: 744 -178-178-268 = 120 B+ only
                                C+ only
                                A+ only
Step 8: 120+120+120+178+178+178+268 =1162
Step 9: sensitivity = (1162/1240)*100 = 93.7%

Net specificity with simultaneous testing

"believe the positive" so A- and B-

Suppose that in a population of 10,000 people, 1,000 have the asthma, and 9,000 don't.

Clinical test (A) specificity = 75%
Lab test (B)   specificity = 80%
Net specificity = A+ and B+

Step 1: 0.75 x 9,000 = 6,750 who are A-
Step 2: 0.80 x 6,750 = 5,400 who are A- and B-
Step 3: 5,400/9,000 = 60%

Screening

- **Definition:** The "presumptive identification of unrecognized disease or defect by the application of tests, examinations, or other procedures that can be applied rapidly and inexpensively to populations."

Source: Valanis (1999).

Screening concepts

- Major strategy of secondary prevention

- Purpose: To distinguish well people with disease from those without

- Not supposed to be diagnostic

- Can apply screening to entire population or selectively to at-risk groups

- Can be part of periodic health exam

Criteria for a good screening program

- High specificity and sensitivity
- Simplicity, cost, safety, patient acceptability
- Disease should be serious enough
- Test detects disease at earlier stage
- Treatment if screen positive easier/more effective than treatment after symptoms
- Available treatment is acceptable to patients
- Prevalence of disease should be high in population to be screened
- Follow-up diagnostic/treatment available for patients who test positive

Source: Valanis (1999).

Individual risk versus benefit of screening

- **True negatives:** Peace of mind and sigh of relief

- **True positives:** Benefit from detection if:
  - Test detected disease before symptoms appear
  - Earlier detection → improved prognosis
  - Available treatment acceptable to patient

- **False positives:**
  - Worry for a period of time
  - Discomforting/risky/costly diagnostic tests

- **False negatives:** False sense of security

Screening versus diagnostic tests

- **Stage:** Screening before symptoms, diagnostic tests after symptoms
- **Characteristics:** Diagnostic tests ordered by doctor; require specialized equipment; are more expensive, more time consuming; may incur pain, discomfort, or risk; can give definitive diagnosis
- **Population:** Screening tests applied to healthy populations to identify disease before symptoms, to permit early treatment, simpler, less accurate, less expensive, less risky, more acceptable