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Micronutrient Detective: Solving the Clinical Puzzle

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Disclosure

None

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Learning Objectives

- Identify high-risk clinical scenarios for micronutrient depletion
- Recognize clinical signs and laboratory patterns suggestive of micronutrient deficiencies
- Select and interpret appropriate laboratory tests for assessment
- Develop practical individualized repletion strategies for micronutrient deficiencies

The Mystery

Meet the Case

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Meet the Case

- PHI: A 32-year-old female (weight 66.8 kg) is admitted to the ICU due to severe trauma in a motor vehicle collision.
- On ICU day 5, she requires ECMO cannulation because of acute respiratory distress syndrome. She also needs a blood transfusion because of blood loss during cannulation.
- On ICU day 7, she becomes septic and develops an acute kidney injury (SCr 3.87 mg/dL), which requires initiation of CRRT. She remains intubated, sedated, and paralyzed and in a nothing-by-mouth status since admission.

ICU: Intensive care unit
ECMO: Extracorporeal membrane oxygenation
CRRT: Continuous renal replacement therapy

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Meet the Case

- Social history:
  - Daily alcohol use (≥ 2 drinks/day)
- Past medical history:
  - Gastroesophageal reflux disease (GERD)
  - Diabetes mellitus (DM) Type II
- Home medications:
  - Pantoprazole, metformin
- Consult:
  - On ICU day 8, the nutrition support team was consulted to initiate parenteral nutrition

Incidence of Specific Micronutrient Deficiency

- One-third of the world's population has at least one micronutrient deficiency
  - **Iron:** 1/3 of the global population & >40% of children and pregnant women
  - **Vitamin A**: ~190 million global preschool children
  - **Zinc**: ~17% of the global population & ~82% of pregnant women
  - **Folate**: Inadequate intake estimated in 54% of the global population
  - **Vitamin D**: 5–7% of the U.S. population
  - **Vitamin B_6**: 16–23% of U.S. adults
  - **Vitamin B_{12}**: ~2–4% of U.S. adults

Allen LH. NEJM 2025;392(10):1006-16.
Han X, et al. EClinicalMedicine. 2022;44:101299.
Passarelli S, et al. Lancet Glob Health. 2024;12(10):e1590-9.

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Key Roles and Functions

Micronutrients	Roles: Cofactor	Roles: Coenzyme	Roles: Genetic Control	Roles: Antioxidant	Key Functions
Water-Soluble Vitamins					
Vitamin B_1 (thiamine)	–	✓	–	–	• Energy and carbohydrate metabolism • Nerve function
Vitamin B_2 (riboflavin)	✓	✓	–	–	• Energy production • Cell function • Fat metabolisms
Vitamin B_3 (niacin)	–	–	✓	–	• Macronutrients metabolism • Skin health
Vitamin B_5 (pantothenic acid)	–	–	✓	–	• Fatty acid synthesis • Energy metabolism
Vitamin B_6 (pyridoxine)	✓	✓	–	–	• Protein metabolism • Neurotransmitters formation
Vitamin B_7 (biotin)	–	✓	–	–	• Fatty acid, amino acids, and glucose metabolism • Skin, hair, and nails health
Vitamin B_9 (folate)	–	–	✓	–	• Cell division • DNA synthesis • Fetal development
Vitamin B_{12} (cobalamin)	–	✓	–	–	• RBC formation • Nervous system and brain function
Vitamin C (ascorbic acid)	–	–	–	✓	• Collagen synthesis • Neurotransmitters biosynthesis • Peptide hormone synthesis

Zhao VM. pp 123-145; In: CCSAP Nutrition and Fluids; 2024. Book 2.

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Key Roles and Functions

Micronutrients	Roles: Cofactor	Roles: Coenzyme	Roles: Genetic Control	Roles: Antioxidant	Key Functions
Fat-Soluble Vitamins					
Vitamin A (retinol)	–	–	–	✓	• Vision • Immune function • Skin and reproductive health
Vitamin D (cholecalciferol)	✓	✓	–	–	• Immune function • Bone health
Vitamin E (tocopherol)	–	–	–	✓	• Immune function
Vitamin K (phylloquinone)	–	✓	–	–	• Blood clotting • Bone metabolism

Zhao VM. pp 123-145; In: CCSAP Nutrition and Fluids; 2024. Book 2.

Key Roles and Functions

	Roles				
Micronutrients	Cofactor	Coenzyme	Genetic Control	Antioxidant	Key Functions
Trace Minerals					
Chromium	✓	–	–	–	• Enhances insulin action • Carbohydrate, protein, and fat metabolism • Intervenes in oxidase state
Copper	✓	–	–	✓	• Collagen synthesis • Iron metabolism • Connective tissue formation
Iron	–	–	✓	–	• Hemoglobin formation • Energy metabolism
Manganese	✓	–	–	✓	• Carbohydrate, amino acid, and cholesterol metabolism • Bone health
Selenium	✓	–	–	✓	• Thyroid function • Selenocysteine synthesis • Intra- and extracellular redox-regulation
Zinc	✓	–	✓	✓	• Immune function • Wound healing

Zhao VM. pp 123-145; In: CCSAP Nutrition and Fluids; 2024. Book 2.

Why It Matters Clinically

Micronutrient deficiencies drive clinically significant morbidity across multiple organ systems.

Physiologic Systems Affected

- 🩸 Anemia and functional impairment
- 🧠 Neurodevelopment and cognition
- 👁️ Vision and immunity

Clinical Outcomes Impacted

- 🤰 Maternal and perinatal outcomes
- ❤️ Cardiovascular risk
- ⚠️ Worsens outcomes in critical illness (infection, organ failure, mortality)

Allen LH. NEJM 2025;392(10):1006-16.
Passarelli S, et al. Lancet Glob Health. 2024;12(10):e1590-9.
Wendt AS, et al. Maternal & Child Nutrition. 2025;21: e70043.
An P, et al. J Am Coll Cardio. 2022:80(24):2269-85.

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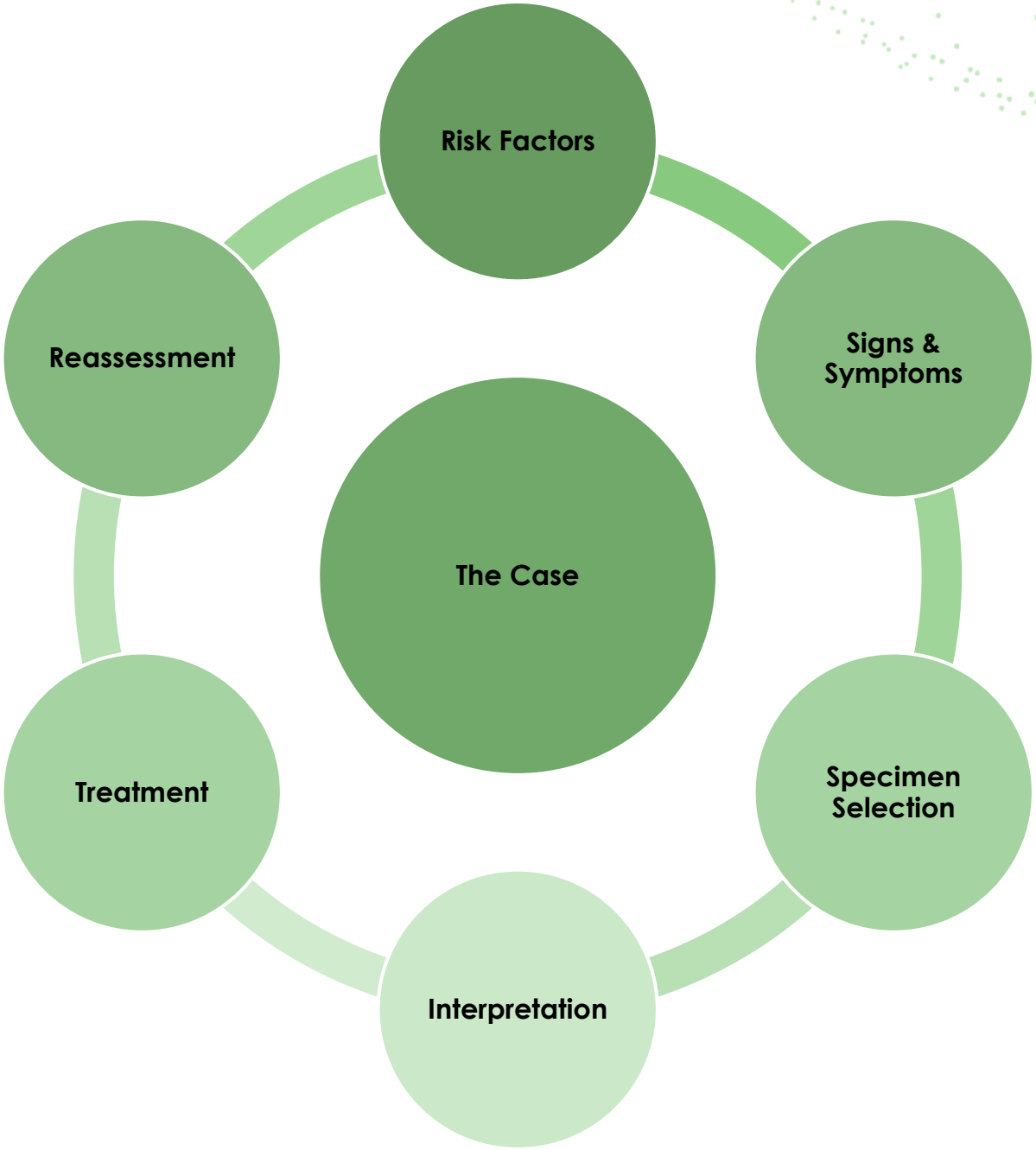
Polling Questions

What is the biggest challenge when evaluating micronutrient deficiencies?

A. Identifying who is at risk
B. Knowing what lab to order
C. Interpreting abnormal labs
D. Choosing treatment
E. All of the above



The Clinical Detective Framework

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Clue #1: Risk Factors

Who is at risk?

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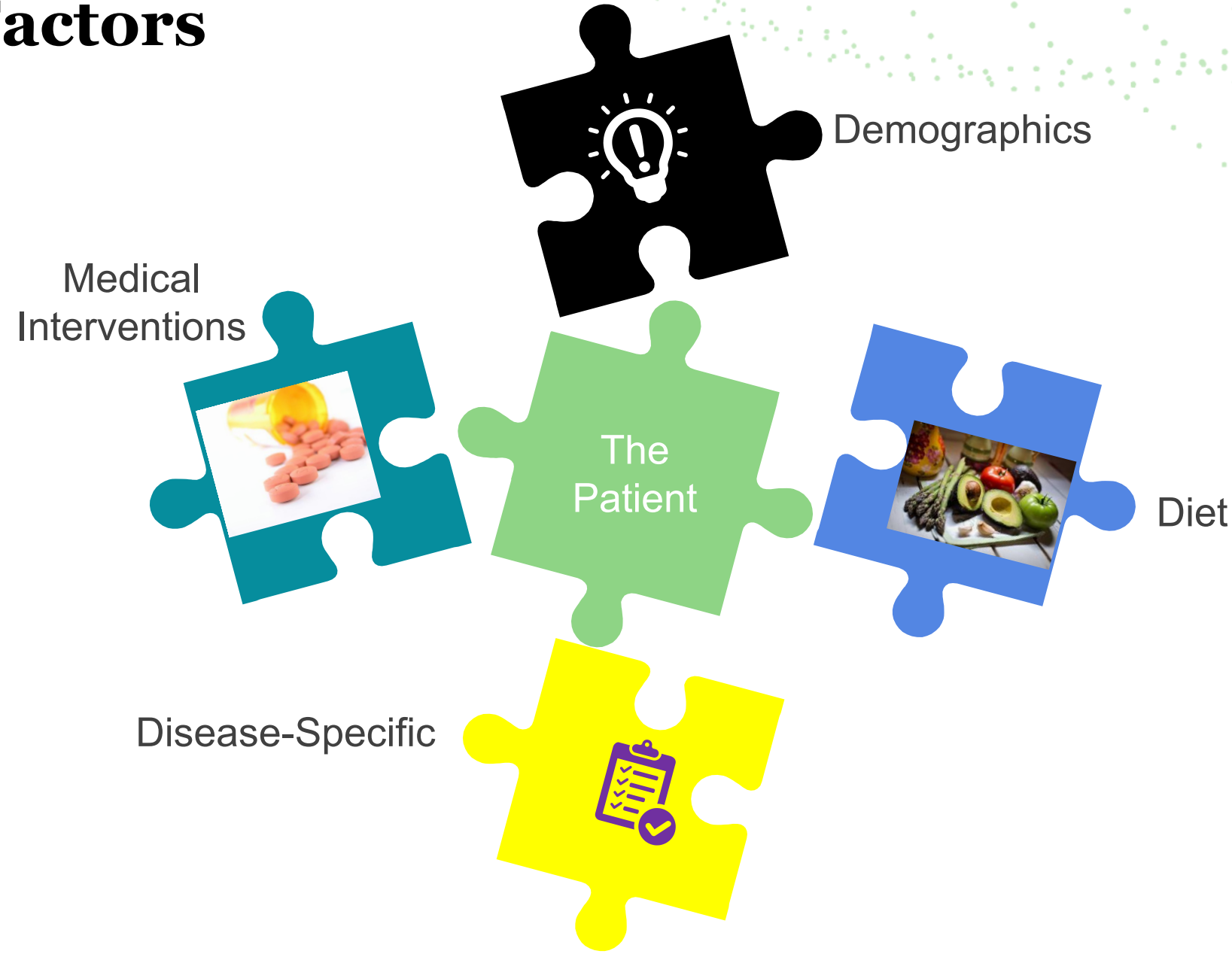
Risk Factors



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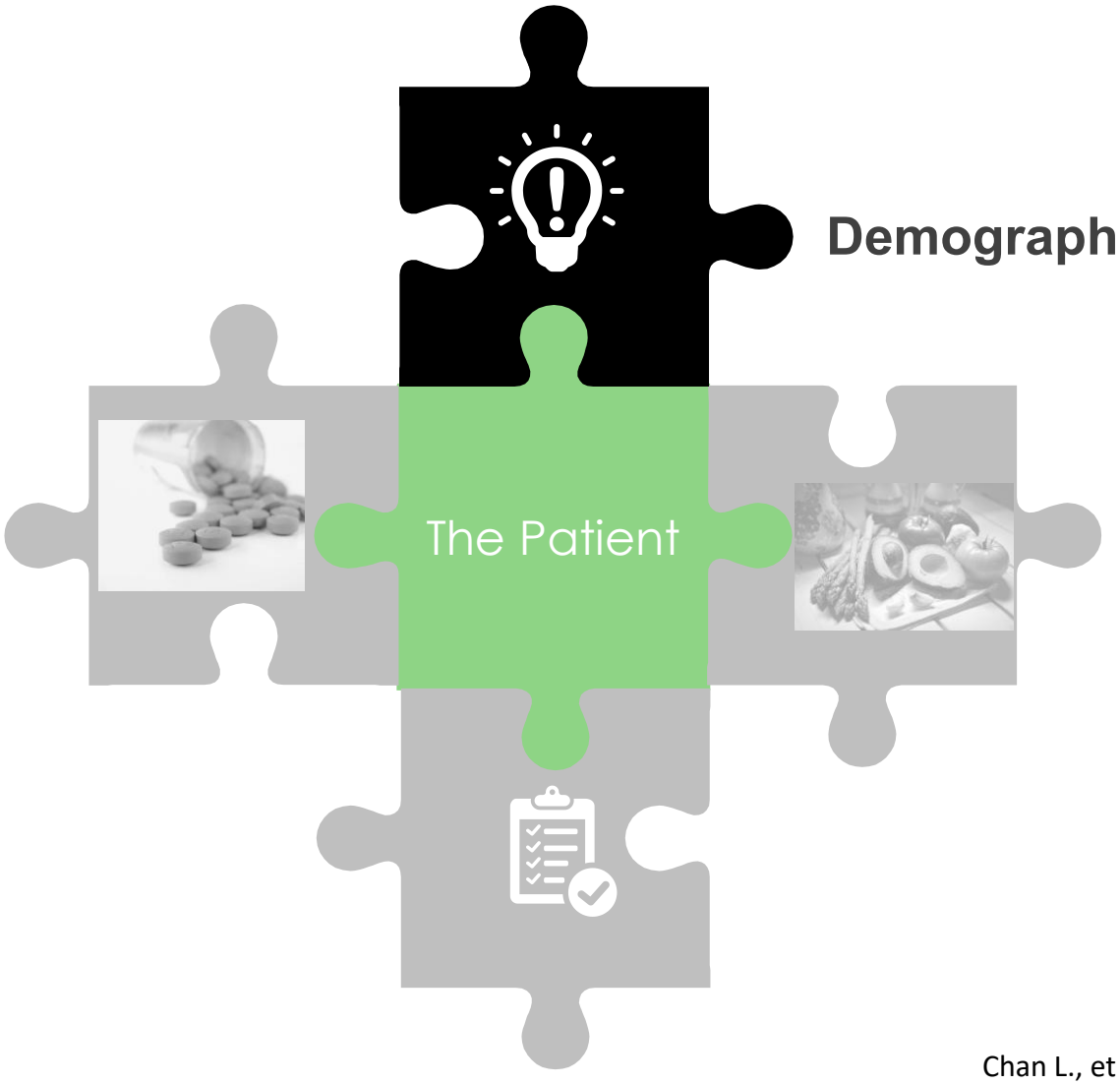
Patient –Specific Risk Factors



Demographic

- Infant
- Pregnant woman
- Older adults

Chan L., et al. JPEN. 2014;38:656-672

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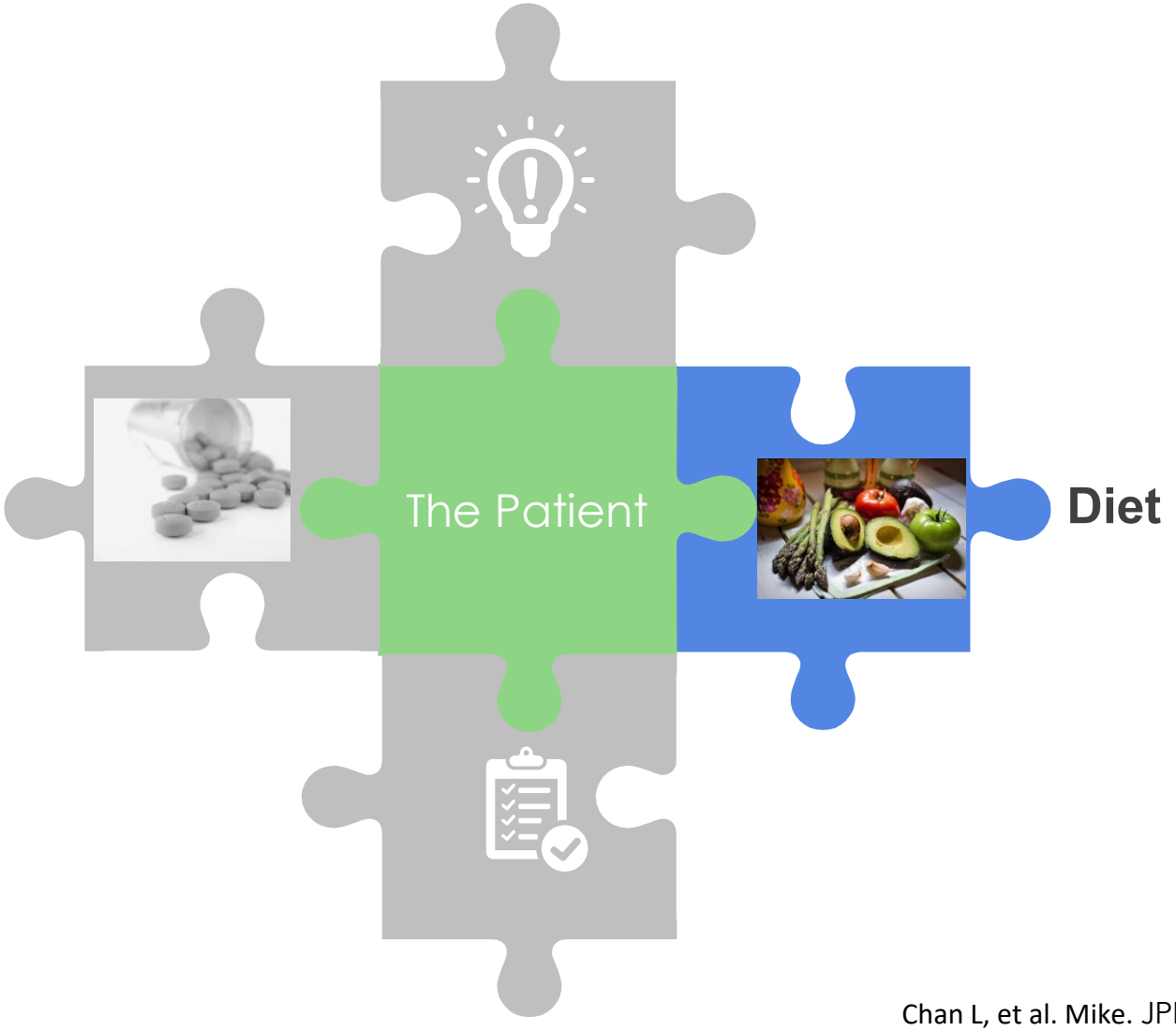
Patient –Specific Risk Factors



- Malnutrition
- Restrictive diets (vegetarian, vegan, etc.)
- Jejunostomy tube feeds

Chan L, et al. Mike. JPEN. 2014;38:656-672

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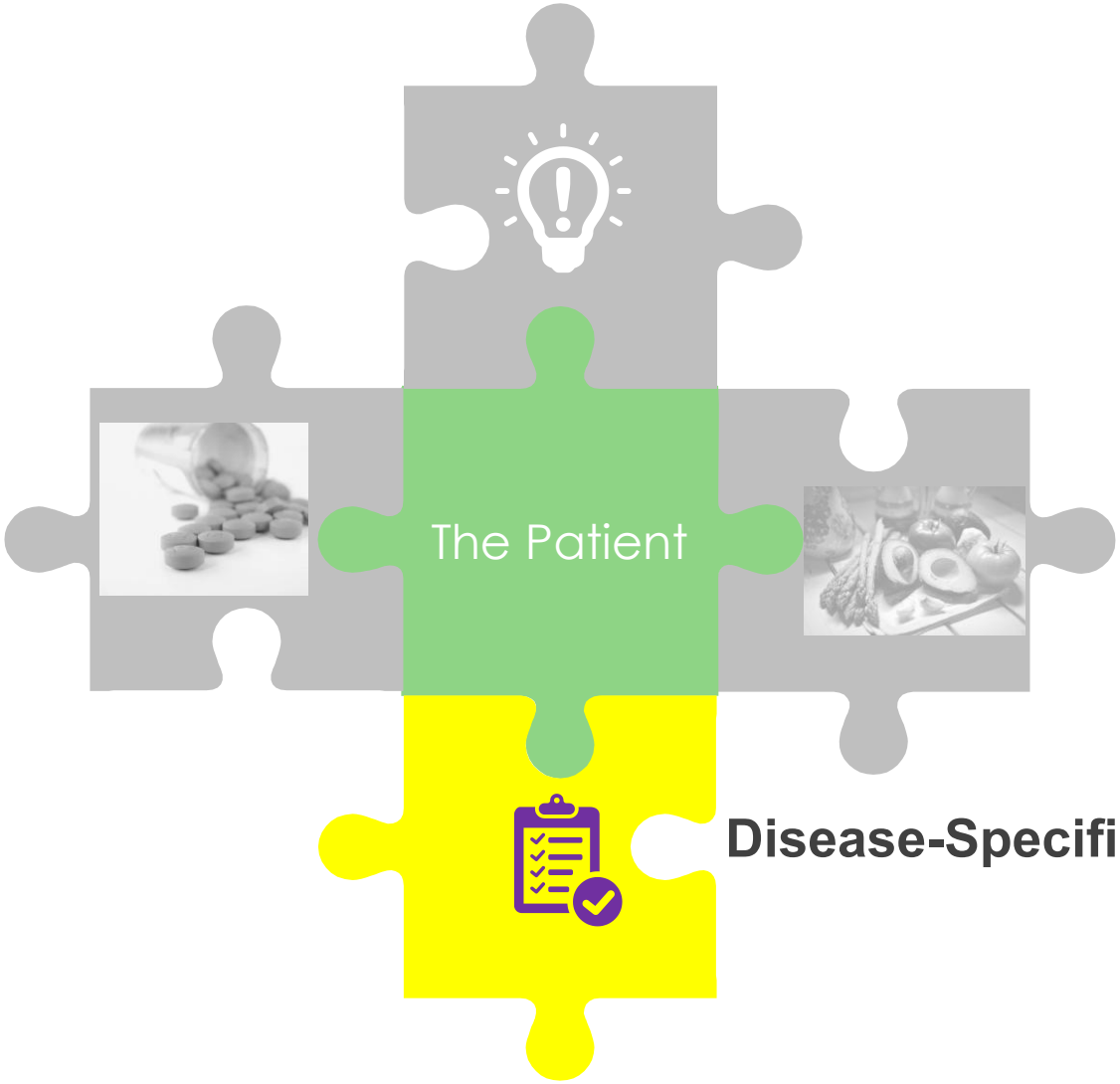
Patient –Specific Risk Factors



Patient-Specific: Disease-Specific

Disease	Deficiency favouring disease development	Inadequacy or deficit worsening the condition	Deficiency as a result of disease
Alcoholism		B1, Fe	A, D, E, K, B1, B2, B6, B7, B9, B12, C, Zn
Alcoholic hepatitis	B6, Zn	Se, Zn	
Anaemia	B1, B6, B9, B12, Fe, Cu, Co		
Cancer cachexia	D, Zn		
Cardiomyopathies/ Heart failure	B1, B6, D, Se, Fe	Se	
Chronic obstructive pulmonary disease	D, Cu, Se, Mn, Zn		
Chronic intestinal failure			B2, B7, B9, B12, A, D, E, K, Cu, Fe, Zn
Chronic (atrophic) gastritis			B9, B12, C, D, Fe
Diabetes mellitus	B9, Cr		
Inflammatory bowel diseases		Zn	B1, B6, B12, A, D, E, K, Fe, Se, Zn
Non-alcoholic fatty liver disease	Cu		
Liver diseases		Zn	B12, A, D, E, Se, Zn
Multiple Sclerosis	B7		
Obesity	β-carotene, E, Se, Zn	B1, B9, D, Fe, Se, Zn	
Obesity Post Bariatric surgery			A, D, E, K, B1, B9, B12, C, Cu, Fe, Zn
Osteoporosis	B12, D, K, Cu, Fe, Zn, Mn, F, Bo		
Renal failure (chronic)			B1, B6, B9, K, D, Cu, Se, Zn
Sarcopenia	B1, B12, D, carnitine, Zn	D, Se, Zn	
Critical illness		B1, C, D, Cu, Fe, Se, Zn	B1, B12, C, D, Fe, Se, Zn

Berger MM, et al. Clin Nutr 2022;41:1357-424

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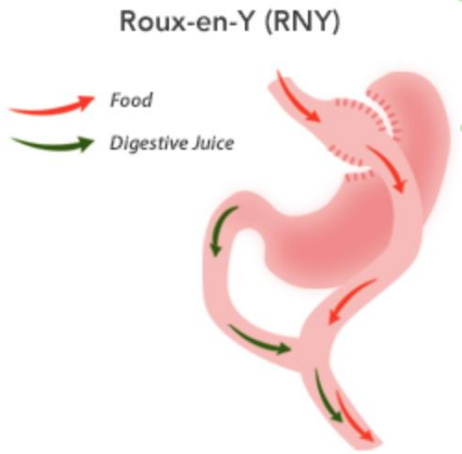
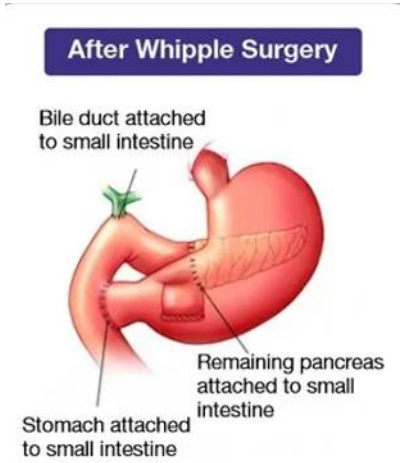
Sites of Micronutrient Absorption

Micronutrients	Stomach	Duodenum (25–30 cm)	Jejunum (250 cm)		Ileum (360 cm)			Colon (150 cm)
			Proximal	Entire	Proximal	Terminal	Entire	
Water-Soluble Vitamins								
Vitamin B_1 (thiamine)	–	–	–	✓	–	–	✓	–
Vitamin B_2 (riboflavin)	–	–	–	✓	–	–	–	–
Vitamin B_3 (niacin)	–	–	–	✓	–	–	–	–
Vitamin B_5 (pantothenic acid)	–	–	–	✓	–	–	–	–
Vitamin B_6 (pyridoxine)	–	–	–	✓	–	–	–	–
Vitamin B_7 (biotin)	–	–	–	✓	–	–	–	✓
Vitamin B_9 (folate)	–	–	–	✓	–	–	–	–
Vitamin B_{12} (cobalamin)	Intrinsic factor	✓	–	–	–	✓; intrinsic factor	–	–
Vitamin C (ascorbic acid)	–	–	–	✓	–	–	✓	–
Fat-Soluble Vitamins								
Vitamin A	–	✓	✓	–	–	–	✓	–
Vitamin D	–	✓	–	✓	–	–	✓	–
Vitamin E	–	✓	–	✓	–	–	✓	–
Vitamin K	–	✓	–	✓	–	–	✓	✓
Trace Minerals								
Chromium	–	–	–	✓	–	–	–	–
Copper	✓	✓	✓		–	–	–	–
Iron	–	✓	✓	–	–	–	–	–
Manganese	–	–	–	✓	–	–	–	–
Selenium	–	✓	–	–	–	–	–	–
Zinc	–	✓	–	✓	–	–	✓	–





Zhao VM. pp 123-145; In: CCSAP Nutrition and Fluids; 2024. Book 2.

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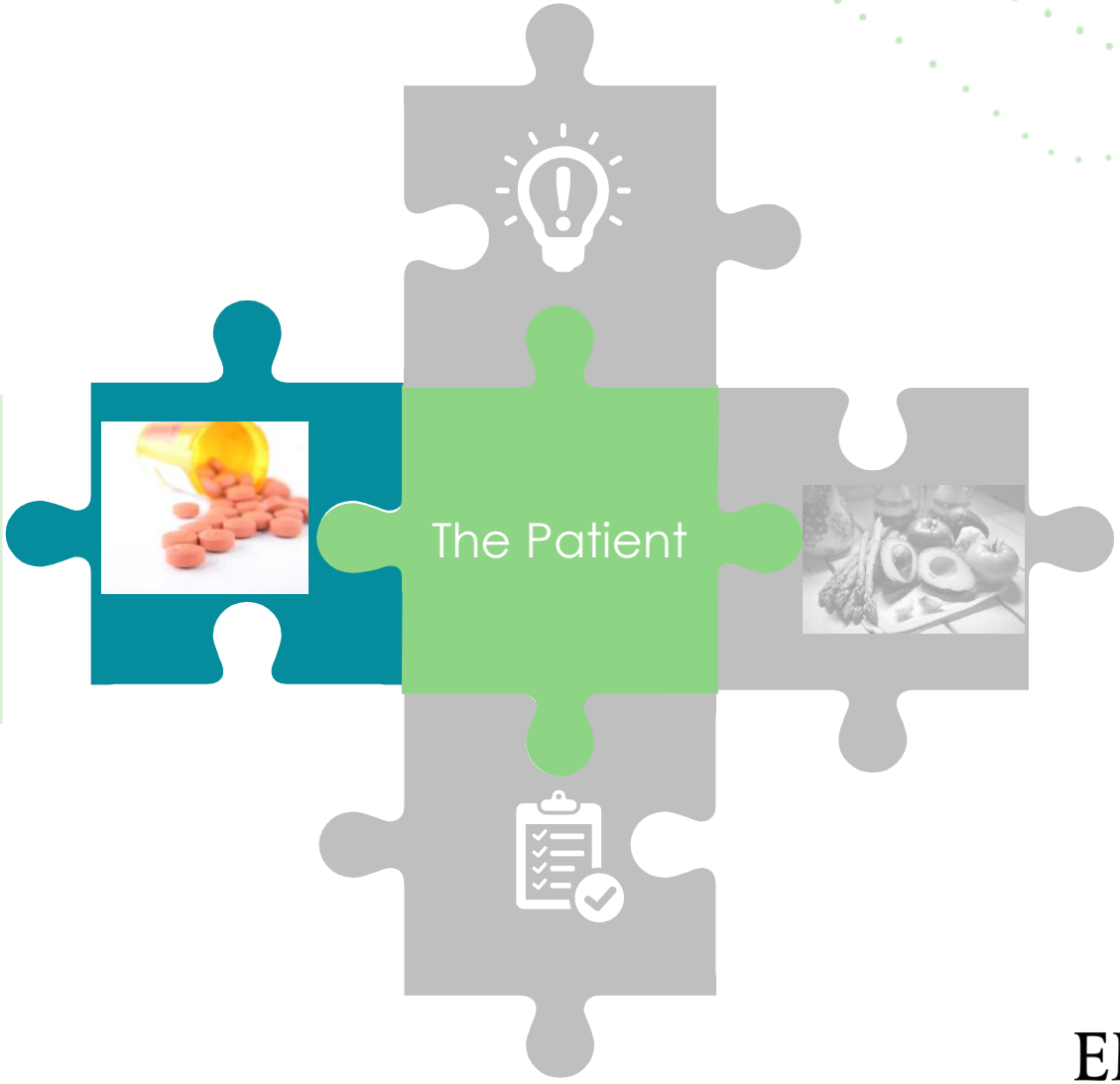
Patient –Specific Risk Factors

Medical Interventions

- ECMO
- Renal replacement therapy
- Medications



L. Chan, L.A. Mike. JPEN J Parenter Enteral Nutr. 2014;38:656-672

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Risk Factors: The Medication - Mechanisms

Mechanism	Examples	Micronutrients
↓ GI absorption	PPIs/H2 blockers	B12, Fe
	Metformin	B12
	Bile acid sequestrants	Vitamins A, D, E, K
↑ Renal losses	Loop/thiazide diuretics	B1, Zn
Altered metabolism/antagonism	Isoniazid	B6
	Methotrexate / trimethoprim	Folate
	Anticonvulsants	Vitamin D, folate
	Warfarin	Vitamin K
↑ Requirements, utilization, or redistribution	Valproate	Carnitine

PPI, Proton Pump Inhibitors

Not all mechanisms apply equally to all patients; consider dose, duration, and comorbidities.

Daniles MS et al. Annu Rev Nutr 2021;41-411-32.
Miller JW. Adv Nutr 2018;9(4):S511-8.

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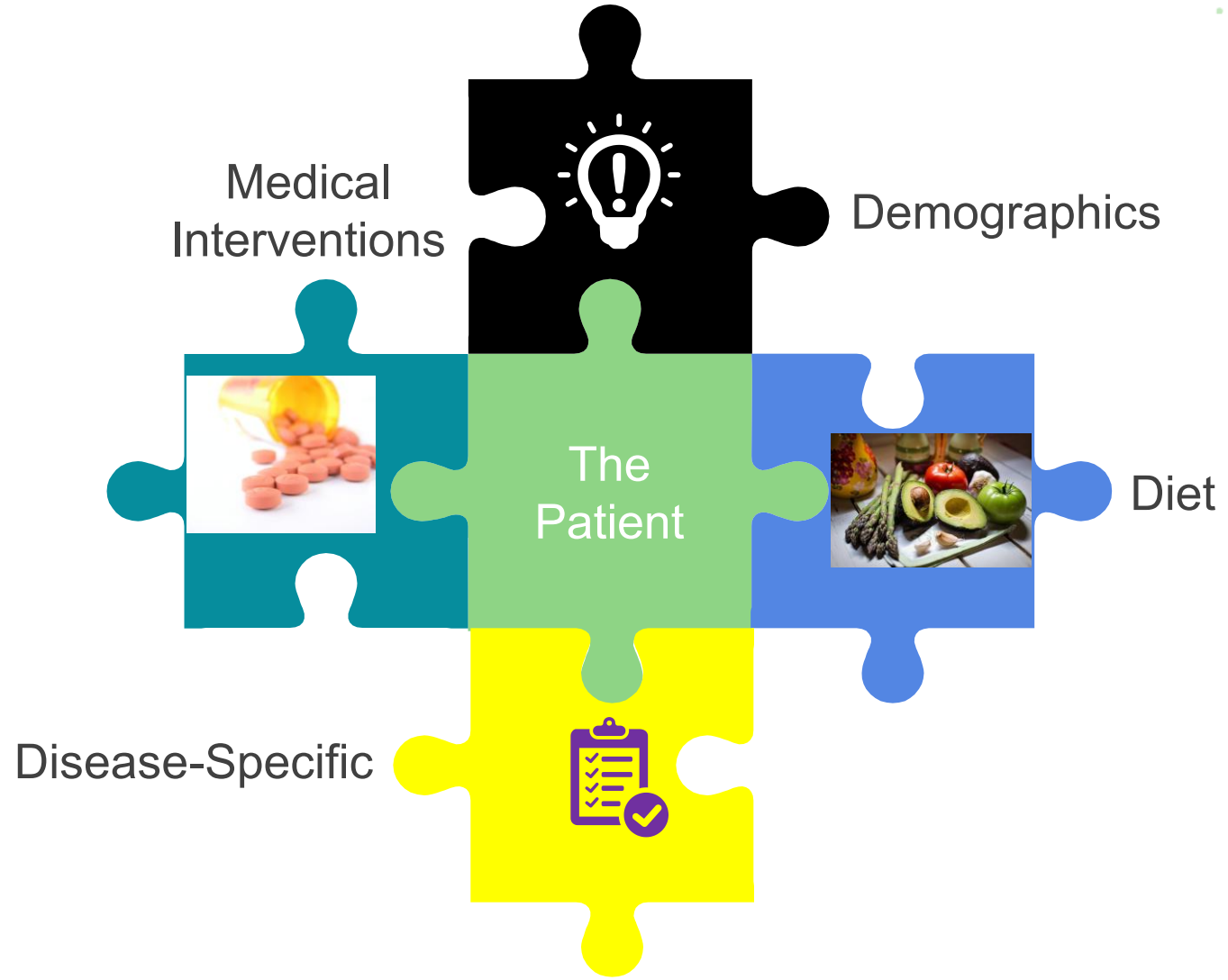
Risk Factors Summary



Clue #2: Signs & Symptoms

What does the body reveal before labs?

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Clinical Signs & Symptoms

Body Site	Signs and Symptoms[a]	Micronutrients
Head/ Hair	Corkscrew	Vitamin C, copper
	Diffuse alopecia	Biotin, iron, selenium, zinc
	Follicular hyperkeratosis	Vitamins A, C, E
	Hair color changes	Selenium, copper
	Kinky Hair Syndrome	Copper
Eyes	Angular palpebritis	Vitamins B_2, B_3, B_6, zinc
	Bitot spot	Vitamin A
	Conjunctival xerosis	Vitamin A, zinc
	Excessive tearing	Vitamins B_2, B_6
	Keratomalacia	Vitamin A
	Night blindness	Vitamin A
	Pallor conjunctiva	Vitamins B_6, B_9, B_{12}
	Photophobia	Zinc
Mouth	Angular cheilitis	Vitamins B_2, B_3, B_6, iron
	Atrophic glossitis	Vitamins B_2, B_3, B_6, B_9, B_{12}, E, iron, zinc
	Dysgeusia/Dysosmia	Zinc
	Gingivitis	Vitamin C
	Glossitis	Vitamin B_{12}
	Stomatitis	Vitamin B_2, iron
Skin	Seborrheic dermatitis	Vitamins B_2, B_6, B_{12}
	Hyperpigmented or sunburned-like skin	Niacin
	Dermatitis of the central face	Biotin
	Scurvy	Vitamin C
	Follicular hyperkeratosis	Vitamins A, E
	Petechiae	Vitamins E, K
	Dry and scaly	Vitamin A
	Acrodermatitis enteropathica	Zinc
	Pallor	Iron, vitamins B_9, B_{12}
Nails	Brittle	Biotin
	Koilonychia	Iron
	Pale nail beds	Iron, vitamins B_9, B_{12}
	Leukonychia	Selenium, zinc
	Half and half nails	Zinc
Neurologic	Ataxia	Vitamins B_1, B_{12}, copper
	Confusion	Vitamins B_1, B_2, B_{12}
	Peripheral neuropathy	Vitamins B_2, B_6, B_{12}
Hematologic	Anemia	Vitamins B_9, B_{12}, copper, iron

[a]Table does not include all the signs and symptoms associated with micronutrient deficiencies.

Zhao VM. pp 123-145; In: CCSAP Nutrition and Fluids; 2024. Book 2.

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Back to the Evidence

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Detective Checkpoint #1

Clue:

- A 32-year-old female (weight 66.8 kg) is admitted to the ICU due to severe trauma in a motor vehicle collision. On ICU day 5, she requires ECMO cannulation because of acute respiratory distress syndrome. She also needs a blood transfusion because of blood loss during cannulation. On ICU day 7, she becomes septic and develops an acute kidney injury (SCr 3.87 mg/dL), which requires initiation of CRRT. She remains intubated, sedated, and paralyzed and has had a nothing-by-mouth status since admission.
- Social history: daily alcohol use (≥ 2 drinks/day)
- Past medical history: GERD, DM II
- Home medications: pantoprazole, metformin

What hidden risk factors does this patient have that increase the risk for micronutrient deficiency?

- A. CRRT
- B. Alcoholism
- C. ECMO
- D. Pantoprazole
- E. Blood transfusion

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Clue #3: Testing

What to check, when to check, and how to collect it

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Differentiation Between Specimens

Test Type	What it Measures	Advantages	Disadvantages
Serum/Plasma	Concentration in the fluid component of blood	- Widely available - Easy to perform - Relatively inexpensive	- Reflects only short-term status - May not reflect true tissue/cellular status - **Affected by inflammation**
Intracellular (Red Blood Cells / Whole Blood)	Concentrations within intracellular	- Reflects true intracellular and long-term status - Detects subclinical deficiencies - **Not influenced by inflammation**	- Not widely available - More expensive - Complex lab procedures
Functional	Specific physiological activity of specific micronutrients	- Detects deficiencies not visible in blood concentrations - Reflects impact on body function	- Limited availability - High cost - Complex and less standardized - Unclear reference ranges

Plasma = Serum + clotting proteins

Zhao VM. pp 123-145; In: CCSAP Nutrition and Fluids; 2024. Book 2.

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Choosing the Right Tests

Micronutrients (Test Name)[a]	Serum/ Plasma	Intracellular	Functional	Alternative Biomarkers
Water-Soluble Vitamins				
Vitamin B_1	√	Whole blood	–	–
Vitamin B_2	√[b]	–	–	–
Vitamin B_3	√	–	–	–
Vitamin B_5	√	–	–	–
Vitamin B_6 (pyridoxal 5-phosphate)	√[b]	–	–	–
Vitamin B_7	√	–	–	–
Vitamin B_9	√	RBC	–	Plasma homocysteine
Vitamin B_{12}	√[b]	–	Plasma methylmalonic acid	–
Vitamin C	√[b]	–	–	–
Fat-Soluble Vitamins				
Vitamin A	√[b]	–	–	–
Vitamin D (25-hydroxyvitamin-D)	√[b]	–	–	–
Vitamin E (alpha-tocopherol)	√[b]	–	–	–
Vitamin K	√[b]	–	–	–

[a]These tests are confirmed to be available in the United States through the laboratory test directory in ARUP laboratories (available at https://ltd.aruplab.com/).

[b]Unreliable in the presence of inflammatory acute phase response.

Zhao VM. pp 123-145; In: CCSAP Nutrition and Fluids; 2024. Book 2.

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Choosing the Right Tests

Micronutrients (Test Name)[a]	Serum/ Plasma	Intracellular	Functional	Alternative Biomarkers
Trace Minerals				
Chromium	√	–	–	–
Copper[c]	√[b]	RBC	–	Ceruloplasmin
Iron	√	–	Plasma soluble transferrin receptor	Ferritin[c], transferrin saturation[c]
Manganese	√	RBC Whole blood	–	–
Selenium[c]	√	RBC	Glutathione peroxidase-3[d]	–
Zinc[c]	√	RBC	–	–

[a]These tests are confirmed to be available in the United States through the laboratory test directory in ARUP laboratories (available at https://ltd.aruplab.com/).

[b]Unreliable in the presence of inflammatory acute phase response.

[c]Urine specimens help assess toxicity.

[d]Currently unavailable in the United States.

Zhao VM. pp 123-145; In: CCSAP Nutrition and Fluids; 2024. Book 2.

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Specimen Collection Matters

Preanalytical factor	Why it matters
Specimen type	Serum ≠ plasma ≠ whole blood
Collection site	Capillary ≠ venous
Collection tube	Tube material/contamination can affect trace elements
Processing & storage	Delay, temperature, light, and freeze-thaw can alter some analytes
Specimen quality	Hemolysis, lipemia, and icterus may interfere with selected tests

Berger MM, et al. NCP. 2023;38(1):56-69.
Haber PS. NEJM 2025;392:258-66.
Karin A, et al. Clin Chem Lab Med. 2023;61(6):1035-45.

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Timing Matters

What was happening when this sample was collected?

Consider	Examples
Recent intake/supplementation	Meals, oral/enteral supplements, IV replacement
Recent interventions	Blood transfusion, PN/EN initiation
Fluid/renal changes	Fluid shifts, CRRT
Clinical state	Refeeding, acute illness, inflammation
Collection requirements	Follow test-specific instructions

When feasible, obtain baseline levels before replacement.

Berger MM, et al. NCP. 2023;38(1):56-69.
Haber PS. NEJM 2025;392:258-66.
Karin A, et al. Clin Chem Lab Med. 2023;61(6):1035-45.

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Clue #4: Interpreting the Evidence

What do the results actually mean?

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Interpreting Micronutrient Concentrations: Context Matters

What affects interpretation?	Examples	What to remember
Gender	Copper, ferritin, iron, zinc	Cutoffs differ by gender
Age	Pediatric vs adult vs older adult	Reference intervals can vary with age; Don't automatically apply adult values to children.
Laboratory & assay	All biomarkers	Reference intervals are method- and laboratory-specific
Clinical context	Ferritin, retinol, zinc,	Inflammation and other physiologic factors can alter concentrations

Reference interval ≠ deficiency cutoff ≠ functional deficiency

Allen LH. NEJM. 2025;392(10):1006-16.
Berger MM, et al. *Clin Nutr*. 2022;41(6):1357-424.

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Inflammation Can Distort the Clues

Micronutrients	Severity of Inflammation (CRP Concentration) Minor (< 1 mg/dL)	Moderate (1.1–8 mg/dL)	Major (> 8 mg/dL)
Water-Soluble Vitamins			
Vitamin B_1	ND	ND	ND
Vitamin B_2	NS	ND	↓ 40%
Vitamin B_3	ND	ND	ND
Vitamin B_5	ND	ND	ND
Vitamin B_6	NS	ND	↓ 45%
Vitamin B_7	ND	ND	ND
Vitamin B_9	ND	ND	ND
Vitamin B_{12}	NS	ND	↓ 10%
Vitamin C	NS	↓ 60%	↓ 65%
Fat-Soluble Vitamins			
Vitamin A	NS	ND	↓ 50%–60%
Vitamin D	↓ 20%–30%	↓ 40%	↓ 40%
Vitamin E	NS	ND	↓ 30%
Vitamin K	NS	NS	↓ 60%

Micronutrients	Severity of Inflammation (CRP Concentration) Minor (< 1 mg/dL)	Moderate (1.1–8 mg/dL)	Major (> 8 mg/dL)
Trace Minerals			
Chromium	ND	ND	ND
Copper	NS	↑ 10%–15%	↑ 30%
Iodine	ND	ND	ND
Iron	ND	ND	ND
Manganese	ND	ND	ND
Selenium	NS	↓ 10%–35%	↓ 50%
Zinc	NS	↓ 25%–33%	↓ 25%–40%

↓ = decreased; ↑ = increased; NS = no significant effect; ND = no data available.

Zhao VM. pp 123-145; In: CCSAP Nutrition and Fluids; 2024. Book 2.

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Interpreting the Evidence:
Depletion ≠ Deficiency

Status	What it means (ESPEN definition)	Clinical clue
Depletion	Low intake **or** increased losses **plus** low blood levels	No symptoms yet
Deficiency	Low levels **plus** symptoms **or** functional markers	Clinical signs present

Berger MM, et al. Clin Nutr 2022;41:1357-424

Back to the Evidence

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Detective Checkpoint #2

Clue: available lab results

- CRP: 125.7 mg/L
- Zinc: 51.5 µg/dL
- Vitamin B_1: low-normal
- Vitamin B_9: borderline
- Vitamin B_{12}: low-normal
- Albumin: 2.1 g/dL
- Copper: 65 mg/dL

What is the MOST accurate interpretation of this zinc level?

A. True zinc deficiency

B. Zinc is falsely low due to inflammation

C. Zinc is falsely low due to hypoalbuminemia

D. Zinc is normal

E. Repeat in 3 months

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Decision Node: Ask Yourself These Questions

✅ Is this the right specimen?

- **Specimen appropriate** → proceed
- **Specimen inappropriate** → reorder correctly

✅ Is this the right timing?

- **Timing acceptable** → interpret
- **Timing problematic** → repeat later

✅ Is inflammation present?

- **Inflammation present** → use adjusted cutoffs
- **No inflammation** → standard interpretation

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Clue #5: Treatment Strategy

When to treat and how to choose the right strategy?

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The Treatment Decision: Do We Act Now?

- 🚨 **Treat empirically / immediately**
  High clinical suspicion + potentially serious consequences if delayed
- ⚠️ **Treat promptly while confirming**
  Strong suspicion; labs guide ongoing therapy
- 🔎 **Test first, then treat**
  Stable patient; results will meaningfully guide therapy
- 📈**Maintenance + Monitoring**
  Watch for symptom improvement, lab trends, and new risk factors

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Empiric Treatment

- Refeeding Syndrome
  - ASPEN Consensus Recommendation
- CRRT
  - thiamine 100 mg/day, vitamin C 250 mg/day, and selenium 100 µg/day
- Alcohol withdrawal
  - American Society of Alcohol Addition Clinical Practice Guideline on Alcohol Withdrawal Management 2020
  - Identification & treatment of alcohol use disorder (NJEM 2025)
- Major Burns (≥ 20% total body surface area)
  - ESPEN-endorsed recommendations: Nutritional Therapy in Major Burns
- Suspected Wernicke encephalopathy

da Silva JSV, et al. NCP. 2020;35(2):178-95.
Wiesen P, et al. JEPN 2011;35(2):217-22.
Kumar AY et al. NCP.2018;33:439-46.

Lindsay DL, et al. J Addict Med 2020;14(5):376-92.
Haber PS. NEJM 2025;392:258-66.
Rousseau A, et al. Clin Nutr. 2013;32(4):497-502.

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Targeted Treatment: Thiamine

Clinical situation	Dose
Mild deficiency – outpatients	10 mg/day thiamin for a week, followed by 3–5 mg/daily for at least 6 weeks
Chronic diuretic therapy	Suggestion: 50 mg a day, by mouth
At risk for deficiency	100 mg, 3 times a day, IV
High suspicion or proven deficiency	200 mg, 3 times a day, IV
Encephalopathy of uncertain etiology including Wernicke encephalopathy	500 mg, 3 times a day, IV
Maintenance dose in proven deficiency	50–100 mg/day, orally
Refeeding syndrome	300 mg IV before initiating nutrition therapy, 200–300 mg IV daily for at least 3 more days
Continuous renal replacement therapy	100 mg/day
Hospitalized patients-critical illness	100–300 mg/day

Berger MM, et al. Clin Nutr 2022;41:1357-424.

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#5

Targeted Treatment: Choosing the Right Strategy

Route	Use When…	Key Considerations
Oral / Enteral	GI absorption is intact; patient is stable	Formulation, tolerability, tube location
IV	Rapid or reliable replacement needed; severe deficiency; malabsorption	Dose, infusion rate, compatibility
IM / SQ	Selected nutrients or special situations	Absorption, frequency
PN Supplementation	Patient is receiving PN	Adjust to regimen, losses, labs

Match the route to urgency, absorption, and clinical status.

Berger MM, et al. Clin Nutr 2022;41:1357-424.

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Choosing the Right Replacement Strategy

Micronutrients	Oral/Enteral	Intravenous[a]	Intramuscular	Subcutaneous
Water-Soluble Vitamins				
Vitamin B_1 (thiamine)	✓	✓	✓	–
Vitamin B_2 (riboflavin)	✓	–	–	–
Vitamin B_3 (niacin)	✓	–	–	–
Vitamin B_5 (pantothenic acid)	✓	–	–	–
Vitamin B_6 (pyridoxine)	✓	✓	–	–
Vitamin B_7 (biotin)	✓	–	–	–
Vitamin B_9 (folate)	✓	✓	✓	Pediatric use[b]
Vitamin B_{12} (cobalamin)	✓	✓	✓	✓
Vitamin C (ascorbic acid)	✓	✓	✓	✓
Fat-Soluble Vitamins				
Vitamin A (retinol)	✓	–	✓	–
Vitamin D (cholecalciferol)	✓	–	–	–
Vitamin E (tocopherol)	✓	–	–	–
Vitamin K (phylloquinone)	✓	✓	–	Avoid[c]
Trace Minerals				
Chromium	–	✓	–	–
Copper	✓	–	–	–
Iron	✓	✓	–	–
Manganese	–	✓	–	–
Selenium	✓	✓	–	–
Zinc	✓	✓	–	–

NOTE:

- Fixed-dose multivitamins
- Fixed-dose multi-trace
- Oral/Enteral (Tablets, capsules, liquid)
- Vitamin B12 is also available in a nasal spray

[a]Available as an individual MN product.
[b]Subcutaneous use in pediatrics.
[c]Subcutaneous route should be avoided because of unpredictable absorption.
Information from: Lexicomp Online [Internet database]. Updated periodically.

Zhao VM. pp 123-145; In: CCSAP Nutrition and Fluids; 2024. Book 2.

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Clinical Pearls: Treatment Nuances

- **Thiamine**
  - Oral thiamine has **poor and saturable absorption**; only ~4–5 mg is absorbed even from large oral doses.
  - IV thiamine is preferred in critical illness, alcohol withdrawal, or refeeding risk.
- **Copper**
  - IV copper **must be diluted** before administration
  - General infusion rate 0.5 mg/hour; maximum infusion rate 1 mg/hour
- **Zinc**
  - High-dose oral zinc can **induce copper deficiency**; monitor copper if zinc is given for >2–3 weeks.
  - Separate oral zinc and copper supplementation by at least 2 hours

Back to the Evidence

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Detective Checkpoint #3

Clue:

This patient is critically ill with multiple high-risk features:

- CRRT
- ECMO
- Daily alcohol use
- NPO for 8 days

Which of this patient's risk factors should prompt empiric micronutrient supplementation now?

(Select all that apply)

- A. Alcohol withdrawal
- B. CRRT
- C. ECMO
- D. Mild malnutrition with normal CRP
- E. Refeeding syndrome

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Clue #6: Reassessment

Closing the loop

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Reassessing the Case

- **Clinical**
  - Are symptoms improving?
- **Biochemical**
  - Is the biomarker responding?
- **Therapy**
  - Does supplementation need adjustment?
- **Risk**
  - Is the underlying risk still present?
- **Safety**
  - Have we caused excess/toxicity?

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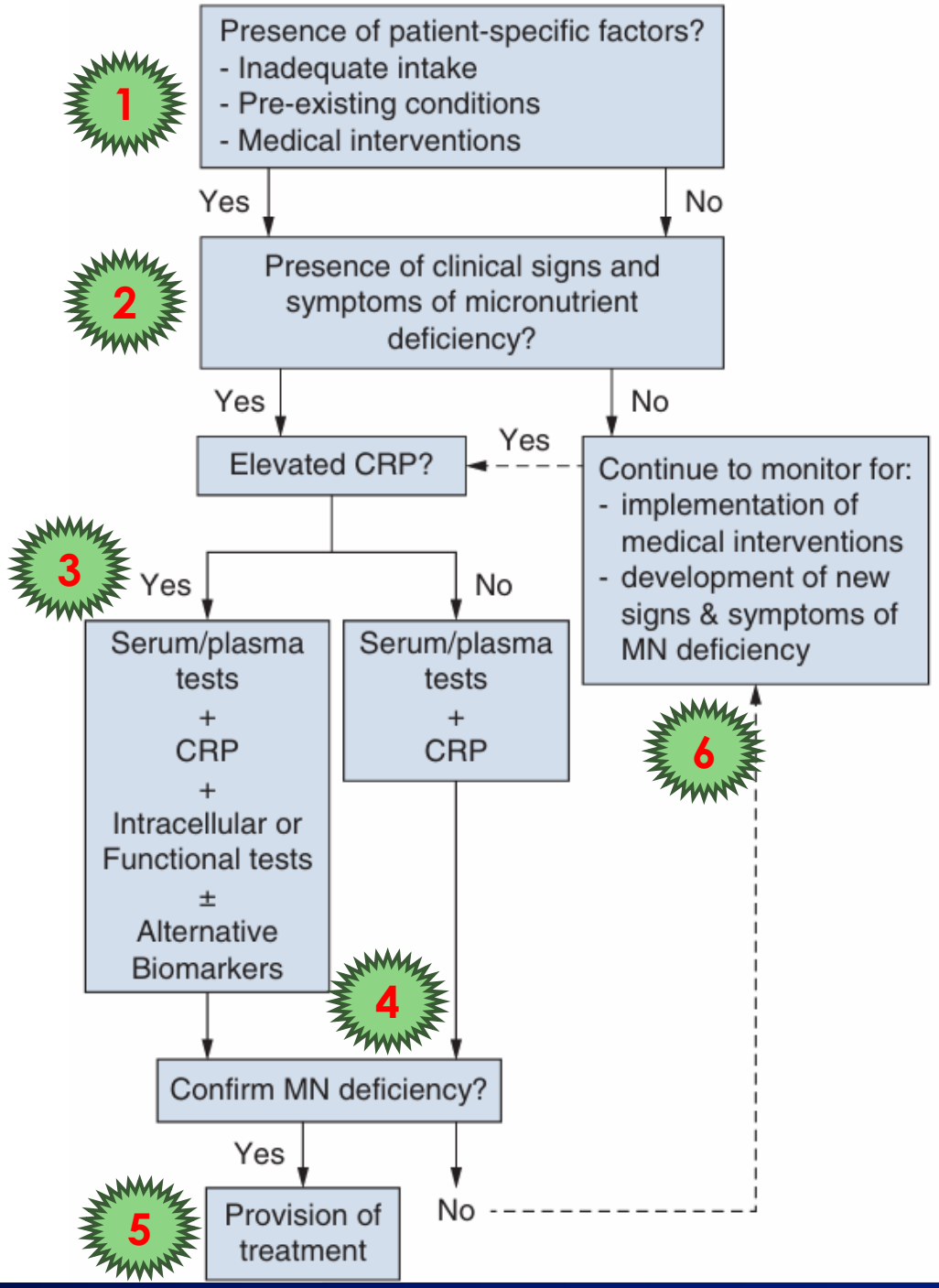
Practical Clinical Algorithm

General approach to the evaluation of micronutrient status:

- Solid lines indicate the steps for initial evaluation
- Dotted lines indicate the steps of ongoing assessment.

CRP = C-reactive Protein; MN = micronutrient



Zhao VM. pp 123-145; In: CCSAP Nutrition and Fluids; 2024. Book 2.

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Case Solved:
How the Clues Fit Together for THIS Patient

- **Risk Factors:**
  - Alcohol use, DM, 8 days NPO, CRRT and ECMO losses, pantoprazole/metformin
- **Testing Context:**
  - Levels drawn during severe inflammation (CRP ↑)
- **Interpretation:**
  - Low zinc = **depletion**, not confirmed deficiency
- **Treatment:**
  - Empiric supplement for CRRT + alcohol use + refeeding risk
  - Targeted supplementation (e.g., B1, Copper, etc.)
- **Reassessment:**
  - Trend micronutrient concentrations with CRP
  - Adjust PN micronutrients based on ongoing CRRT and ECMO losses

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Key Takeaways: What You Can Apply Tomorrow

Think Like a Micronutrient Detective

- **1. Find the risk.**
- **2. Look for the clues.**
- **3. Choose the right test and the right time.**
- **4. Interpret the result in context.**
- **5. Treat the patient, not just the number.**
- **6. Reassess and close the loop.**

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Thank you

Questions?

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