Micronutrients

Dr Vidushi

Vitamins

VITAMIN A

NAMES AND SYNONYMS	CHARACTERISTICS	BIOCHEMICAL ACTION	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	SOURCES
VITAMIN A					
Retinol (vitamin A_1);	Fat-soluble;heat-stable;destroyed oxidation, drying; bile necessary for absorption; stored in liver; protected by vitamin E	In vision, as retinal, for synthesis of the visual pigments rhodopsin and iodopsin; in growth, reproduction, embryonic and fetal development, bone growth, immune and epithelial functions, via retinoic acid as a ligand for specific nuclear transcription factors, regulating genes involved in many fundamental cellular processes	Nyctalopia;photophobia, xerophthalmia, Bitot spots, conjunctivitis, keratomalacia leading to blindness; faulty epiphyseal bone formation; defective tooth enamel; keratinization of mucous membranes and skin; retarded growth; impaired resistance to infection, anemia, reproductive failure, fetal abnormalities	Anorexia, slow growth, drying and cracking of skin, enlargement of liver and spleen, swelling and pain of long bones, bone fragility, increased intracranial pressure, alopecia, carotenemia; fetal abnormalities	Liver, fish liver oils, dairy products, except skim milk; egg yolk, fortified margarines and fortified skim milk; carotenoids from plants: green vegetables, yellow fruits and vegetables

VITAMIN B_1

NAMES AND SYNONYMS	CHARACTERISTICS	BIOCHEMICAL ACTION	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	SOURCES
Thiamin:vitamin B_1; (antiberiberi vitamin)	Water and alcohol soluble; fat-insoluble;stable in slightly acid solution; labile to heat, alkali, sulfites	Component of thiamine pyrophosphate involved in oxidative decarboxylation of α-keto acids, such as pyruvate, and in transketolation reactions	Beriberi, fatigue, irritability, anorexia, constipation, headache, insomnia, tachycardia, polyneuritis, cardiac failure, edema, elevated pyruvic acid in blood	None from oral intake	Meat, especially pork; whole-grain or enriched cereals; legumes; nuts

VITAMIN B_2

NAMES AND SYNONYMS	CHARACTERISTICS	BIOCHEMICAL ACTION	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	SOURCES
Riboflavin:vitamin B_2	Sparingly soluble in water; sensitive to light and alkali; stable to heat, alkali, oxidation, acid	Constituent of flavoprotein enzymes important in oxidation-reduction reactions: amino acid, fatty acid, and carbohyrate metabolism and cellular respiration	Ariboflavinosis ;photophobia blurred vision, burning and itching of eyes, corneal vascularization , poor growth, cheilosis	Not harmful	Milk, cheese; whole-grain or enriched grains; meat, fish; eggs;green leafy vegetables; liver and other organ meats

VITAMIN B_3

NAMES AND SYNONYMS	CHARACTERISTICS	BIOCHEMICAL ACTION	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	SOURCES
Niacin:nicotinamide;nicotinc acid (antipellagra vitamin)	Water- and alcohol-soluble;stable to acid, alkali, light, heat, oxidation	Constituent of NAD and NADP, coenzymes in numerous oxidation-reduction reactions	Pellagra, multiple B-vitamin deficiency syndrome, diarrhea, dementia, dermatitis Irritability, convulsions, hypochromic anemia; peripheral neuritis in patients receiving isoniazid; oxaluria	Nicotinic acid (not the amide) is vasodilator; skin flushing and itching; hepatopathy	Meat, fish, poultry; whole-grain and enriched cereals; green vegetables; peanuts; liver;also from conversion of trytophan to niacin

Pellagra

- Aggression
- Light sensitivity
- Dermatitis
- Skin lesions
- Dementia

VITAMIN B_6

NAMES AND SYNONYMS	CHARACTERISTICS	BIOCHEMICAL ACTION	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	SOURCES
Vitamin B_6 active forms: pyridoxine, pyridoxal, pyridoxamine	Water-soluble;destroyed by ultraviolet light and by heat	Constituent of coenzymes for decarboxylation, transaminatio n, trans-sulfuration;fatty acid metabolism; heme synthesis; homocysteine metabolism		Sensory neuropathy (from high-dose supplements, not food)	Meat, fish, poultry; whole-grain and fortified cereals; soybeans;nuts ; potatoes; noncitrus fruits; liver and kidney

VITAMIN Biotin

NAMES AND SYNONYMS	CHARACTERISTICS	BIOCHEMICAL ACTION	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	SOURCES
Biotin	Crystallized from yeast; soluble in water	Coenzyme carboxylases; involved in CO_2 transfer	Dermatitis, seborrhea; inactivated by avidin in raw egg white	Unknown	Widely distributed in foods; animal products, yeast, liver

VITAMIN B_5

NAMES AND SYNONYMS	CHARACTERISTICS	BIOCHEMICAL ACTION	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	SOURCES
Pantothenic acid	Limited data on stability during cooking and food processing	Component of coenzyme A and acyl carrier protein involved in fatty acid metabolism	Experimentally produced deficiency in humans: irritability, fatigue, gastric complaints, numbness, paresthesias, muscle cramps	Unknown	Widely distributed in foods; beef, poultry, whole grains, liver and kidney, yeast, egg yolks

VITAMIN - Folate

NAMES AND SYNONYMS	CHARACTERISTICS	BIOCHEMICAL ACTION	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	SOURCES
Folate:folic acid, folacin; group of related compounds containing pteridine ring, para-amino benzoic acid, and glutamic acid; pteroylglutamic acid	Slightly soluble in water: labile to heat, light, acid	Concerned with formation and metabolism of 1-carbon units; participates in synthesis of purines, pyrimidines, nucleoproteins, homocysteine metabolism	Megaloblastic anemia (infancy, pregnancy) usually secondary to malabsorption disease, glossitis, pharyngeal ulcers, impaired immunity	Unknown	Green vegetables, enriched grain products, oranges and other fruits, legumes, nuts, liver, yeast

VITAMIN B_{12}

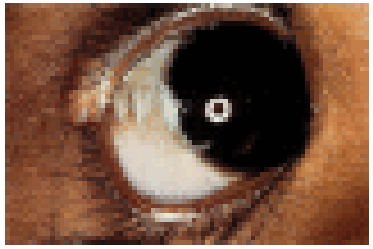
NAMES AND SYNONYMS	CHARACTERISTICS	BIOCHEMICAL ACTION	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	SOURCES
Vitamin B_{12}:cyanocobalamin	Slightly soluble in water; stable to heat in neutral solution; labile in acid or alkaline ones; destroyed by light; castle intrinsic factor of the stomach required for absorption	Transfer of 1-carbon units in purine and labile methyl group metabolism; essential for maturation of red blood cells in bone marrow; metabolism of nervous tissue; homocysteine metabolism; Adenosylcobalamin is coenzyme for methylmalonyl coenzyme A mutase	Pernicious anemia due to defect in absorption rather than dietary lack; also secondary to gastrectomy, celiac disease, inflammatory lesions of small bowel, long-term drug therapy (PAS, neomycin); methylmalonic aciduria; homocystinuria	Unknown	Animal foods: muscle and organ meats, fish; eggs;milk;cheese; fortified cereal products; fortified soy products

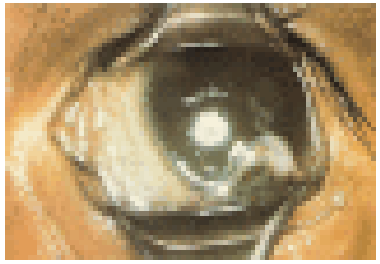
VITAMIN C

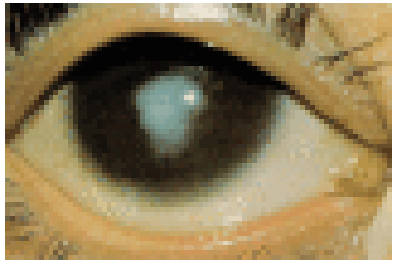
NAMES AND SYNONYMS	CHARACTERISTICS	BIOCHEMICAL ACTION	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	SOURCES
Ascorbic acid, antiscorbutic vitamin	Water-soluble;easily oxidized, accelerated by heat, light, alkali, oxidative enzymes, traces of copper or iron	As an antioxidant, maintains Fe and Cu ions in reduced state in hydroxylases involved in collagen synthesis, metabolism of cholesterol and neurotransmitters; may be needed to maintain folate in a reduced form; facilitates non-heme Fe absorption and Fe transfer from	Scurvy:poor wound healing, bleeding gums, petechiae, ecchymoses, follicular hyperkeratosis, arthralgia	Adverse effects usually not serious; may include osmotic diarrhea, other gastrointestinal symptoms; oxaluria	Citrus fruits, tomatoes, berries, cantaloupe, cabbage, broccoli, cauliflower, spinach, potatoes; cooking has destructive effect

Xerophthalmia

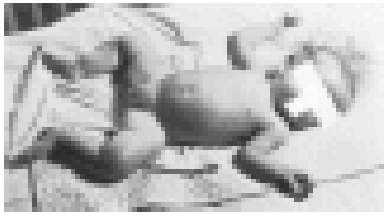
Hyperosteosis

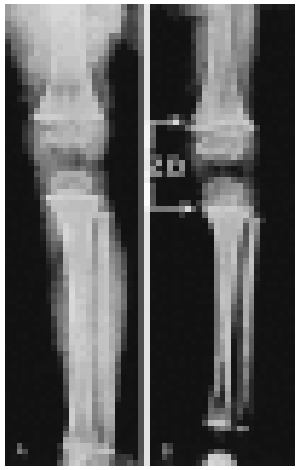


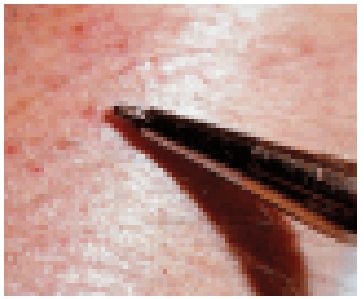




Scurvy







VITAMIN D

NAMES AND SYNONYMS	CHARACTERISTICS	BIOCHEMICAL ACTION	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	SOURCES
Vitamin D_3 (3-cholecalciferol), which is synthesized in the skin, and vitamin D_2 (from plants or yeast) are biologically equivalent; 1 µg = 40 IU vitamin D biologic activity	Fat-soluble, stable to heat, acid alkali, and oxidation; bile necessary for absorption; hydroxylation in the liver and kidney necessary for	Necessary for gastrointestinal absorption of calcium; also increases absorption of phosphate; direct actions on bone, including mediating resorption	Rickets in growing children; osteomalacia; hypocalcemia may cause tetany and seizures	Hypercalcemia, which may cause emesis, anorexia, pancreatitis, hypertension, arrhythmias, central nervous system effects, polyuria, nephrolithiasis, and renal failure	Exposure to sunlight (ultraviolet light); fish oils, fatty fish, egg yolks, and vitamin D–fortified formula, milk, cereals, and bread

Vitamin D Deficiency

- Rickets
- Bone softening
- Bad teeth

VITAMIN E

NAMES AND SYNONYMS	CHARACTERISTICS	BIOCHEMICAL ACTION	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	SOURCES
Group of related compounds with similar biologic activities; α-tocopherol is the most potent and the most common form	Fat-soluble;readily oxidized by oxygen, iron, rancid fats; bile acids necessary for absorption	Antioxidant;protection of cell membranes from lipid peroxidation and formation of free radicals	Red cell hemolysis in premature infants; posterior column and cerebellar dysfunction; pigmentary retinopathy	Unknown	Vegetable oils, seeds, nuts, green leafy vegetables, and margarine

VITAMIN K

NAMES AND SYNONYMS	CHARACTERISTICS	BIOCHEMICAL ACTION	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	SOURCES
Group of naphthoquinones with similar biologic activities; K_1 (phylloquinone) from diet; K_2 (menaquinones) from intestinal bacteria	Natural compounds are fat-soluble; stable to heat and reducing agents; labile to oxidizing agent, strong acids, alkali, light; bile salts necessary for intestinal absorption	Vitamin K–dependent proteins include coagulation factors II, VII, IX, and X;proteins C, S, Z; matrix Gla protein, osteocalcin	Hemorrhagic manifestations; long-term bone and vascular health	Not established; analogues (no longer used) caused hemolytic anemia, jaundice, kernicterus, and death	Green leafy vegetables, liver, and certain legumes and plant oils; widely distributed

Rickets

VITAMIN D DISORDERS

Nutritional vitamin D deficiency

Congenital vitamin D deficiency

Secondary vitamin D deficiency

- Malabsorption
- Increased degradation
- Decreased liver 25-hydroxylase

Vitamin D–dependent rickets type 1

Vitamin D–dependent rickets type 2

Chronic renal failure

CALCIUM DEFICIENCY

Low intake

- Diet
- Premature infants (rickets of prematurity)

Malabsorption

- Primary disease
- Dietary inhibitors of calcium absorption

PHOSPHORUS DEFICIENCY

Inadequate intake

- Premature infants (rickets of prematurity)
- Aluminum-containing antacids

RENAL LOSSES

X-linked hypophosphatemic rickets[*]

Autosomal dominant hypophosphatemic rickets[*]

Hereditary hypophosphatemic rickets with hypercalciuria

Overproduction of phosphatonin

- Tumor-induced rickets[*]
- McCune-Albright syndrome[*]
- Epidermal nevus syndrome[*]
- Neurofibromatosis[*]

Fanconi syndrome

Dent disease

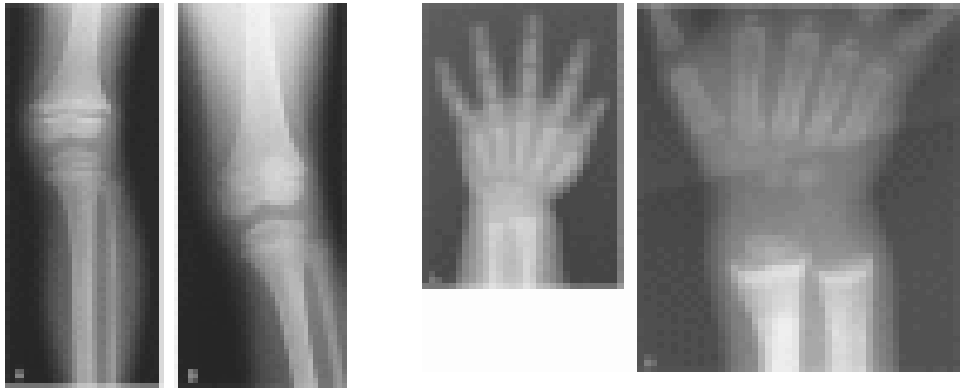
DISTAL RENAL TUBULAR ACIDOSIS

GENERAL	
	Failure to thrive
	Listlessness
	Protuding abdomen
	Muscle weakness (especially proximal)
	Fractures
HEAD	
	Craniotabes
	Frontal bossing
	Delayed fontanelle closure
	Delayed dentition; caries
	Craniosynostosis
CHEST	
	Rachitic rosary
	Harrison groove
	Respiratory infections and atelectasis[*]
BACK	
	Scoliosis
	Kyphosis
	Lordosis

EXTREMITIES	
	Enlargement of wrists and ankles
	Valgus or varus deformities
	Windswept deformity (combination of valgus deformity of 1 leg with varus deformity of the other leg)
	Anterior bowing of the tibia and femur
	Coxa vara
	Leg pain
HYPOCALCEMIC SYMPTOMS[†]	
	Tetany
	Seizures
	Stridor due to laryngeal spasm

DISORDER	Ca	Pi	PTH	25-OHD	1,25-$(OH)_2D$	ALK PHOS	URINE Ca	URINE Pi
Vitamin D deficiency	N, ↓	↓	↑	↓	↓, N, ↑	↑	↓	↑
VDDR, type 1	N, ↓	↓	↑	N	↓	↑	↓	↑
VDDR, type 2	N, ↓	↓	↑	N	↑↑	↑	↓	↑
Chronic renal failure	N, ↓	↑	↑	N	↓	↑	N, ↓	↓
Dietary Pi deficiency	N	↓	N, ↓	N	↑	↑	↑	↓
XLH	N	↓	N	N	RD	↑	↓	↑
ADHR	N	↓	N	N	RD	↑	↓	↑
HHRH	N	↓	N, ↓	N	RD	↑	↑	↑
Tumor-induced rickets	N	↓	N	N	RD	↑	↓	↑
Fanconi syndrome	N	↓	N	N	RD or ↑	↑	↓ or ↑	↑
Dietary Ca deficiency	N, ↓	↓	↑	N	↑	↑	↓	↑

Rickets



Minerals

- **Group A micronutrients:**
- **Sufficient data exist to evaluate different prevention programs in different settings and populations-Fe, I, vitA**
- **Group B micronutrients:**
- **These nutrients are receiving increasing attention in the literature. We will be able to assess the effectiveness of the preventive programs in the future-folate, Zn**

Trace Elements

ELEMENT	PHYSIOLOGY	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	DIETARY SOURCES
Chromium	Potentiates the action of insulin	Impaired glucose tolerance, peripheral neuropathy and encephalopathy	Unknown	Meat, brewer's yeast
Copper	Absorbed via specific intestinal transporter; circulates bound to ceruloplasmin; enzyme cofactor (superoxide dismutase, cytochrome oxidase, and enzymes involved in iron metabolism and connective tissue formation)	Microytic anemia, osteoporosis, neutropenia, neurologic symptoms, depigmentation of hair and skin	Acute: nausea, emesis, abdominal pain, coma, and hepatic necrosis; chronic toxicity (liver and brain injury) occurs in Wilson disease	Oysters, nuts, liver, margarine, legumes, corn oil

Trace Elements

ELEMENT	PHYSIOLOGY	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	DIETARY SOURCES
Fluoride	Incorporated into bone	Dental caries	Chronic:dental fluorosis water	Toothpaste, fluoridated water
Iodine	Component of thyroid hormone	Hypothyroidism	Hypothyroidism and goiter; maternal excess may cause congenital hypothyroidism and goiter	Saltwater fish, iodized salt

Iodine Deficiency

- Goiter
- Swollen thyroid gland

Trace Elements

ELEMENT	PHYSIOLOGY	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	DIETARY SOURCES
Iron	Component of hemoglobin, myoglobin, cytochromes, and other enzymes	Anemia decreased alertness, impaired learning	Acute : nausea, vomiting, diarrhea, abdominal pain, and hypotension; chronic excess usually secondary to hereditary disorders; causes organ dysfunction	Deficiency may also result from blood loss (hookworm infestation, menorrhagia)
Manganese	Enzyme cofactor	Hypercholesterolemia, weight loss, decreased clotting proteins[*]	Neurologic manifestations, cholestatic jaundice	Nuts, grains, tea

Trace Elements

ELEMENT	PHYSIOLOGY	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	DIETARY SOURCES
Molybdenum	Enzyme cofactor (xanthine oxidase and others)	Tachycardia, tachypnea, night blindness, irritability, coma[*]	Hyperuricemia and increased risk of gout	Legumes, grains, liver
Selenium	Enzyme cofactor (prevents oxidative damage)	Cardiomyopathy (Keshan disease), myopathy	Nausea, diarrhea, neurologic manifestations, nail and hair changes, garlic odor	Meat, seafood, whole grains, garlic

Trace Elements

ELEMENT	PHYSIOLOGY	EFFECTS OF DEFICIENCY	EFFECTS OF EXCESS	DIETARY SOURCES
Zinc	Enzyme cofactor; constituent of zinc finger proteins, which regulate gene transcription	Decreased growth, dermatitis of extremities and around orifices, impaired immunity, poor wound healing, hypogonadism, diarrhea; supplements beneficial in diarrhea and improve neurodevelopmental outcomes	Abdominal pain, diarrhea, vomiting; may worsen copper deficiency	Meat, shellfish, whole grains, legumes, cheese

Remedies

- **Very short term intervention: Therapeutic measures**
- **Short term interventions: Supplementation**
- **Medium term interventions: Food fortification and public health measures such as control of infectious diseases and improved hygiene**
- **Long term interventions: Dietary diversification**

Solutions: *Supplementation*

- Vitamins and minerals are supplied in the form of tablets, capsules and syrups to the vulnerable groups
- Low cost:
  - 5 cents per person per year for salt iodization
  - 2 cents for a capsule of vitamin A
  - 20 cents for a three-months supply of iron tablets

Solutions: *Fortification*

- Vitamins and minerals are added to foods or condiments that are commonly used by a significant proportion of the target population – flour, salt, sugar, cooking oil, margarine, sauces
- The cost can be as little as a few cents per person/year

Solutions: *Education*

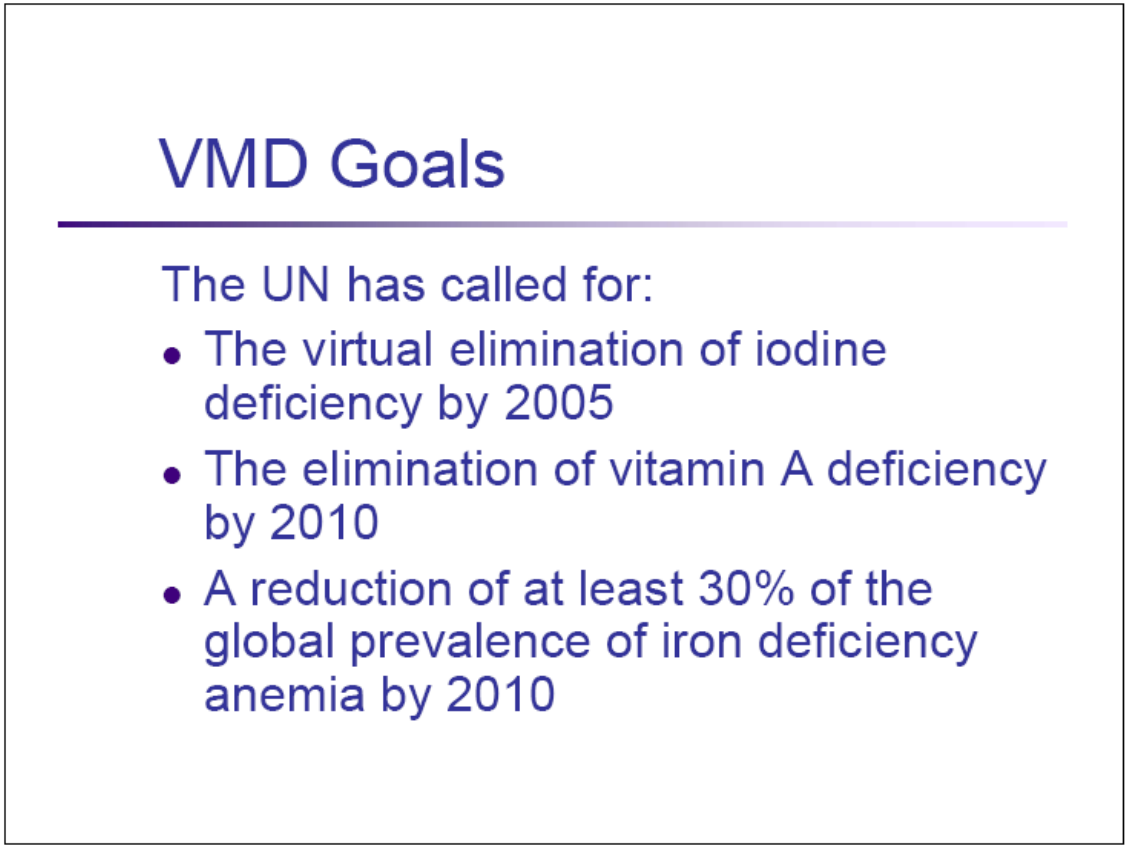
- Inform the public about the need for supplementation or fortification and dietary modification
- Assistance growing and using a wider variety of foods

Solutions: *Disease control*

- Control of diseases such as malaria, measles, diarrhea, and parasitic infections
- Deworming:
  - *"a crucial and neglected step towards improving public health"*
  - Could contribute to achieve 7 out of the 8 Millenium Development Goals

Thinking beyond deworming
Lancet 2004; 364:1993-4

VMD Goals


VMD Goals
The UN has called for:
• The virtual elimination of iodine deficiency by 2005
• The elimination of vitamin A deficiency by 2010
• A reduction of at least 30% of the global prevalence of iron deficiency anemia by 2010

Childhood Obesity: public health problem, common sense cure

Epidemiology

- **Prevalence of overweight and obesity among** 425 **preschool** (2 to 5 years) **children in semi urban South India** was 4.5% and 1.4%, respectively. Overweight and obesity were defined as body mass index (BMI) > 85th and 95th percentiles for that age and sex, respectively.

  Indian Pediatr. 2008 Jun;45(6):497-49.

- **Prevalence of obesity and overweight in 1000 affluent adolescents from Ludhiana, Punjab** was 3.4% and overweight was 12.7%. A significantly greater number of boys (15%) were overweight as compared to girls (10%).

  Indian Pediatr. 2008 Jun;45(6):500-2.

- Abdominal subcutaneous fat thickness might be a better predictor of the risk for hyperinsulinemia in childhood obesity.

  Indian Pediatr. 2008 Jun;45(6):457-62.

Poorer communities tend to have fewer available parks and green spaces, places to play sports, and public pools and beaches.

(Powell LM, Slater S, Chaloupka FJ. The relationship between physical activity settings and race, ethnicity, and socioeconomic status. Evidence-Based Preventive Medicine 2004;1[2]:135-44)

In 1980, about 50 percent of high school seniors reported eating green vegetables “nearly every day or more.” By 2003, that figure had dropped to about 30 percent.

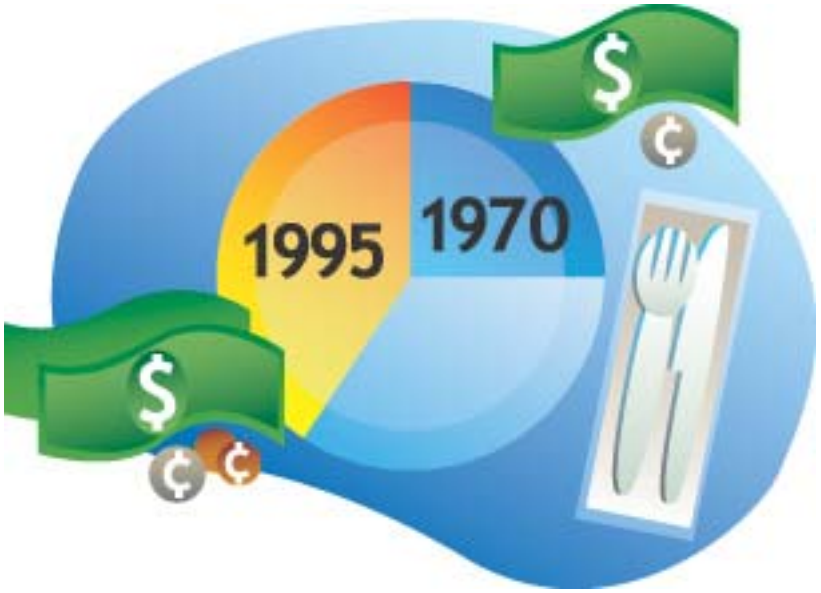
(YES Occasional Papers. Paper 3. Ann Arbor, Mich.: Institute for Social Research, May 2003)

Between 1977-78 and 2000-01, milk consumption decreased by 39 percent in children ages 6-11, while consumption of fruit juice rose 54 percent, fruit drink consumption rose 69 percent and consumption of carbonated soda rose 137 percent.

(Cleveland L. U.S. Department of Agriculture; National Food Consumption Survey, 1977-78; What We Eat in America, NHANES 2001-02)

In 1970, about 25 percent of total food spending occurred in restaurants. By 1995, 40 percent of food dollars were spent away from home.

(Paeratakul S, Ferdinand D, Champagne C, Ryan D, Bray G. Fast-food consumption among US adults and children. J Am Diet Assoc 2003:103:1332-8)



Children eat nearly twice as many calories (770) at restaurants as they do during a meal at home (420).

(Zoumas-Morse C, Rock CL, Sobo EJ, Neuhouser ML. Children's patterns of macronutrient intake and associations with restaurant and home eating. J Am Diet Assoc 2001;101-923-5)

Many of elementary schools do not provide daily physical education classes for all students throughout the entire school year.

(School Health Policies and Programs Study. Journal of School Health 2001;71[7])

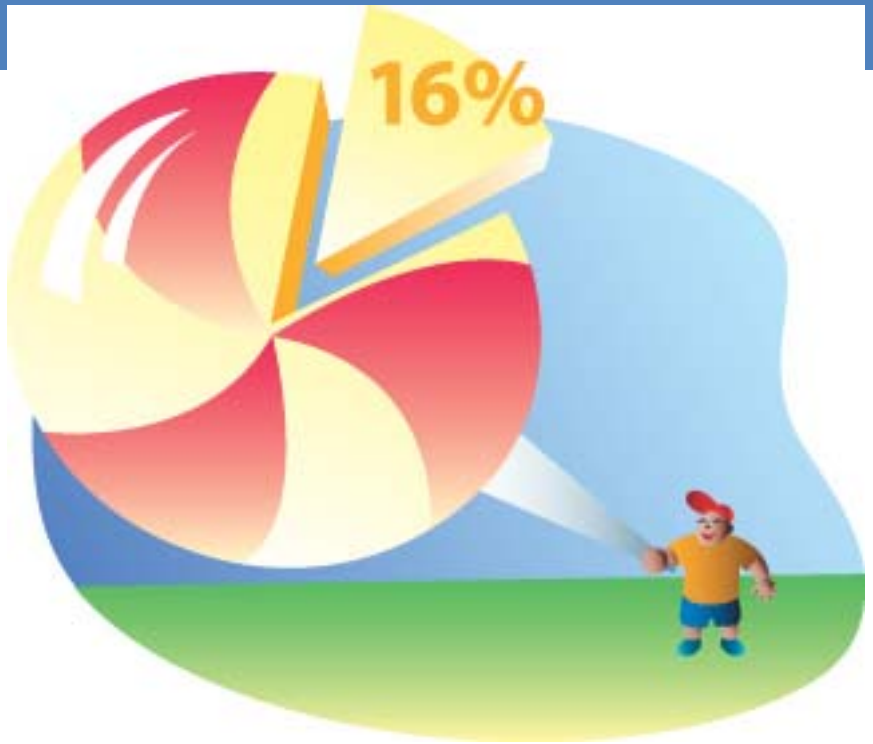
The typical American child spends about 44.5 hours per week using media outside of school.

(Generation M: Media in the Lives of 8-18 Year Olds. Menlo Park, Calif.: Kaiser Family Foundation, 2005)

Six out of 10 children ages 9-13 don’t participate in any kind of organized sports/physical activity program outside of school, and children whose parents have lower incomes and education levels are even less likely to participate. Nearly 23 percent don’t engage in any free-time physical activity.

(Physical activity levels among children aged 9-13 years – United States, 2002. MMWR 2003;52[33]:75-8)

Statistics from the Centers for Disease Control and Prevention (CDC) are alarming. Today, about 16 percent of all children and teens in the United States are overweight.



Aetiology

- Genetic/perinatal-complex interaction between at least 250 obesity associated genes and, perhaps, perinatal factors.
- bottle fed children-more at risk

Adiposity rebound

- BMI normally decreases until age 5–6 years, then increases through adolescence. The age at which this BMI nadir occurs has been termed the adiposity rebound.
- increased risk for obesity later in life in individuals who have an early adiposity rebound

Physical activity

- obesity risk decreased by 10% for each hour per day of moderate-to-vigorous physical activity, and increased by 12% for each hour per day of television viewing.
- Television viewing: promote weight gain displaces physical activity
- increases energy intake
- television advertising could adversely affect dietary patterns

Diet

- Type of dietary fat important than total fat consumption
- saturated fat –risk of cardiovascular disease
- partially hydrogenated (trans) fat(commercial bakery products and fast foods)- cardiovascular disease and type 2 diabetes
- unsaturated fats from vegetable and marine sources decrease risk of these diseases.

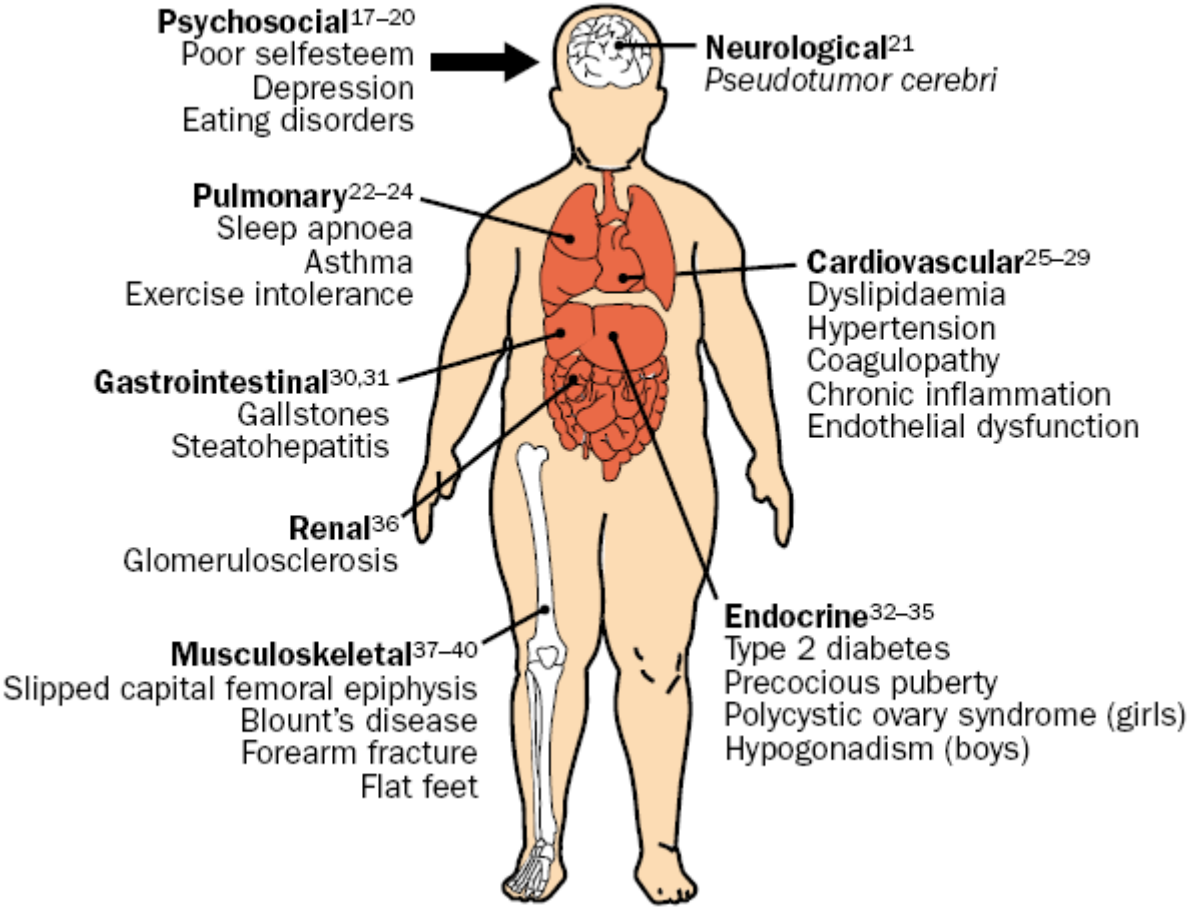
Diet…

- High glycaemic index foods like eg breads, ready-to-eat cereals, potatoes, soft drinks, cakes, and biscuits.
- produce fairly large increases in postprandial blood glucose concentrations and could play a part in appetite regulation.

Family factors

- family dinner- decrease television viewing
- improve diet quality(less saturated and trans fat, less fried food, lower glycaemic load, more fibre, fewer soft drinks, and more fruits and vegetables).
- social support from parents and others correlates strongly with participation in physical activity.
- children who suffer from neglect, depression, or other related problems-at risk

Complications of childhood obesity



Obesity-associated annual hospital costs for children more than tripled between 1979 and 1999.

(Wang G, Dietz WH. Economic burden of obesity in youths aged 5 to 17 years: 1979-1999. Pediatrics 2002;109(5):E81-E86)

BACKGROUND

- **Proactive strategies required to prevent childhood obesity**
- **Individual behaviors must be addressed in the context of societal and environmental influences**
- **Most prevention studies target school environments**
- **Community-based interventions that have a theoretical framework and are mutli-level and participatory in nature are needed**

INTERVENTION

- *Family based*: Designed to increase energy expenditure (EE) of up to 125 kcals per day beyond the increases in EE and energy intake that accompany growth
  - Variety of increased opportunities for physical activity
  - < 2 hr. per day of Screen Time, No TV in bedroom
  - Increased availability of foods of lower energy density, emphasizing fruits, vegetables, whole grains, and low-fat dairy
  - Foods high in fat and sugar to be discouraged
  - Family Meals encouraged – structure, modeling, education, emotional connection: practice as often as possible

At least 30 minutes of moderate physical activity on most days of the week is the recommended minimum. However, nearly 23 percent of children and nearly 40 percent of adults get no free-time physical activity at all.

(Physical activity levels among children aged 9-13 years – United States, 2002. MMWR 2003;52[33]:785-8) and (National Center for Health Statistics. National Health Interview Survey, 1999-2001)

- Note: “Vigorous activity” is defined as activity causing sweating and hard breathing for at least 20 minutes on 3 or more of the 7 days. “Moderate activity” is defined as activities such as walking or bicycling lasting for at least 30 minutes on 5 or more of the 7 days.
- *(Youth Risk Behavior Surveillance – United States, 2003. MMWR 2004;53[SS-2]) and (National Center for Health Statistics, Centers for Disease Control and Prevention. The Third National Health and Nutrition Examination Survey, 1988-94)*

*School based:*eat smart, play hard

Growing food, knowing food

School Gardens and Nutrition Education