

## Recommendations for Dietary Salt Intake

Lawrence J Appel, MD, MPH  
 Professor of Medicine, Epidemiology and  
 International Health  
 (Human Nutrition)

Oct 22, 2008



## Dietary Reference Intakes

## IOM Panel on Water and Electrolytes

### LARRY J. APPEL *chair*

Johns Hopkins University,  
 Baltimore, MD

### DAVID H. BAKER

University of Illinois, Champaign-  
 Urbana

### ODED BAR-OR

McMaster University, Hamilton, ON

### KENNETH L. MINAKER

Massachusetts General Hospital &  
 Harvard Medical School, Boston

### R. CURTIS MORRIS, JR

University of California, San  
 Francisco

### LAWRENCE M. RESNICK

New York Presbyterian Hospital &  
 Cornell University Medical College

### MICHAEL N. SAWKA

U.S. Army Research Institute of  
 Environmental Medicine, Natick, MA

### STELLA L. VOLPE

University of Pennsylvania,  
 Philadelphia

### MYRON H. WEINBERGER

Indiana University School of Medicine,  
 Indianapolis

### PAUL K. WHELTON

Tulane University Health Sciences  
 Center, New Orleans

### ALLISON A. YATES

Study Director (from June 2003)

### PAUL R. TRUMBO

Study Director (through May 2003)

## Useful Conversions

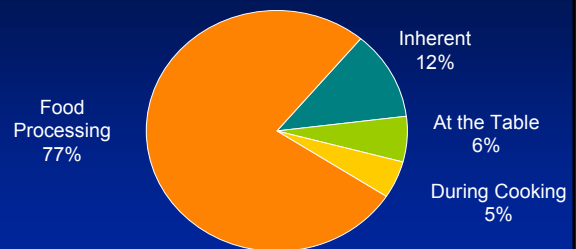
	Adequate Intake (AI)	Upper Level (UL)
Sodium (g)	1.5	2.3
Sodium (mmol)	65	100
Sodium Chloride (g)	3.8	5.8

## Forms of Sodium

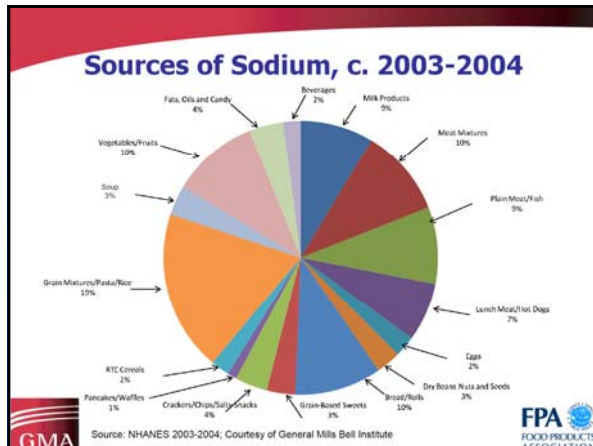
- 90% of sodium consumed as sodium chloride (salt)
- Other forms:
  - sodium bicarbonate
  - sodium in processed foods, such as sodium benzoate and sodium phosphate

## Sources of Dietary Sodium

(62 adults who completed 7 day dietary records)



Mattes and Donnelly, JACN, 1991; 10: 383



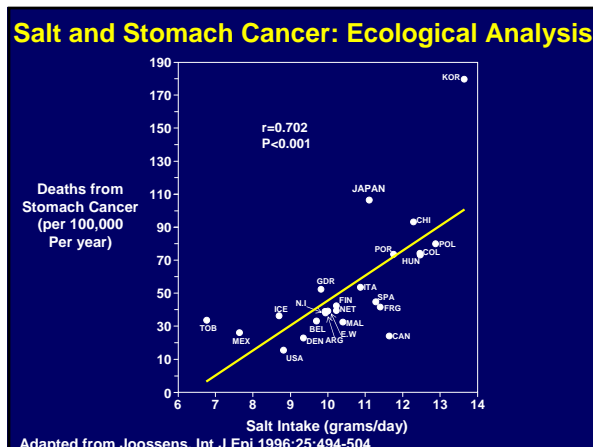
### PREMIER Sodium Intake\* at Baseline by BMI Category

	BMI Category		
	Non-Overweight (n=44)	Overweight (n=238)	Obese (n=528)
mg of Na	2,991	3,708	4,235
% with Na < 2,300 mg	32%	20%	11%

\* as estimated from 24 Hour Urinary Sodium Excretion

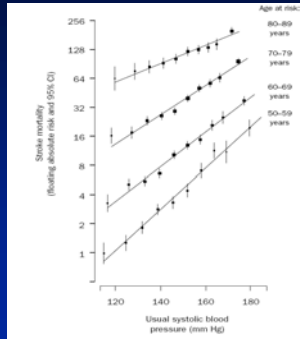
# SETTING AN UPPER LIMIT

- ### Potential Adverse Effects of Excess Sodium Intake
- Increased urinary calcium excretion (but no trials with bone mineral density or fractures)
  - Increased left ventricular mass in cross-sectional studies (and one randomized trial)
  - Increased risk of gastric cancer (ecologic studies, case-control studies)
  - Increased blood pressure



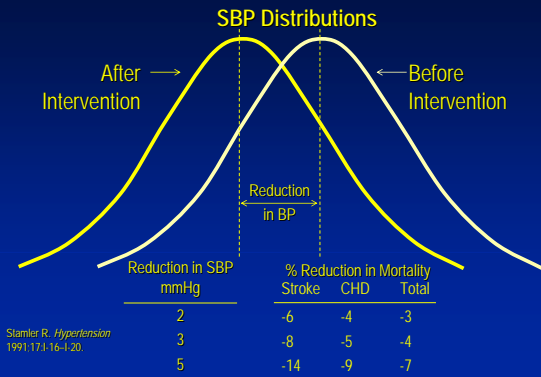
- ### Magnitude of the BP Problem
- 62% of strokes and 49% of CHD events attributed to elevated BP\*
  - 26% of adults worldwide (972 million) have hypertension\*\*
  - Estimated lifetime risk of developing hypertension is 90%\*\*\*
- \*WHO, World Health Report 2002: Reducing Risks, Promoting Healthy Life.  
\*\*Kearney Lancet 2005;305:217, \*\*\*Vasan, JAMA 2002;287:1003.

## Stroke Mortality by Level of Usual Systolic BP\*



\*Prospective Studies Collaboration, Lancet, 2002: Meta-analysis of 61 prospective studies with 2.7m person-yrs, 11.9k deaths

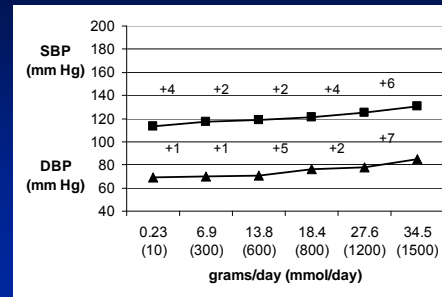
## Population-Based Strategy



## Effect of Reduced Sodium Intake on Blood Pressure

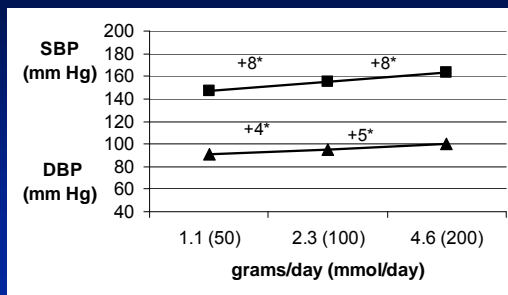
- > 50 trials of sodium reduction on blood pressure
- 10 dose response trials
- 3 trials of sodium reduction as a means to prevent hypertension

## Sodium: Dose Response Trials



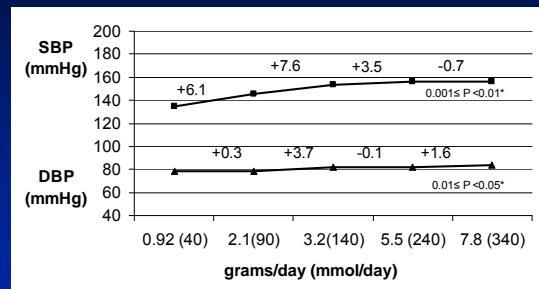
Luft, 1979 (14 non-hypertensive)

## Sodium: Dose Response Trials



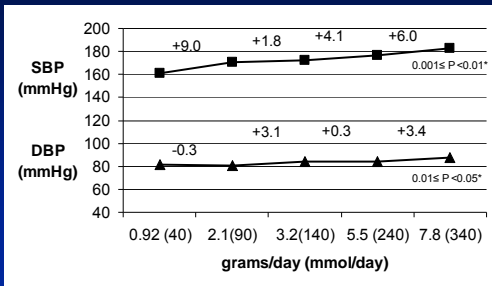
MacGregor, 1989 (20 hypertensive)

## Sodium: Dose Response Trials



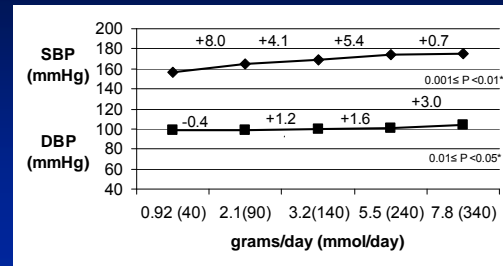
Johnson, 2001 (n=17 non-hypertensive elderly)

## Sodium: Dose Response Trials



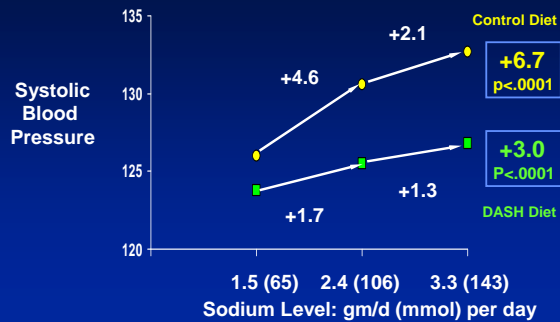
Johnson, 2001 (n=15 elderly with isolated systolic hypertension)

## Sodium: Dose Response Trials



Johnson, 2001 (n=8 elderly with systolic-diastolic hypertension)

## Sodium Dose Response Trials: DASH-Sodium Trial\*

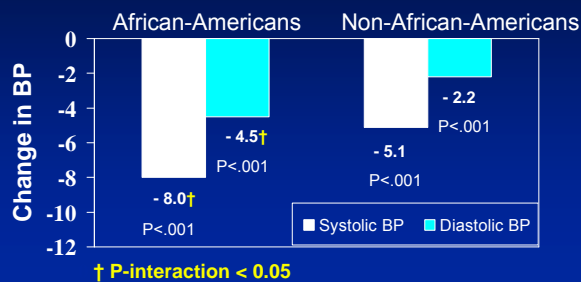


\*Sacks, 2001 (412 prehypertensive and hypertensive adults)

## Factors Associated with Increased Salt Sensitivity

- Fixed factors
  - Middle and older-aged persons
  - African-Americans
  - Genetic Factors
  - Individuals with:
    - Hypertension
    - Diabetes
    - Chronic Renal Insufficiency
- Modifiable
  - Low potassium intake
  - Poor quality diet

## Effect of Sodium Reduction (Higher to Lower) in African-Americans and Non-African-Americans on the Control Diet



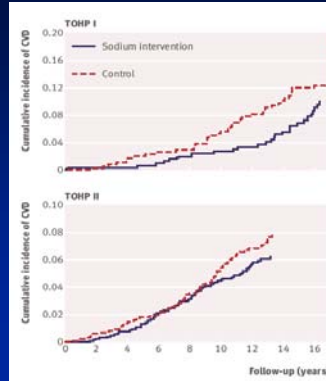
## Bottom Line on Sodium Chloride

- The relationship between salt (sodium chloride) intake and blood pressure is direct and progressive without an apparent threshold

## Arguments Made by Those who Oppose Sodium Reduction

- No clinical trial has tested the effects of sodium reduction on clinical cardiovascular outcomes
- Only those who are 'salt sensitive' should reduce their salt intake
- Other lifestyle factors (weight, potassium, DASH diet, exercise) are more important than sodium
- Sodium reduction has effects on plasma renin activity, lipids and insulin resistance that potentially mitigate the beneficial effects of blood pressure reduction

Effects of Reduced Na Intake on CVD: Longterm Results from the Trials of Hypertension Prevention (Cook et al, BMJ, 2007)



## Effects of Reduced Na on CVD Events: Results from 3 Randomized Trials

	INTERVENTION	OUTCOME	FU
TONE (2001) 639 Elderly	↓ Na	21% ↓ CVD events	2.3 yrs
Taiwan Veterans (2006) 1,981 Elderly	↓ Na / ↑ K Salt	41%* ↓ CVD Mortality	2.6 yrs
TOHP Follow-up (2007) 3,126 Prehypertensives	↓ Na	30%* ↓ CVD events	10-15 yrs

\*p<0.05

## SETTING A LOWER LIMIT

## Obligatory Losses of Sodium (in g/d and mmol/d)

Source of Loss	g/d	mmol/d
Urine	0.005 to 0.035	0.2 to 1.5
Skin (nonsweating)	0.025	1.1
Feces	0.010 to 0.125	0.4 to 5.4
<b>Total</b>	<b>0.040 to 0.185</b>	<b>1.7 to 8.0</b>

Source: Dahl (1958)

## Rationale for a Lower Limit

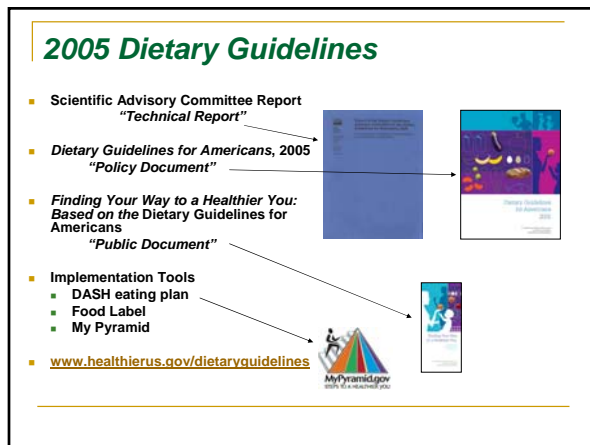
- Nutrient Adequacy:
  - ensure that the overall diet provides an adequate intake of other important nutrients
- Replacement of Sweat Losses:
  - cover sodium sweat losses in unacclimatized individuals who are exposed to high temperatures or who are moderately physically active.

## Lower Limit: Two Caveats

- The AI of 65 mmol/d does not apply to highly active individuals, such as endurance athletes, who lose large amounts of sweat on a daily basis.
- Inadequate sodium intake is not a public health problem

## Sodium Recommendations from IOM Report

- Upper Limit (UL):  
2.3 g (100 mmol)/day for adults
- Adequate Intake (AI):  
1.5 g (65 mmol)/day for adults



## 2005 Dietary Guideline Scientific Advisory Committee

Janet King, PhD, RD (Chair)  
Children's Hospital Oakland Research Institute,  
Oakland, CA

Lawrence J. Appel, MD, MPH  
Johns Hopkins Medical Institutions, Baltimore,  
MD

Yvonne L. Bronner, ScD, RD, LD  
Morgan State University, Baltimore, MD

Benjamin Caballero, MD, PhD  
Johns Hopkins University Bloomberg School of  
Public Health, Baltimore, MD

Carlos A. Camargo, MD, DrPH  
Harvard University, Boston, MA

Fergus M. Clydesdale, PhD,  
University of Massachusetts, Amherst, Amherst,  
MA

Vay Liang W. Go, MD  
University of California at Los  
Angeles, Los Angeles, CA

Penny M. Kris-Etherton, PhD, RD  
Penn State University,  
University Park, PA

Joanne R. Lupton, PhD  
Texas A&M University,  
College Station, TX

Theresa A. Nicklas, DrPH, MPH, LN  
Baylor College of Medicine,  
Houston, TX

Russell R. Pate, PhD  
University of South Carolina, Columbia, SC

F. Xavier Pi-Sunyer, MD, MPH  
Columbia University College of Physicians and  
Surgeons,  
New York, NY

Connie M. Weaver, PhD  
Purdue University, West Lafayette, IN



## August 2004 Recommendations from the Scientific Advisory Committee

1. Consume a variety of foods within and among the basic food groups while staying within energy needs
2. Control calorie intake to manage body weight
3. Be physically active every day
4. Increase daily intake of fruits and vegetables, whole grains, and reduced-fat milk and milk products
5. Choose fats wisely for good health
6. Choose carbohydrates wisely for good health
7. Choose and prepare foods with little salt
8. If you drink alcoholic beverages, do so in moderation
9. Keep food safe to eat



## 2005 Dietary Guidelines for Americans from Policy Document

- 41 Key Recommendations in Dietary Guidelines
  - 23 for General Public
  - 18 for Special Populations
- 3 Key Messages in Consumer documents
  - 'Make smart choices from every food group'
  - 'Find your balance between food and physical activity'
  - 'Get the most nutrition out of your calories'



## SODIUM RECOMMENDATIONS

- For general population:
  - consume less than 2,300 mg (approximately 1 teaspoon of salt) of sodium per day
- For individuals with hypertension, blacks, and middle-aged and older adults:
  - consume no more than 1,500 mg of sodium per day

