Salt reduction – time to get serious

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Outline of presentation

- Hypertension and cardiovascular disease
- Salt and blood pressure
  - In early life
  - In adulthood
- Effect of salt reduction on mortality
- World Action on Salt and Health (WASH)
- Conclusion and discussion

Hypertension

Table 3. Classification of blood pressure for adults

Blood Pressure Classification	SBP mmHg	DBP mmHg
Normal	<120	and <80
Prehypertension	120–139	or 80–89
Stage 1 Hypertension	140–159	or 90–99
Stage 2 Hypertension	≥160	or ≥100

SBP, systolic blood pressure; DBP, diastolic blood pressure

Hypertension:
systolic BP ≥140 mmHg or
diastolic BP ≥90 mmHg or on
antihypertensive medication

1 in 3 Dutch adults >30 y has hypertension

www.nationaalkompas.nl

www.nhlbi.nih.gov/guidelines/hypertension/jnc7full.htm

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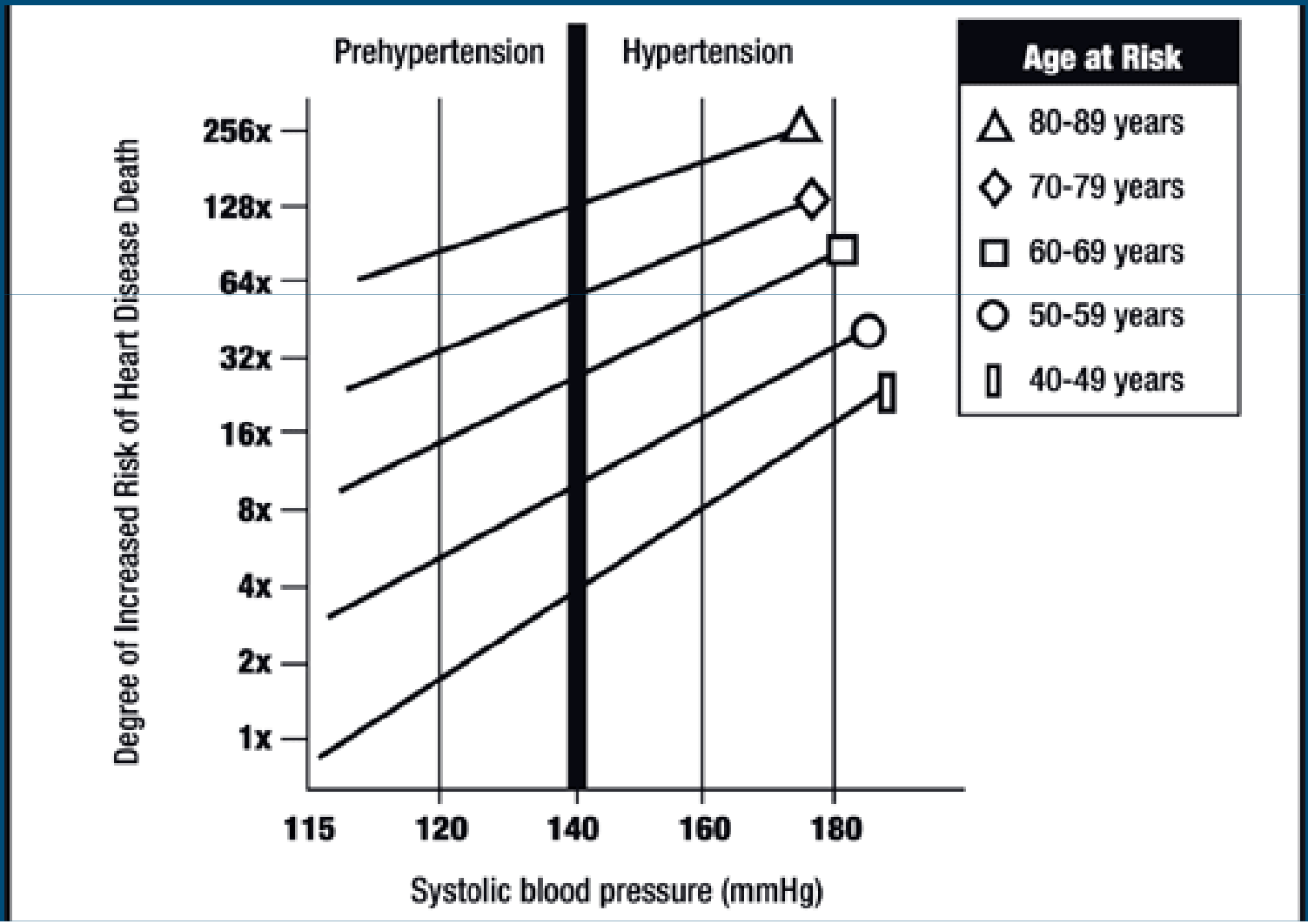
Blood pressure and death from heart disease



Lancet 2002;360:1903-13.

World Health Report 2002: Reducing risks, promoting healthy life

Suboptimal BP (>115 mmHg systolic):

→ responsible for 49% of ischemic heart disease

→ responsible for 62% of cerebrovascular disease

→ no. 1 attributable risk for death throughout the world

http://www.who.int/whr/2002/.

Health care costs in NL due to risk factors, yr 1999 (m€)

		Men	Women	Total
Endo-genous	Blood pressure	359,4	352,5	711,9
	Cholesterol	194,5	122,2	316,7
	Overweight	257,9	247,4	505,4
Exo-genous	Smoking	334,1	174,6	508,7
	Physical inactivity	111,0	89,4	200,4
	Low intake vegs & fruits	86,5	55,0	141,5
	Alcohol & drugs	225,8	86,2	312,0
	Saturated fat	126,5	73,7	200,2

Polder et al, Kosten van ziekten in Nederland - De zorgeuro ontrafeld. RIVM-rapportnummer: 270751005, RIVM 2002.

Diet, lifestyle and blood pressure

Voedings- of leefstijlfactor	Aantal trials	Gemiddelde verandering	Daling systolische bloeddruk (mmHg)
Lichaamsgewicht	25	-5,1 kg	4,4
Lichamelijke activiteit	49	+ 2,5 uur/week	2,8
Alcohol	13	-41 ml/dag	2,6
Natrium	40	1,7 g/dag	2,5
Kalium	27	+1,7 g/dag	2,4
Visolie	36	+3,6 g/dag	2,1
Calcium	40	+1,2 g/dag	1,9
Magnesium	16	+481 mg/dag	1,3
Koffie	18	-725 ml/dag	1,2
Voedingsvezel	24	+11,5 g/dag	1,1

Indien additief:

>20 mmHg !

Geleijnse, Voeding Nu 2005

Diet, lifestyle and blood pressure

Weight reduction	**Maintain normal body weight (BMI 18.5–24.9 kg/m^2)**	**5–20 mm Hg/10 kg**
Adopt DASH eating plan	**Diet rich in fruits, vegetables, and low-fat dairy products with a reduced content of saturated and total fat**	**8–14 mmHg**
Dietary sodium reduction	**Reduce dietary sodium intake to ≤ 100 mmol per day (2.4 g sodium or 6 g sodium chloride)**	**2–8 mmHg**
Physical activity	**Regular aerobic physical activity such as brisk walking (at least 30 minutes per day, most days of the week)**	**4–9 mmHg**
Moderation of alcohol use	**≤ 2 drinks per day in men and ≤ 1 drink per day in women and lighterweight persons**	**2–4 mmHg**

Chobanian et al. 7th report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Hypertension 2003;42;1206-1252.

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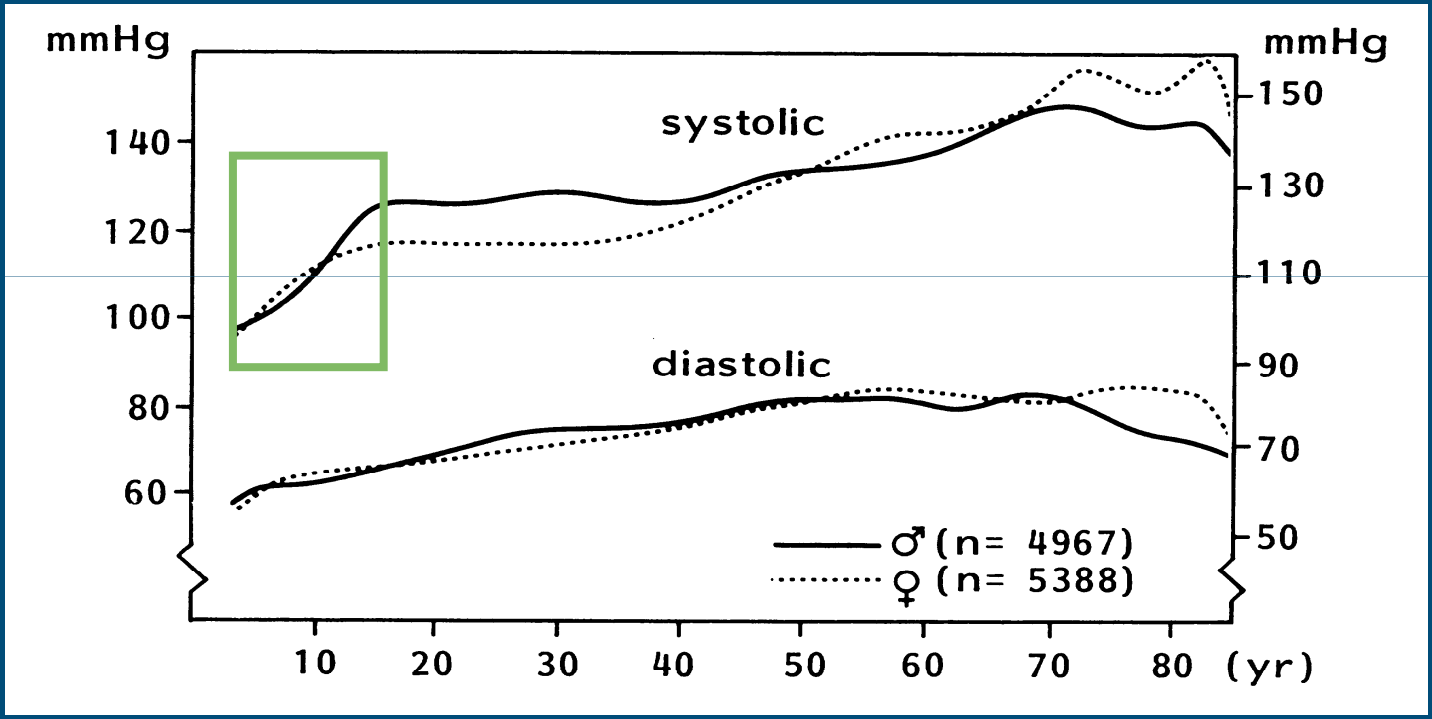
Lifetime course of BP



Geleijnse JM, dissertation, Erasmus MC Rotterdam, 1996.
Combined data from EPOZ-study and Rotterdam study (periode 1970-1990).

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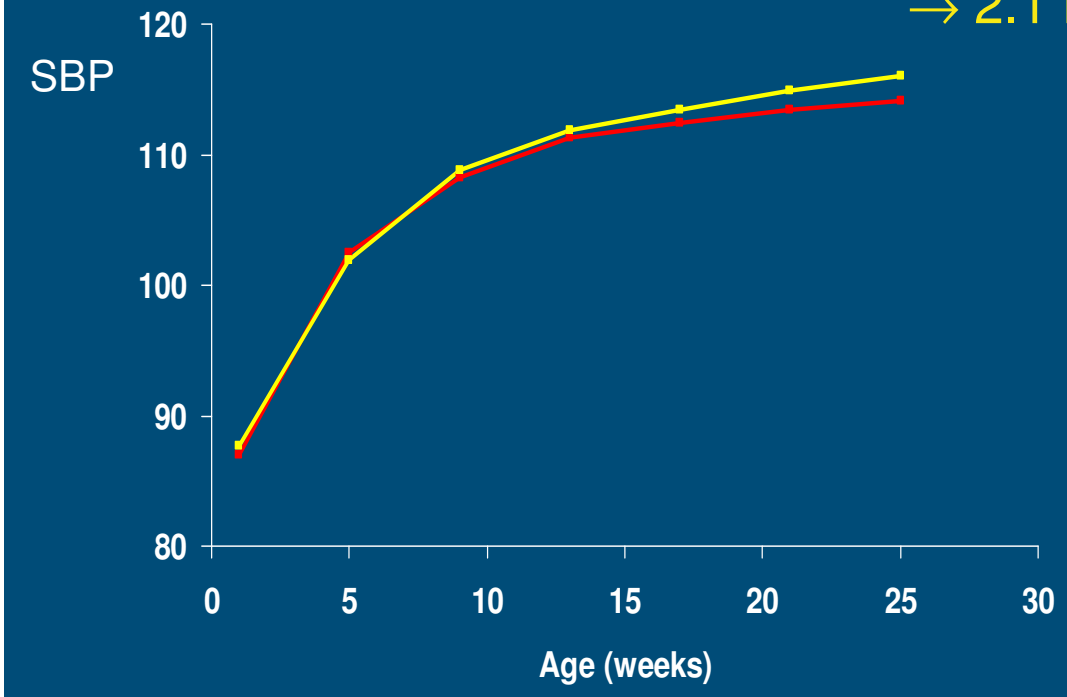
Salt and BP during first months of life



476 term Dutch infants: regular vs. low salt intake
→ 2.1 mmHg lower systolic BP at 25 weeks

Follow-up of 167 children (35%):
Adjusted difference in blood pressure at age 15 y in low-sodium group: -3.6/-2.2 mmHg

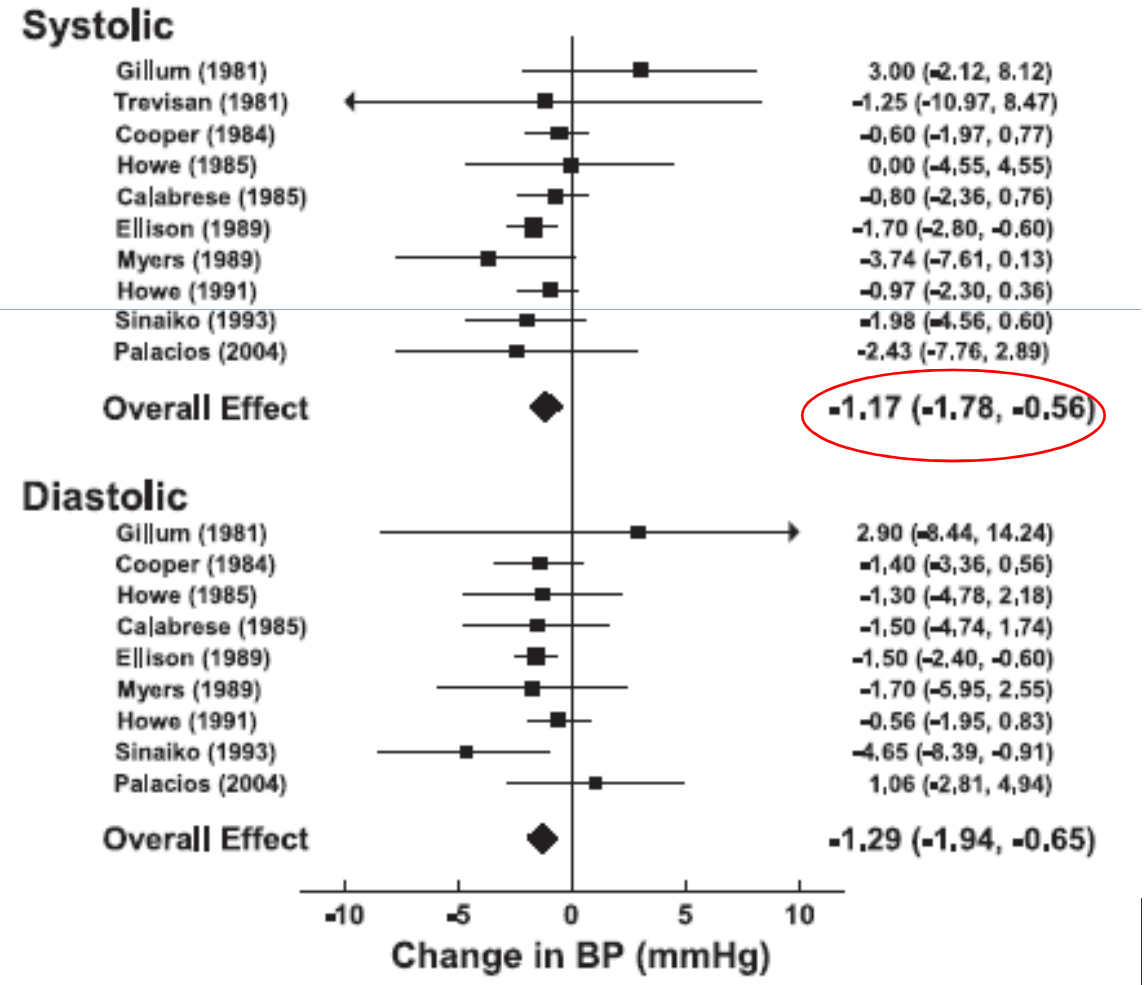
Hofman et al, JAMA 1983;250:370-373
Geleijnse et al, Hypertension 1997;29:913-7.

Meta-analysis of salt and BP in children

- 10 trials of children and adolescents
- 966 participants
- median age: 13 y (8 to 16 y)
- median duration: 4 wk (2 wk to 3 y)
- salt intake reduced by 42%

- Children may eat 8 g salt / day

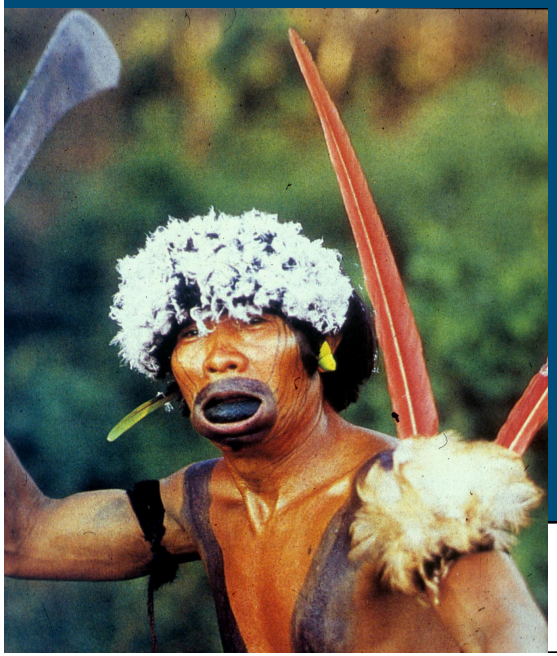
- 3 trials in infants (n=551)
- Change in SBP: -2.5 mmHg



He & MacGregor, Hypertension 2006;48:861-9.

BP in Yanomamo indians (Brasil)

- Sodium excretion: 0.9 mmol/24h = around 0.05 g salt per day
- Also: less obesity, no alcohol
- No rise in BP with age



Blood Pressures Obtained in the Yanomamo Indians

Age	No of subjects	Systolic Mean	Systolic SD	Diastolic Mean	Diastolic SD
Males					
0–9	59	93.2	8.9	58.6	9.2
10–19	63	107.5	9.6	66.9	8.6
20–29	58	108.4	8.6	69.1	7.3
30–39	30	105.9	8.9	69.4	5.7
40–49	27	106.6	7.6	67.1	6.8
50+	7	100.0	8.2	63.7	8.1
Females					
0–9	60	95.7	12.0	61.6	8.0
10–19	72	104.9	9.7	64.5	10.8
20–29	62	99.8	10.0	62.6	6.6
30–39	32	99.5	10.5	62.9	6.3
40–49	19	97.6	11.4	62.2	16.8
50+	17	105.7	17.7	64.1	7.3

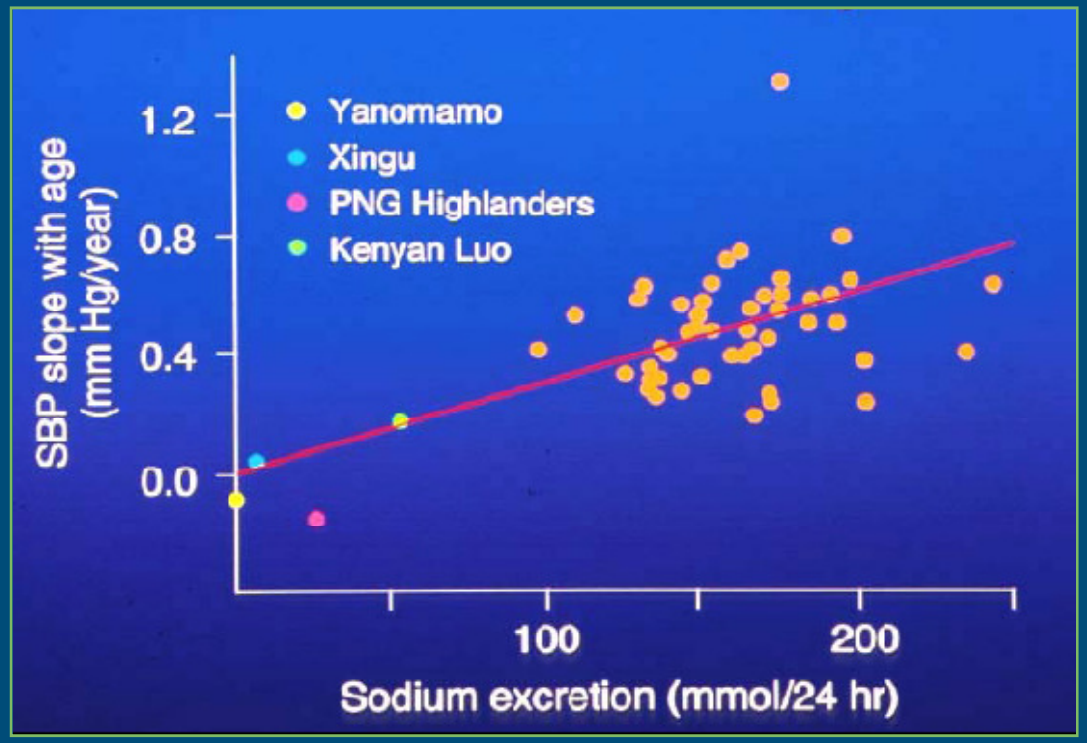
Mancilha-Carvalho et al, J Hum Hypertens 1989; Oliver et al, Circulation 1975;52;146-151

INTERSALT

6 gram/d more salt during 30 y

↓

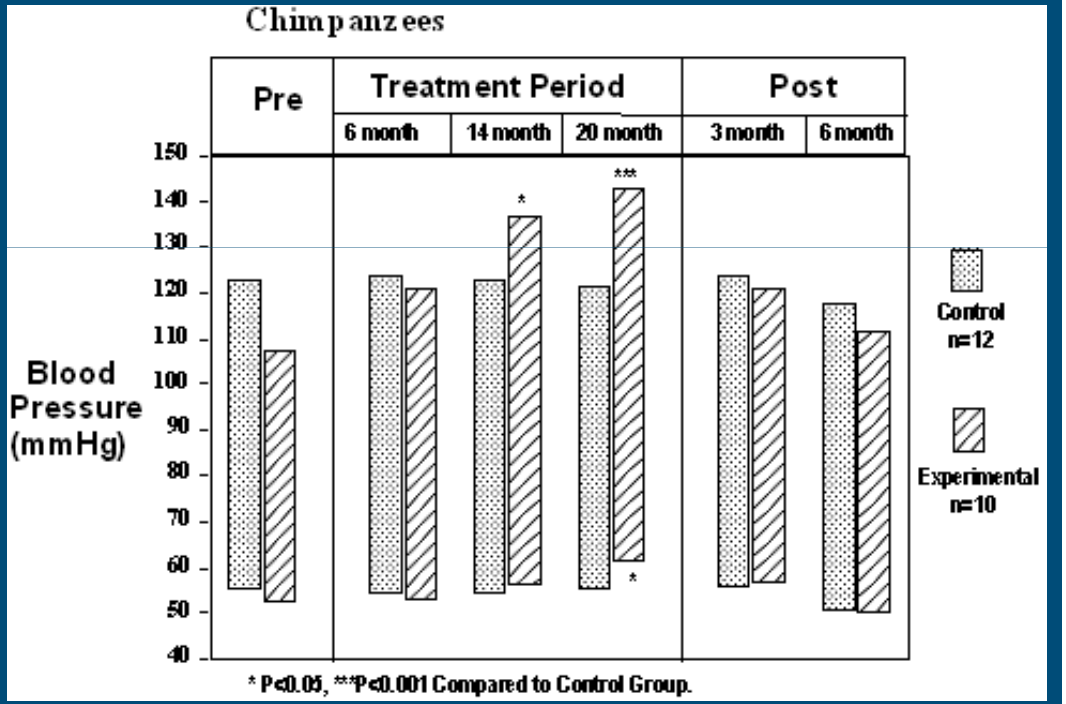
Rise in BP of 10/6 mmHg



Bronnen: Elliott et al, J Hum Hypertens 1989;3:323-330. Elliott et al, BMJ 1996;312:1249-1253.

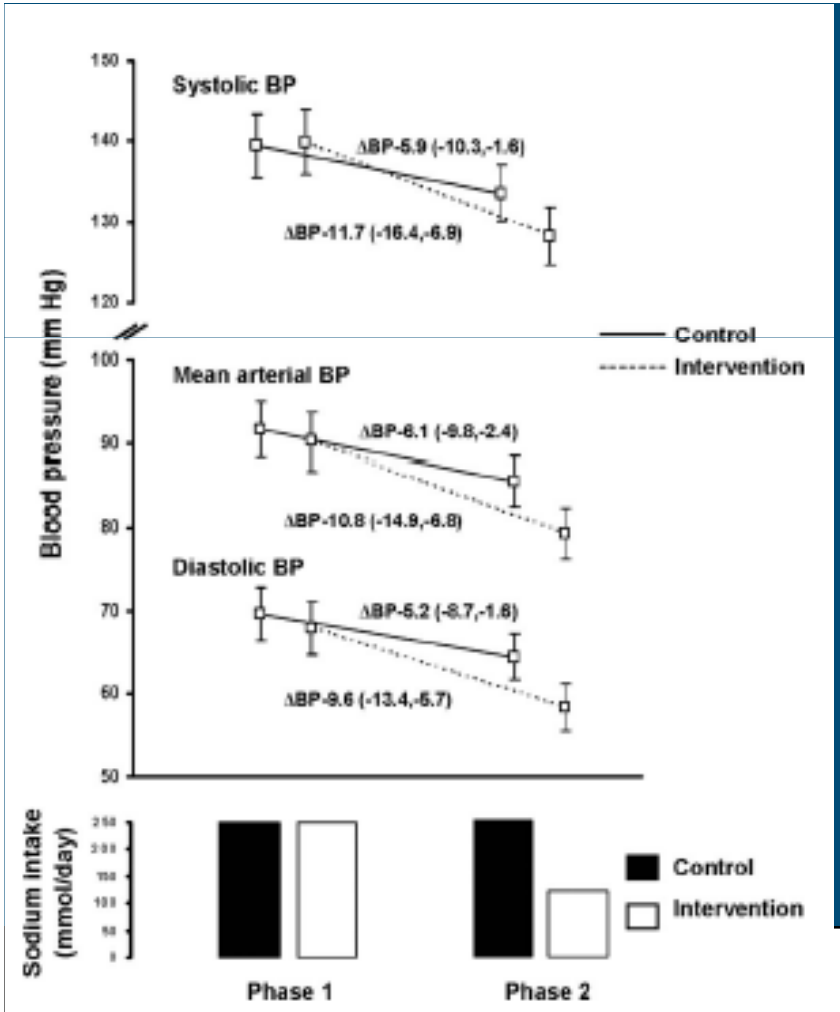
Trial in chimpanzees

- Control group: 0.5 g salt per day
- Experimental group: increased salt intake to 15 g/d for 20 weeks
- Rise in systolic BP: 26 mmHg



Denton et al, Nat Med 1995;1:1009-1016.

Other trial in chimpanzees

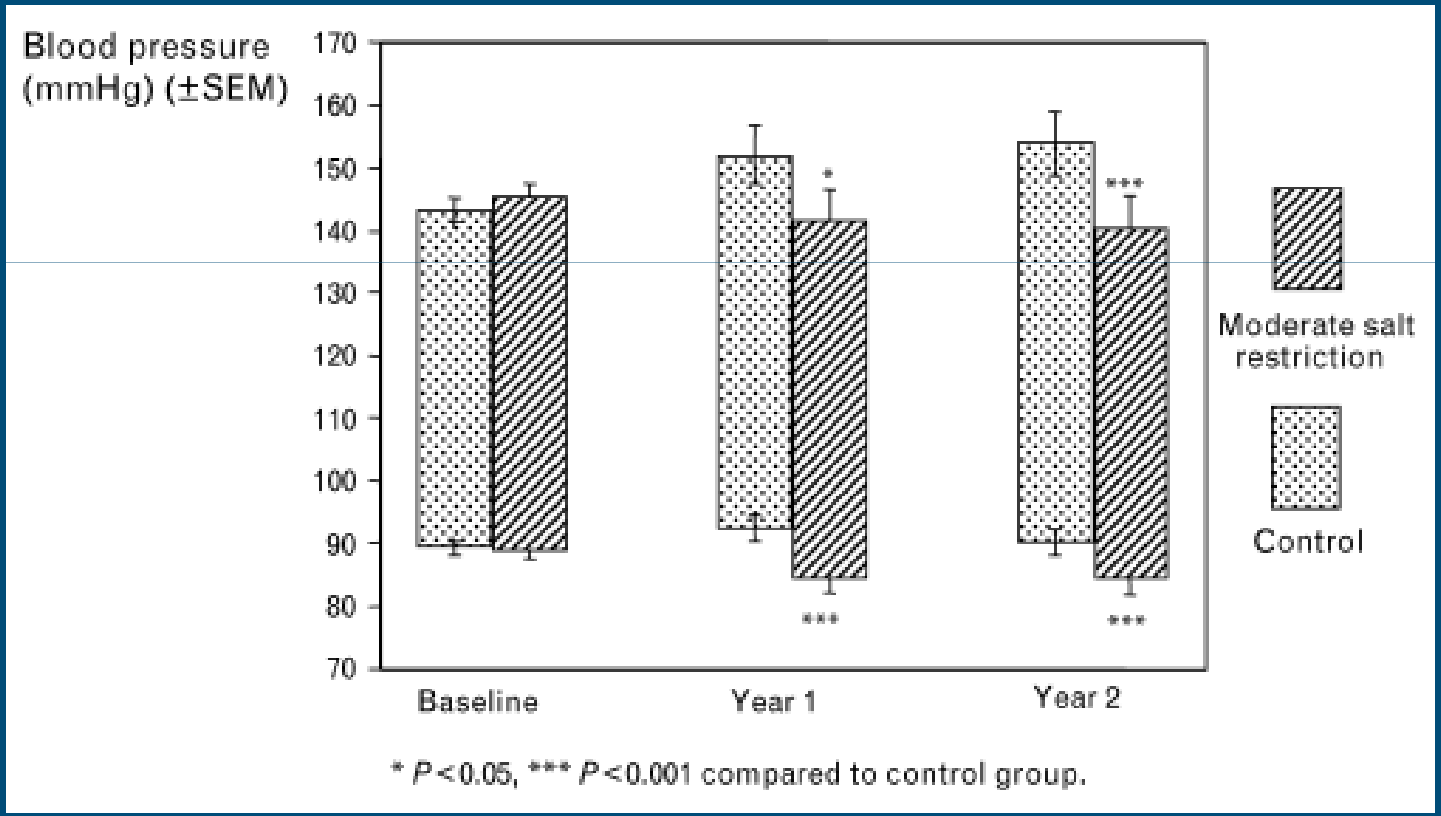


110 chimpanzees in Bastrop:
250 mmol/d sodium vs. 125 mmol/d for 2 yrs

Note: chimpanzees have vegetarian diet with high intake of potassium (350 mmol/d) and calcium (350 mmol/d)

Elliott et al, Circulation. 2007;116:1563-8.

Blood pressure changes during a 2-y intervention in two Portuguese villages



Forte et al. J Hum Hypertens 1989;3:179–84.

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DASH: Dietary Approaches to Stop Hypertension

459 subjects with pre- or mild hypertension

During 8 weeks:

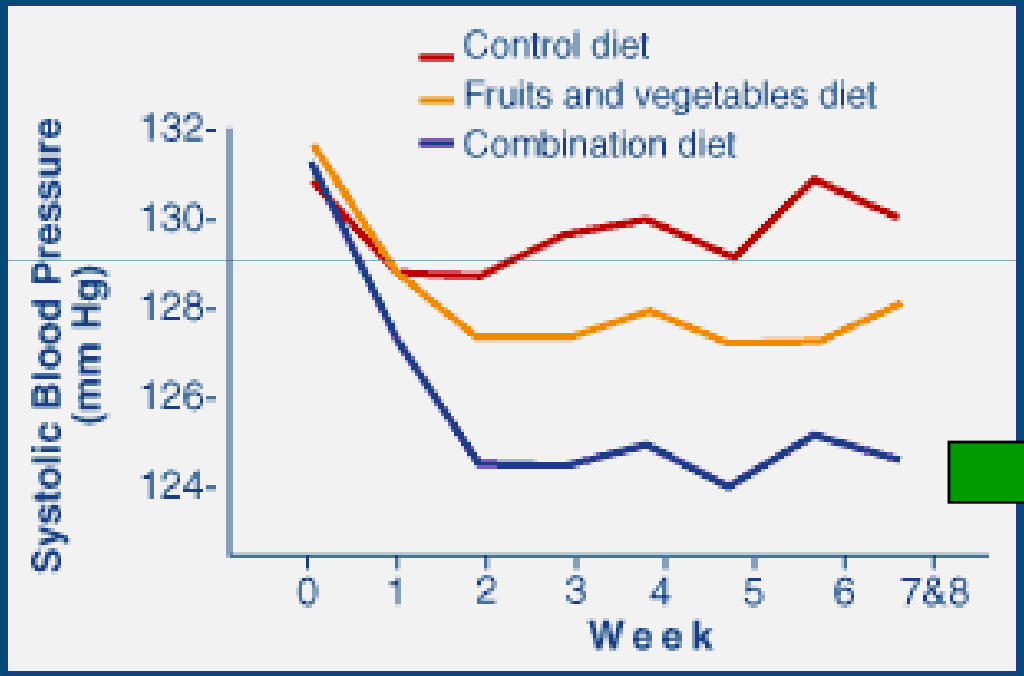
1) standard US diet

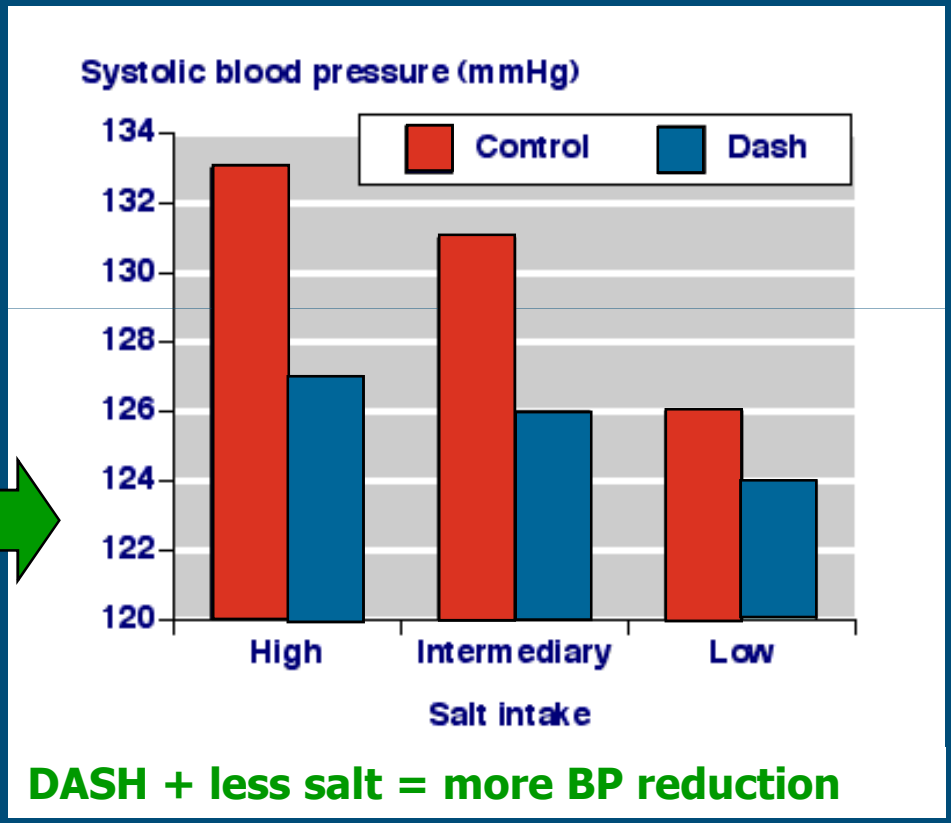
2) healthy diet (more potassium, magnesium, fish, nuts, fiber)

3) combination diet (=DASH diet): see 2, with low-fat dairy, reduced total and saturated fat

Appel et al, N Engl J Med 1997;336:1117-24.

DASH en DASH-Sodium





DASH + less salt = more BP reduction

Appel et al, New Engl J Med 1997;336:1117-1124.
Sacks et al, New Engl J Med 2001;344:3-10.

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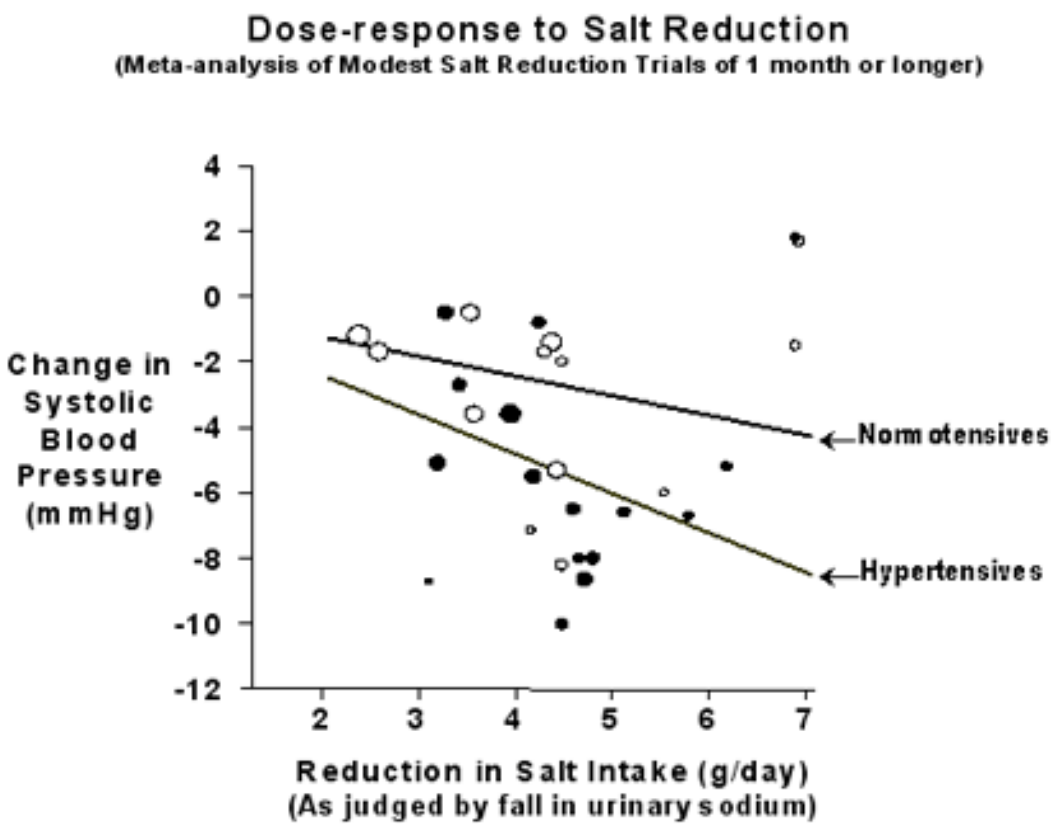
Meta-analysis of salt-BP trials



Effect of 6 g salt reduction on systolic BP:

-7 mmHg in hypertensives

-4 mmHg in normotensives

He & MacGregor. J Hum Hypertens 2002;16:761-70.

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Randomized controlled trial using K- and Mg-enriched salt

- 100 mildly hypertensive Dutch subjects, aged 55+
- Intervention: substitution of regular salt by ‘mineral salt’ that contained 41% NaCl, 41% KCl and 19% Mg salts, for 6 months
- Salt also used in bread, cheese, meats, soups: replacement of 57% of total daily salt intake

Geleijnse et al, BMJ 1994;309:436-440.

Dutch mineral salt trial

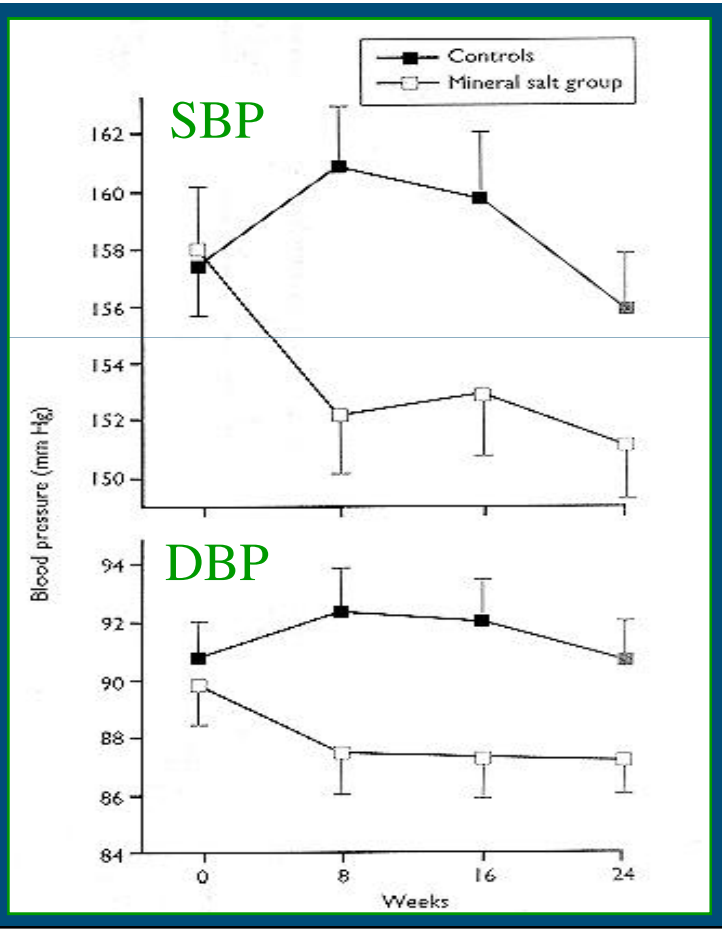
Difference in urinary excretion between experimental and control group:

Sodium: -38 mmol/24h (~ 2 g NaCl)

Potassium: +18 mmol/24h (~ 0.7 g)

= 1 banana + 1.5 kiwi

BP difference: -8/-3 mmHg



Geleijnse et al, BMJ 1994;309:436-40.

K-enriched salt and CVD mortality

- 5 kitchens of a retirement home
- random allocation to K-enriched salt or regular salt
- 1,551 Taiwanese men, age around 75 y, followed for >2.5 years

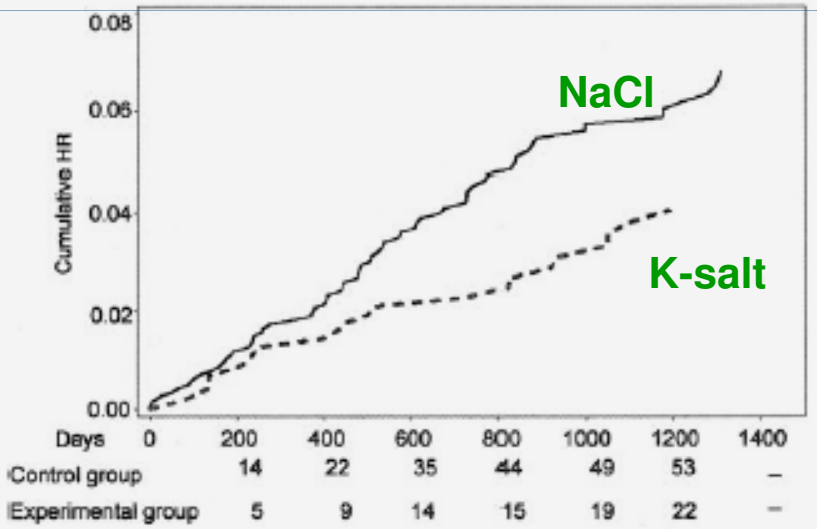


FIGURE 4. Cumulative hazard ratios (HRs) of cardiovascular disease-related deaths for the treatment and control groups. The incidence rate was 1310.0 per 100 000 person-years for the experimental group (dash line) and 2140.0 per 100 000 person-years for the control group (solid line). HR: 0.59; 95% CI: (0.37, 0.95).

- HR for CVD: 0.59 (0.37–0.95) for exp. vs. control
- Exp. subjects lived 0.3–0.9 y longer
- Exp. subjects spent significantly less (ie, US $426/y) in inpatient care for CVD

Chang et al, Am J Clin Nutr 2006;83:1289-96.

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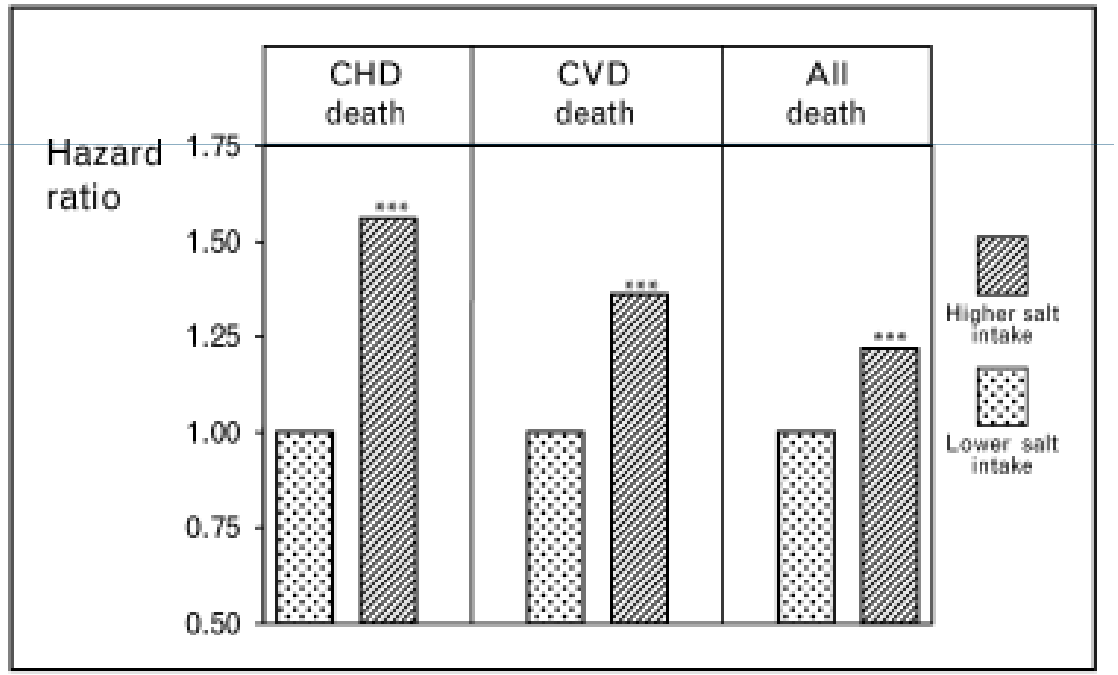
Salt and CVD in Finnish study

- Prospective cohort study
- 2,436 Finnish subjects (25-64 yrs)
- Data on 24h urinary sodium excretion



***$P < 0.001$ compared with lower salt intake. Adjusted for age, study year, smoking, serum total and high-density lipoprotein cholesterol, systolic blood pressure, and body mass index.

Tuomilehto et al, Lancet 2001;357:848-51.

Salt and CVD in TOPH

Trials of Hypertension Prevention (TOHP 1 & 2)

- >3000 prehypertensives (30-54 yrs)
- 2.5 g less salt for 18 mo
- 15 y follow-up
- RR incident cardiovascular events: 0.70
- RR overall mortality: 0.80

Cook et al, BMJ 2007;334:885

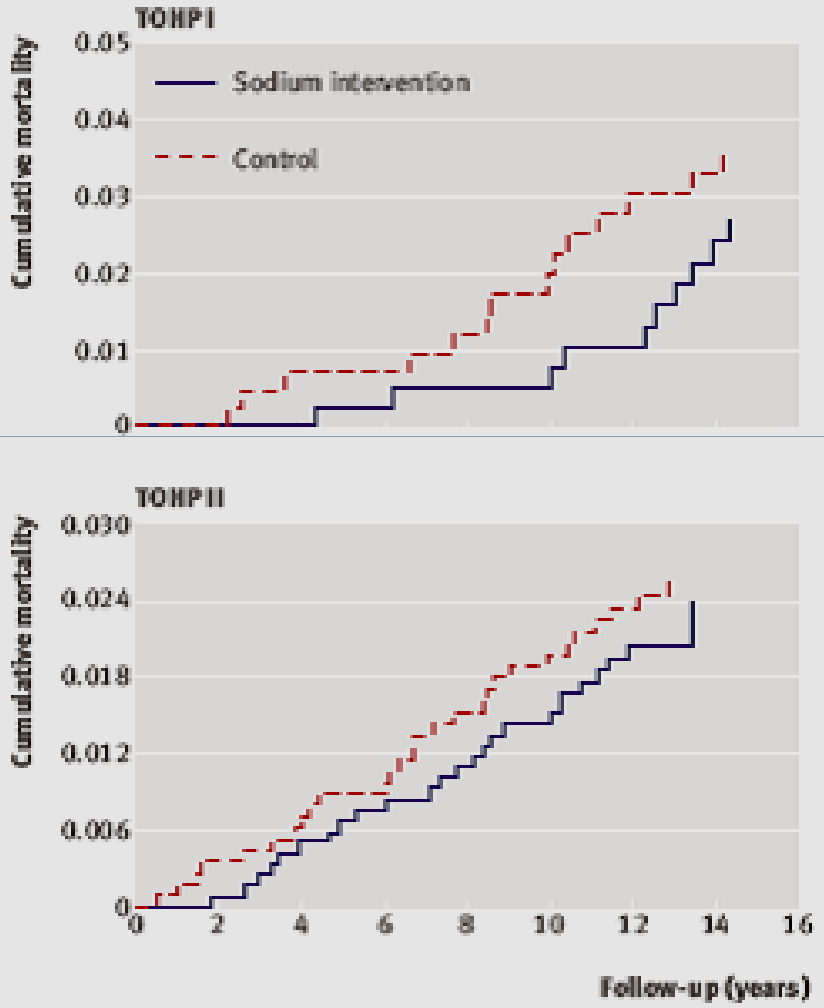


Fig 3 | Total mortality by sodium intervention group in TOHP I and II, adjusted for age, sex, and clinic

Salt and CVD in TOPH

- 2,275 subjects in non-sodium intervention group
- 24-hour urine collections: 3-7 times, 10-15 y post-trial follow-up
- Relative risks in quartiles of sodium/potassium ratio:
  - Q1: RR=1
  - Q2: RR=0.8
  - Q3: RR=1.2
  - Q4: RR=1.5
- RR = 1.42 per 100 mmol/d sodium (=5.8 g salt)
- RR = 0.67 per 50 mmol/d potassium (=1.9 g)

Cook et al, presented at AHA meeting in Colorado Springs, CO - 11-15 March 2008

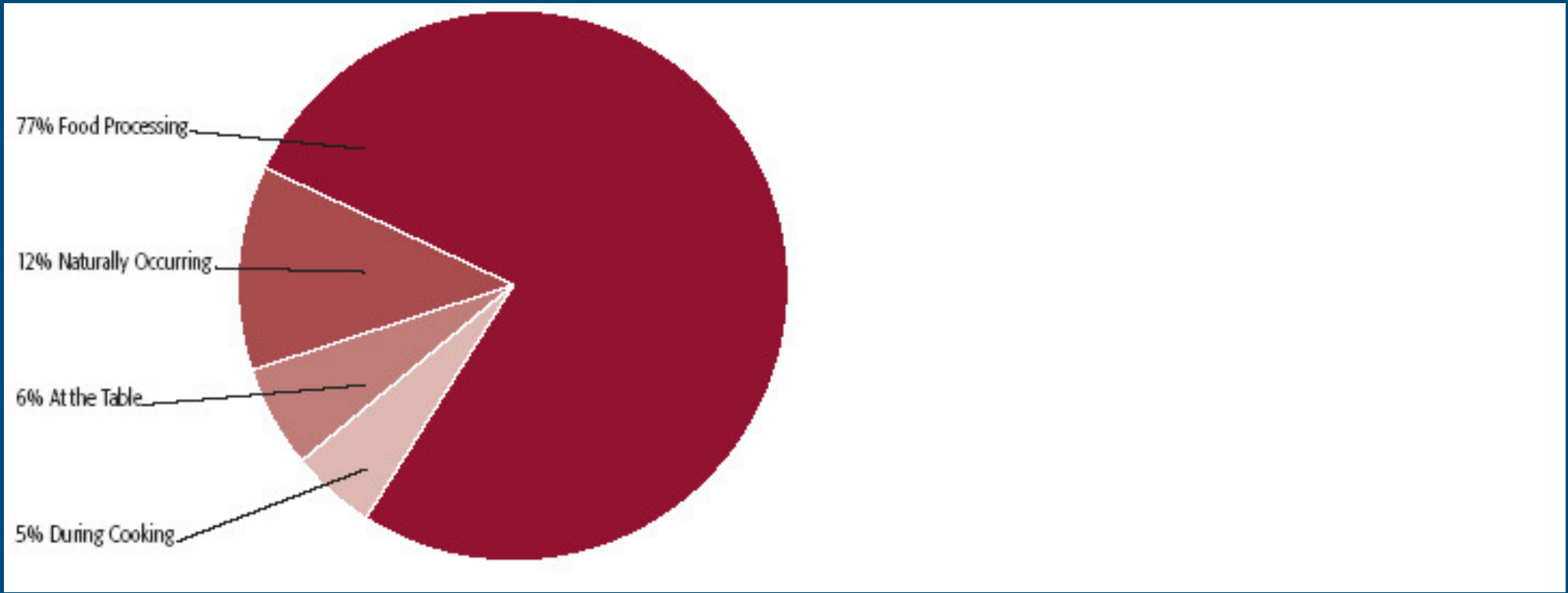
Salt intake in The Netherlands

Current salt intake in the Netherlands: 9 grams per day

RIVM Briefrapport 350050004/2007, 24-uurs urine-excretie van natrium. Voedingsstatusonderzoek bij volwassen Nederlanders.

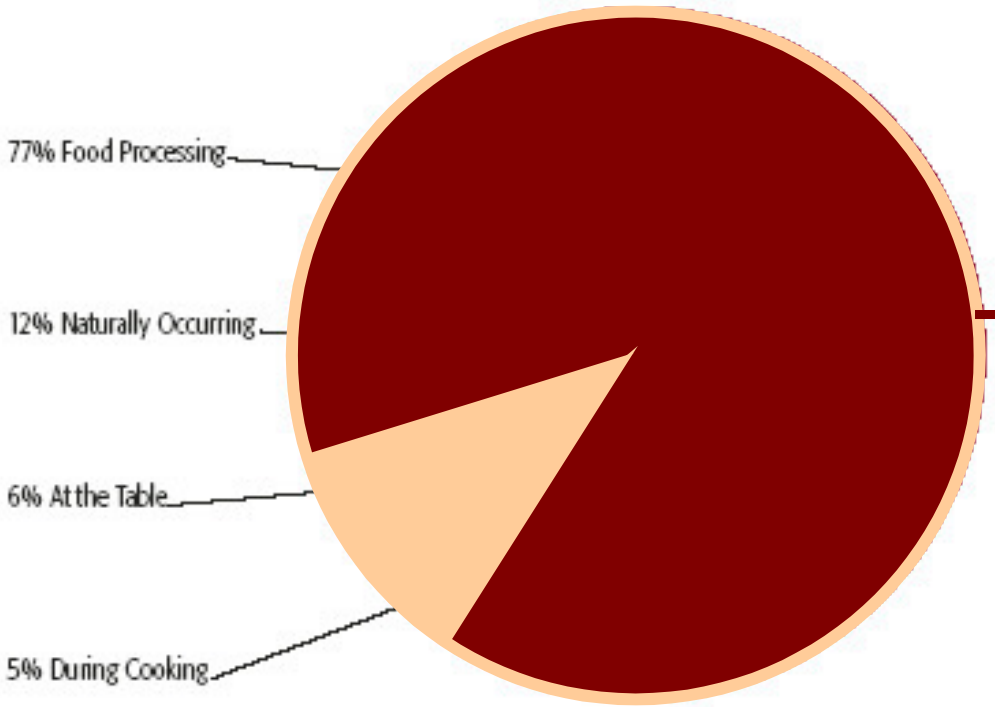
Recommendation by Dutch Health Council: maximum of 6 g/day
WHO target: <5 g/day (WHO Forum on Reducing Salt Intake in Populations, Paris 2006)

Sources of sodium



Source: Mattes RD, Donnelly D. J Am Coll Nutr 1991;10:383-93.

Sources of sodium



Brood	**24%**
Vlees (waren)	**17%**
Soepen	**10%**
Kaas	**8%**
Melk (producten)	**7%**
Noten/zaden/snacks	**6%**
Vetten/oliën/hartige sauzen	**6%**

Source: Mattes RD, Donnelly D. J Am Coll Nutr 1991;10:383-93.

Health gain by salt reduction in the NL

23,772 men and women died from ischemic heart disease or stroke in 2006

Netherlands Heart Foundation, The Hague 2006

Nederlandse Hartstichting

Health gain by salt reduction in the NL

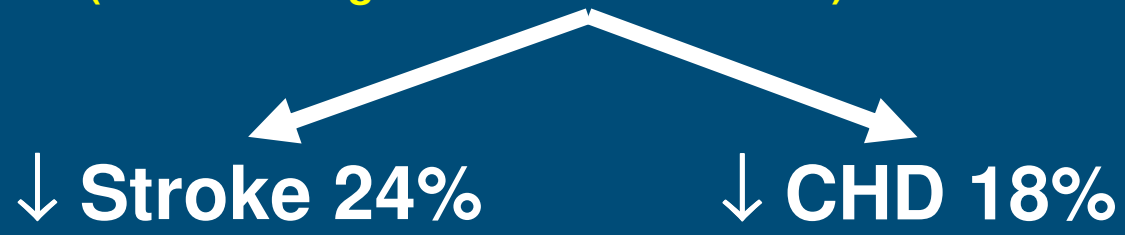
	Salt reduction		
	3 g/d	6 g/d	9 g/d
Reduction in systolic BP	2.5	5	7.5
Decrease in stroke mortality, %	13*	24*	34*
Reduction in no. of stroke deaths	1356	2,503	3,546
Decrease in coronary mortality, %	10*	18*	25*
Reduction in no. of coronary deaths	1334	2,402	3,336
Total no.	2,690	4,905	6,882

* He & MacGregor, Hypertension 2003; 42:1093-9.

Prevention of 21% of all deaths from stroke & ischemic heart disease

Calculations for USA

salt intake reduced by 6 g/d
(10-12 to 5-6 g/d WHO recommended)



USA ≈150,000 stroke & heart attack deaths prevented /year

Worldwide : Approx. 2.5 million prevented / year

He & MacGregor. Hypertension 2003;42:1093

www.worldactiononsalt.com

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WASH - World Action on Salt and Health

Target: ↓ Salt intake worldwide to 5g (WHO target)

- Worldwide network, established in 2005
- Mission: Improve the health of populations by achieving a gradual reduction in salt intake.
- Encourages multi-national food companies to reduce salt in their products
- Works with Governments highlighting the need for a population salt reduction strategy.
- Supported by WHO.
- >300 members, mainly experts in hypertension, from >50 countries
- www.worldactiononsalt.com

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Conclusion and discussion points

- Salt increases BP
- Effect of salt on (CVD) mortality
  - Evidence is accumulating, but more studies needed with 24h urinary sodium data
- Need for a population-wide approach to reduce salt intake
  - Target level → 6 g, 5 g, lower?
- Gradually reduce salt in processed foods and restaurant meals
  - Role of food industry, catering, schools…
  - Increase potassium in foods?
- Susceptible subgroups in population
  - children, blacks, elderly, overweight?

Thank you for your attention!

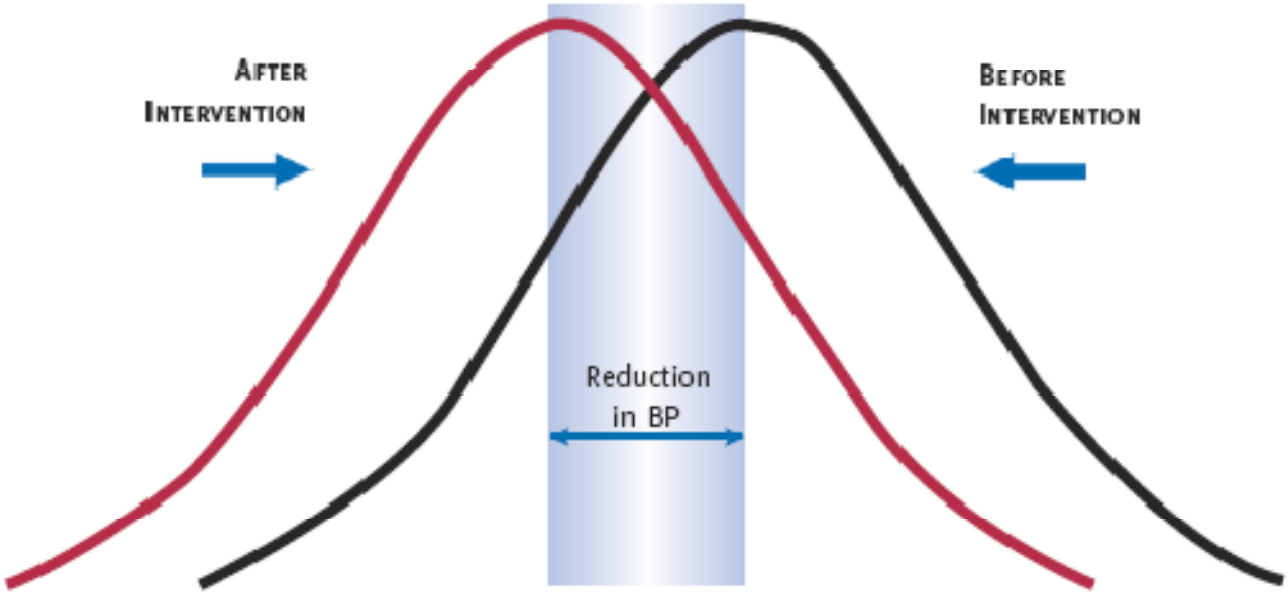
- Extra slides

Quote from website of Salt Institute

Human nutrition is a major market for salt because salt is an essential component of the human diet.[…] Current research shows that where salt is readily available, the vast majority of the world's population chooses to consume about 6-10 grams of salt a day. Including naturally occurring sodium in foods, people worldwide consume about 3,500 milligrams (mg) of sodium, Americans included. Some remote primitive peoples like the Yanamamo Indians of the Brazilian jungle who lack ready access to dietary sodium do have almost unbelievably small levels of sodium intake–far below that judged by the National Academy of Sciences to be safe for Americans. But for the rest of the world, our average intakes are typical. The National Academy of Sciences considers 1,500 mg/day of sodium an "adequate intake." The European Union Population Reference Intake for males aged 18 years (an "acceptable range of intakes") is 575-3500 mg. Nutrition is important to good health. Salt is part of a healthy diet. The Salt Institute recommends the "DASH Diet" which, while not restricting salt, emphasizes consumption of fruits, vegetables and low-fat dairy products. Besides being an essential nutrient and a popular taste, salt adds life and joy to our foods.

www.saltinstitute.org

Prevention of cardiovascular disease: population approach



Reduction in SBP mmHg	% Reduction in Mortality		
	Stroke	CHD	Total
2	-6	-4	-3
3	-8	-5	-4
5	-14	-9	-7

BP, blood pressure; CHD, coronary heart disease; SBP, systolic blood pressure

Source: Whelton PK, et al. Primary prevention of hypertension: Clinical and public health advisory from The National High Blood Pressure Education Program. JAMA 2002;288:1882–8.

WHO statement

- There is conclusive scientific evidence of the adverse effect of excessive dietary salt consumption on health, particularly on blood pressure, leading to cardiovascular disease, gastric cancer, osteoporosis, cataracts, kidney stones and diabetes (Cappuccio & MacGregor, 1997; Cappuccio et al., 2000).

- Current recommendations indicate that in order to prevent chronic diseases, the population average consumption of salt should be <5 g/day (<2 g/day of sodium)

- Population-wide reductions in dietary sodium consumption are highly cost-effective. Hence the need to give priority to the implementation of national strategies/policies/programmes aiming at the reduction of dietary salt consumption.

WHO Forum on Reducing Salt Intake in Populations (2006 : Paris, France)
Reducing salt intake in populations: report of a WHO forum and technical meeting.

Alderman et al, NHANES data, Lancet 1998

Characteristic*	Men				Women			
	Q1 (n=1120)	Q2 (n=1118)	Q3 (n=1120)	Q4 (n=1120)	Q1 (n=1717)	Q2 (n=1721)	Q3 (n=1713)	Q4 (n=1717)
Demographic characteristics								
Age (years)	56·9 (14·3)	54·4 (15·5)	51·7 (15·5)	48·6 (15·1)	49·8 (16·0)	49·2 (16·0)	47·8 (15·9)	43·9 (14·9)
Black race	24·4%	17·0%	13·3%	6·6%	26·0%	18·3%	15·4%	11·5%
History								
CVD	17·6%	15·4%	14·5%	11·3%	11·5%	12·0%	9·4%	9·6%
Hypertension	21·6%	18·1%	15·5%	14·9%	16·8%	15·0%	14·2%	12·6%
Anthropometric characteristics								
Body-mass index (kg/m²)	25·7 (4·3)	25·4 (4·0)	25·2 (4·2)	25·5 (4·1)	26·6 (6·0)	25·6 (5·7)	25·3 (5·5)	24·6 (5·5)
Bodyweight (kg)	76·0 (14·5)	76·4 (13·4)	76·4 (14·2)	77·7 (13·7)	68·4 (16·3)	68·3 (15·2)	65·6 (14·3)	64·3 (14·9)
Blood pressure (mm Hg)								
Systolic	142·4 (24·9)	138·8 (33·2)	136·0 (22·3)	134·4 (20·6)	136·7 (26·8)	134·9 (26·1)	133·7 (26·2)	129·5 (24·5)
Diastolic	87·3 (14·0)	85·8 (13·0)	84·5 (12·1)	84·6 (11·6)	83·5 (13·7)	82·6 (13·8)	81·8 (13·1)	80·2 (12·8)
24 h dietary recall								
Sodium intake (mg)	1041 (322)	1832 (195)	2647 (282)	4538 (1489)	678 (229)	1232 (138)	1791 (196)	3105 (1002)
Calorie intake (kcal)	1473 (638)	1930 (708)	2297 (732)	2937 (1050)	989 (408)	1331 (434)	1589 (518)	1976 (662)
Sodium/calorie (mg/kcal)	0·80 (0·35)	1·07 (0·42)	1·27 (0·44)	1·67 (0·61)	0·76 (0·35)	1·02 (0·35)	1·25 (0·48)	1·70 (0·66)
Use of table salt								
Always	33·9%	39·2%	37·2%	45·9%	20·4%	21·5%	24·5%	30·0%
Never	46·2%	35·5%	36·4%	31·9%	57·4%	57·0%	52·5%	46·9%

*Data presented as mean (SD) or as % of participants.

Salt and (CVD) morality, Alderman et al, NHANES data, Lancet 1998

Variable*	All-cause mortality			CVD mortality		
	β	p	Hazard ratio (95% CI)†	β	p	Hazard ratio (95% CI)†
Male	0·6286	<0·0001	1·88 (1·75–2·01)	0·6361	<0·0001	1·89 (1·71–2·09)
Black race	0·1585	0·0001	1·17 (1·08–1·27)	0·0465	0·4347	1·05 (0·93–1·18)
History of CVD	0·4033	<0·0001	1·50 (1·39–1·62)	0·4859	<0·0001	1·63 (1·46–1·80)
History of hypertension	0·1000	0·0241	1·11 (1·01–1·21)	0·0834	0·1688	1·09 (0·97–1·22)
Age (years)	0·0810	<0·0001	3·62 (3·44–3·82)	0·0922	<0·0001	4·33 (3·98–4·71)
Body-mass index (kg/m²)	−0·0047	0·1932	0·98 (0·94–1·01)	0·0081	0·1000	1·04 (0·99–1·10)
Systolic blood pressure (mm Hg)	0·0057	<0·0001	1·15 (1·11–1·20)	0·0103	<0·0001	1·29 (1·23–1·36)
Sodium (mg)	−0·0001	0·0069	0·88 (0·80–0·96)	−0·00009	0·0864	0·89 (0·77–1·02)
Calories (kcal)	−0·00001	0·8562	0·99 (0·91–1·08)	−0·00002	0·7394	0·98 (0·87–1·11)
Sodium/calories (mg/kcal)	0·1955	0·0004	1·12 (1·05–1·19)	0·2159	0·0056	1·13 (1·04–1·24)
Table salt use (always)	0·0741	0·1201	1·08 (0·98–1·18)	−0·0130	0·8510	0·99 (0·86–1·13)
Table salt use (never)	0·0057	0·8869	1·01 (0·93–1·09)	−0·0012	0·9625	1·00 (0·89–1·12)

*For categorical variables, yes=1. For table salt use variables, reference=sometimes.

†For continuous variables, hazard ratios are for 1 SD change. SDs: age=15·9 years, body-mass index=5·15 kg/m², systolic blood pressure=24·98 mm Hg, sodium=1313 mg, calories=849 kcal, sodium/calorie=0·5787 mg/kcal.

Table 3: **Variables associated with risk of all-cause and CVD mortality in Cox proportional-hazards regression (full model)**

Sodium, CVD and mortality: the Rotterdam Study

Sodium excretion: 117 mmol/24h
= 6.8 g NaCl per day

No relation with CVD or all-cause mortality

In overweight subjects, urinary Na/K related to all-cause mortality: RR = 1.2 (1.0–1.4) per unit, but not related to CVD mortality (RR=0.9)

Geleijnse JM et al, Eur J Epidemiol 2007

Table 3 Relative risk of urinary sodium with cardiovascular events and all-cause mortality in Dutch men and women aged 55 years and over

	All subjects[a]	Subjects initially free of CVD and hypertension[a]
Incident MI		
RR, model 1[b]	1.13 (0.95–1.34)	1.04 (0.75–1.43)
RR, model 2[c]	1.16 (0.98–1.39)	1.07 (0.77–1.50)
RR, model 3[d]	1.19 (0.97–1.46)	1.14 (0.77–1.69)
Incident stroke		
RR, model 1	1.09 (0.89–1.33)	1.16 (0.84–1.61)
RR, model 2	1.09 (0.87–1.35)	1.15 (0.81–1.62)
RR, model 3	1.08 (0.80–1.46)	1.02 (0.66–1.58)
CVD mortality[c]		
RR, model 1	0.74 (0.60–0.91)	0.84 (0.59–1.22)
RR, model 2	0.83 (0.68–1.02)	0.95 (0.66–1.39)
RR, model 3	0.77 (0.60–1.01)	0.83 (0.47–1.44)
All-cause mortality		
RR, model 1	0.90 (0.81–1.02)	1.00 (0.83–1.20)
RR, model 2	0.96 (0.84–1.09)	1.10 (0.91–1.34)
RR, model 3	0.95 (0.81–1.12)	1.12 (0.86–1.46)

[b] Adjusted for age, sex and (in urinary analysis) creatinine excretion; [c] As model 1 + BMI, smoking, diabetes, use of diuretics, education; [d] As model 2 + intake of total energy, alcohol, calcium, saturated fat and urinary K