Drinking water salinity & maternal health in coastal Bangladesh: impacts of climate change

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Overview

- Why is this research important?
- Salinity in Bangladesh
- Maternal health
- Case-control study
- Summary of results
- What can be done?

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Research priority

- Freshwater is crucial to human society
- Grantham Institute for Climate Change, ICL – recent contribution in the Guardian - how fresh water is expected to become increasingly scarce in future, partly due to climate change.
- IPCC: groundwater and many rivers increasingly saline from higher tidal waves, storm surges (IPCC AR4, 2007) – affecting water quality
- Fill in current knowledge gaps regarding associations between water quality and health
- Seek evidence of early changes
- Predict and model future changes
- Inform policy-makers regarding mitigation and adaptation strategies

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INDIAN OCEAN RIM AND THE BAY OF BENGAL

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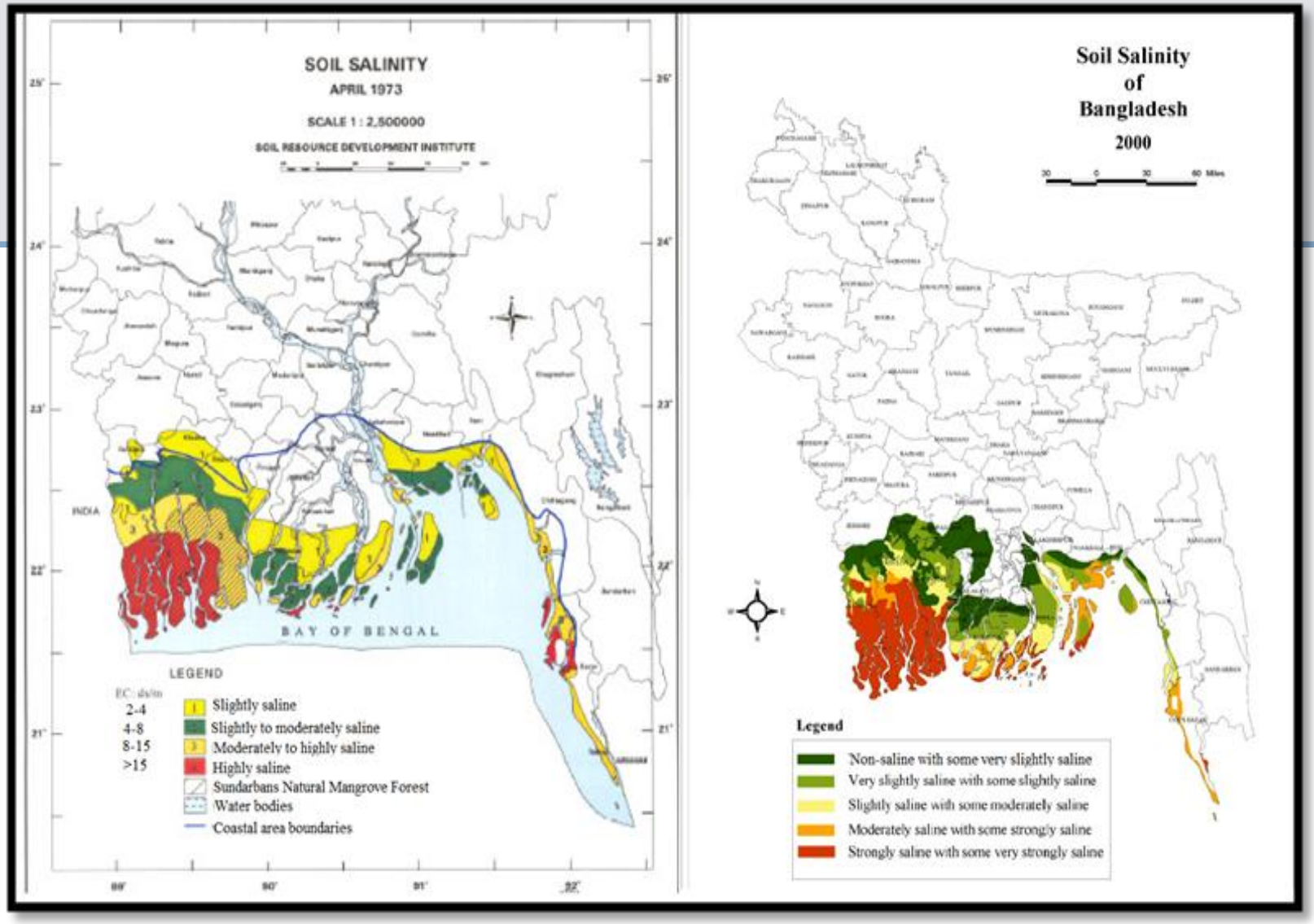
Bangladesh

- Bangladesh located on one of the world's largest deltas
  - The coast inherently vulnerable to tropical cyclones, storms and tidal surge etc.
- **35 million people** (28% of total population) live on coast
- **Coast vulnerable to sea water intrusion from Bay of Bengal: mainly in the south-west**
  - Agricultural land
  - Biodiversity
  - Food security
  - Water quality



- Saline water migrated >100 km inland from Bay of Bengal

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Causes of salinity

Surface & groundwater salinity determined by:

- **Freshwater flow** at the upstream
- Polders, deliberately inundated with saline water to **cultivate shrimp:** poor land/water management
- More frequent & intense tropical cyclones & **sea-level rise:** climate change

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Salinity in drinking water

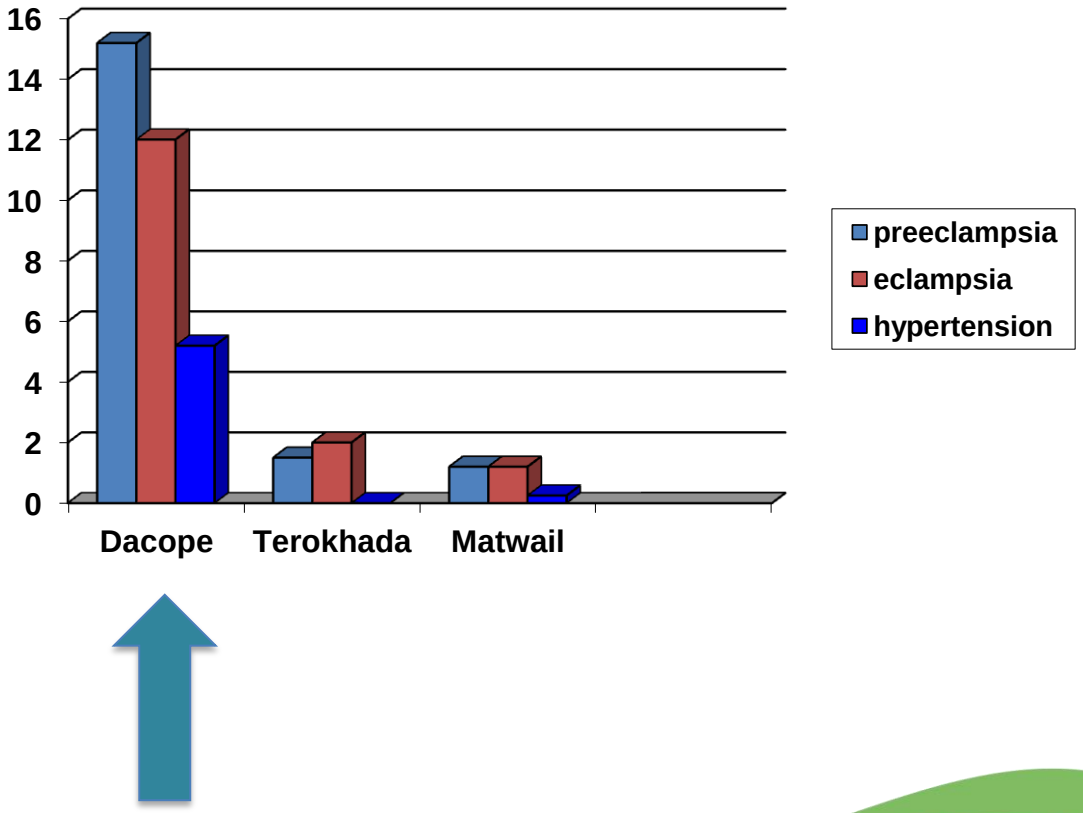
- The ministry of Environment and Forest of the GOB reports that drinking water in coastal areas contaminated by salinity
- Approx. **20 million people**
- In 2005, about 6 million people exposed to very high salinity (>5 ppt)

- GOB Ministry of Environment and Forest/Caritas:
  - High rates of hypertension in the coast
  - Spontaneous fetal abortion
  - Potential links to salinity

Preliminary survey

- Survey by ICL and BCAS in 2008 showed high rates of (pre)eclampsia and gestational hypertension in coastal areas, compared to non-coastal areas.

  (Khan et al, 2008)



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Hypertension in pregnancy

- Hypertensive disorders in pregnancy are among the **leading causes of death and disabilities in women of child-bearing age.**

- Substantial differences in the rates of maternal mortality between high and low income countries .

- Average lifetime risk of dying from pregnancy related causes in high income countries: **1 in 4000 to 1 in 10,000**; low-income countries have a risk between **1 in 15 to 1 in 50** (UNFPA, 2012; Duley 2009).

- Out of all standard health indicators, this PH measure shows the widest disparity between rich and poor countries (UNFPA).

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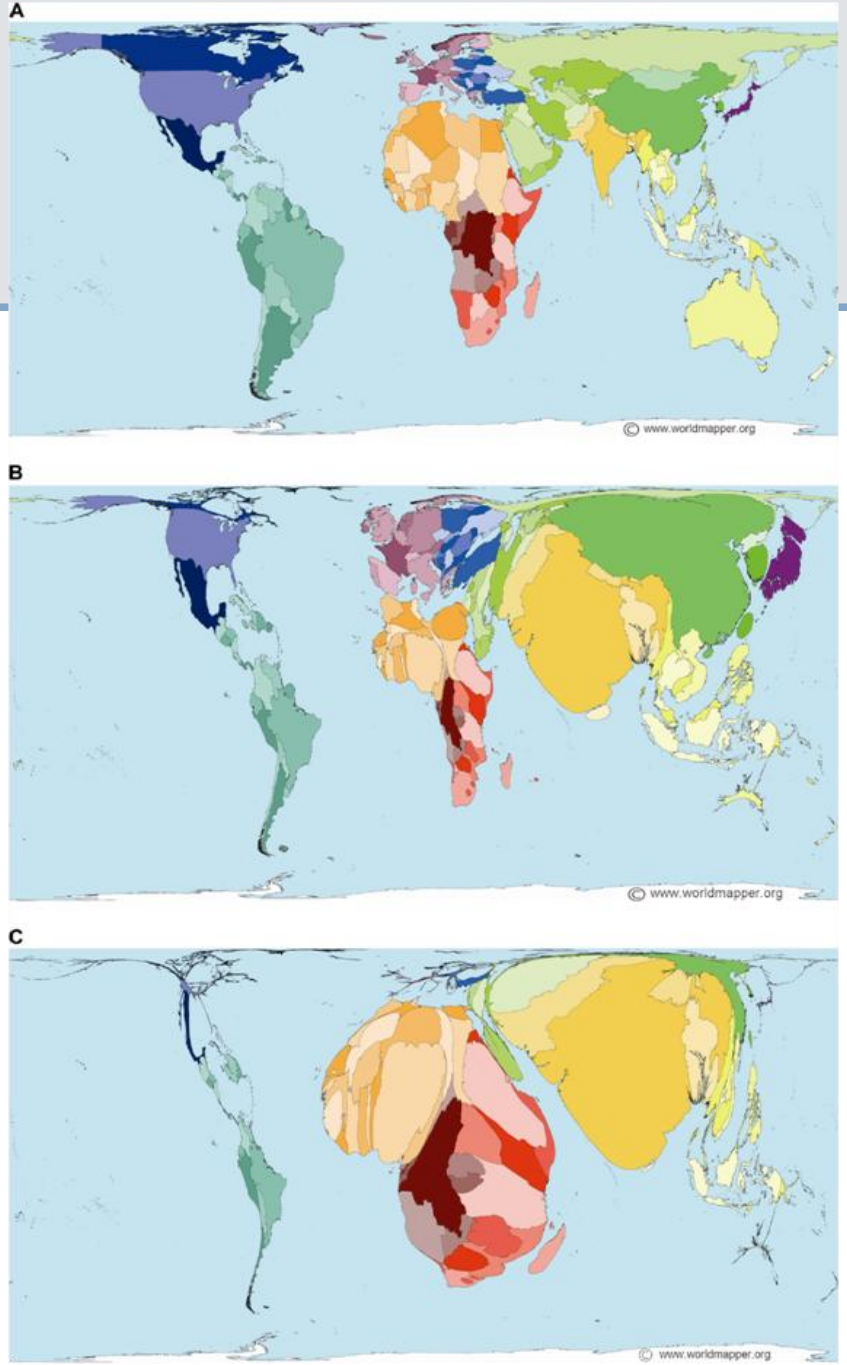
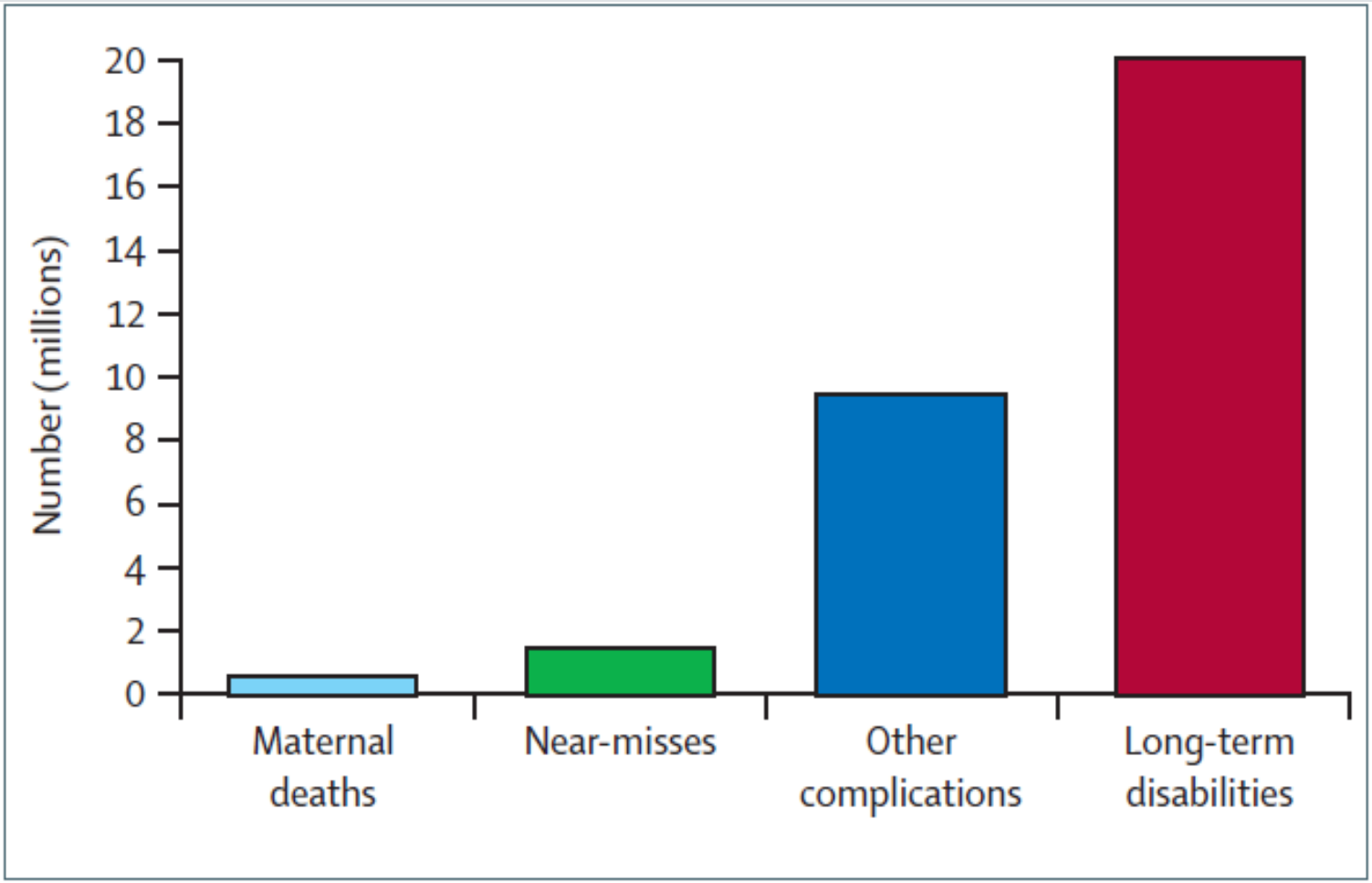


World map with size of each territory drawn by its land area, population, and proportion of its maternal mortality (Duley, 2009)

Maternal morbidity



Filippi, 2006

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Hypertension in pregnancy

- Of greatest importance is pre-eclampsia, a pregnancy-specific disorder, which causes >60,000 maternal deaths worldwide annually (WHO 2005).
  - Maternal death
  - Perinatal death
  - Pre-term birth, intrauterine growth restriction
  - Long-term effect on mother and child
  - Higher child-hood blood pressure
  - Future CVD in mothers

- Despite high health burden, causes and the pathophysiology of (pre)eclampsia poorly understood, making effective primary prevention difficult.

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Salt and hypertension

- Abundant evidence of **causal relationship** between habitual **sodium intake & high blood pressure; well established in epidemiology**

- Studies have mainly focussed on salt intake from food
- INTERSALT study – positive relationship
- Meta-analysis showed: a modest and long-term reduction in population salt intake would reduce stroke deaths immediately by 14% and coronary deaths by 9% in hypertensives; 6% and 4% of those in normotensives, respectively (He and Macgregor 2002).
- WHO/FAO: recommends that sodium intake of adults should be **<85 mmol/day or 2 g/d** (equivalent to 5g/day of salt)

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Salt and eclampsia

- Little evidence that ‘regular amounts’ of dietary salt intake have harmful effects on pregnancy.
- High sodium intake associated with the onset of pre-eclampsia by Lauro *et al*, 1997).
- Zuspan and Bell (1961): dietary salt loading (5 g/day) caused marked sodium retention and worsening of symptoms in moderately severe pre-eclamptic women.
- A multicentre case-control study in Colombia: dietary sodium intake of >2200 mg increased risk of pre-eclampsia (OR: 3.18, 95% 1.19 – 8.48) (Reyes et al. 2012).
- A case-control study conducted in Cairo, Egypt: salty diet associated with a higher pre-eclampsia risk(OR: 1.99, 95% CI: 1.02 – 3.91) (El-Moselhy EA et al. 2011).

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Case-control study

- **Objective:** to investigate the relationship between salinity in drinking water & adverse effects on maternal health, i.e. (pre)eclampsia & gestational hypertension – in a coastal community in Bangladesh through a case-control study.

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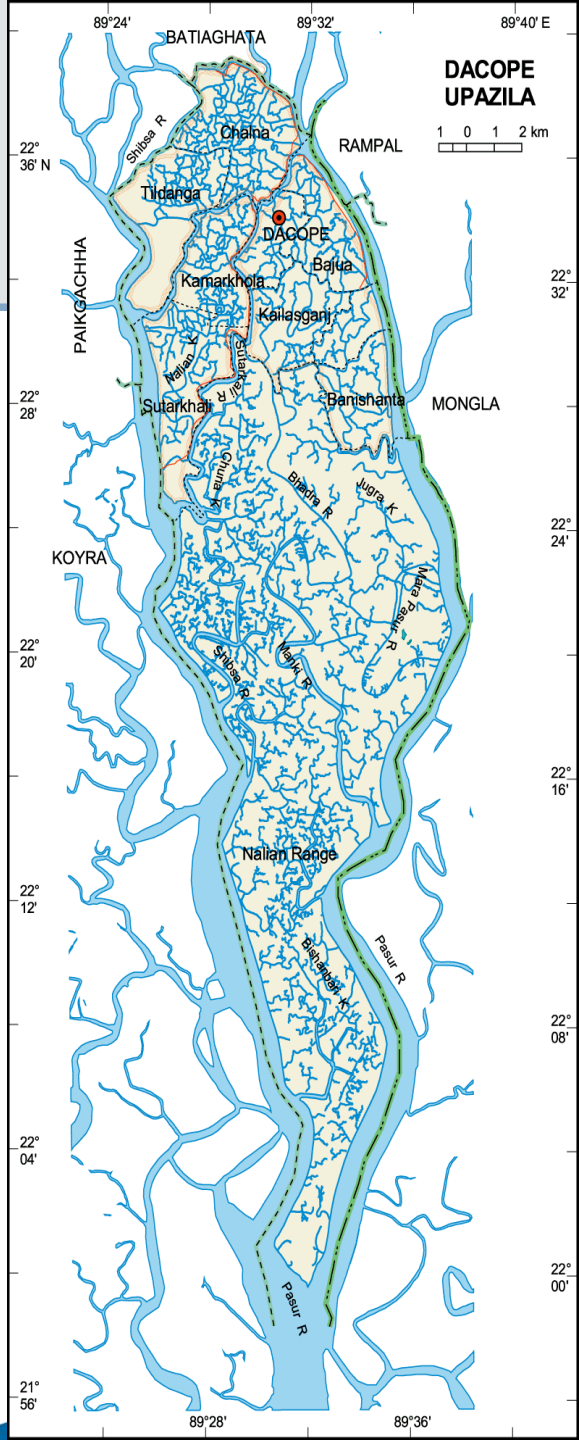
Data & Methodology

Study area

- Dacope sub-district, Khulna, located in south-west
- Consists of 9 administrative unions, 107 villages
- Population: 155,000

Salinity data

- River & groundwater (1998 onwards): Centre for Environment & Geographic Information System, Bangladesh



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Selection of cases and controls

Cases

- Patients of (pre)eclampsia and gestational hypertension (aged 13 - 45) at the UHC
- Pregnant women (aged 13 – 45) with (pre)eclampsia and gestational hypertension identified from the local community within the study area

Controls

- Healthy pregnant women (aged 13 – 45) at week 20 of gestation recruited from the local community within the study area

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Data & Methodology

Data

- **1,208 pregnant women** (13-45 yrs) recruited from Dacope
  - 202 cases
  - 1,006 controls
- Recruitment started in October 2009
- Approved by the BMRC

Exposure assessment

- Sodium measurement in water sources
- 24-hour urine samples for controls, spot urine for cases
- Questionnaire: water source and other confounders

UHC, Dacope

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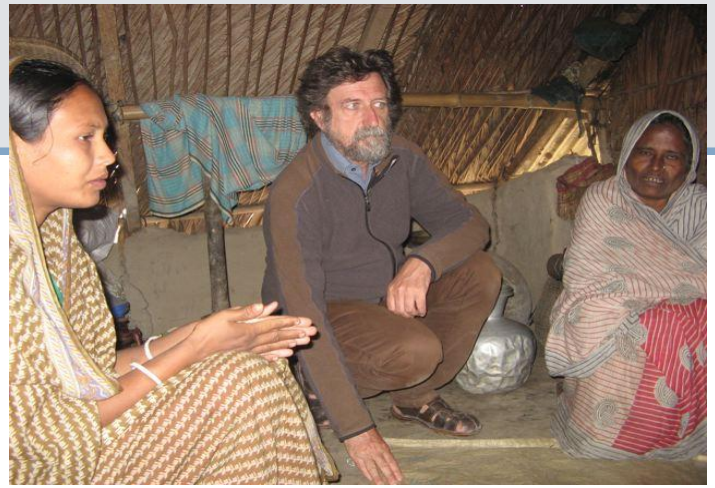

Interviews

Training the health assistants

Data collection

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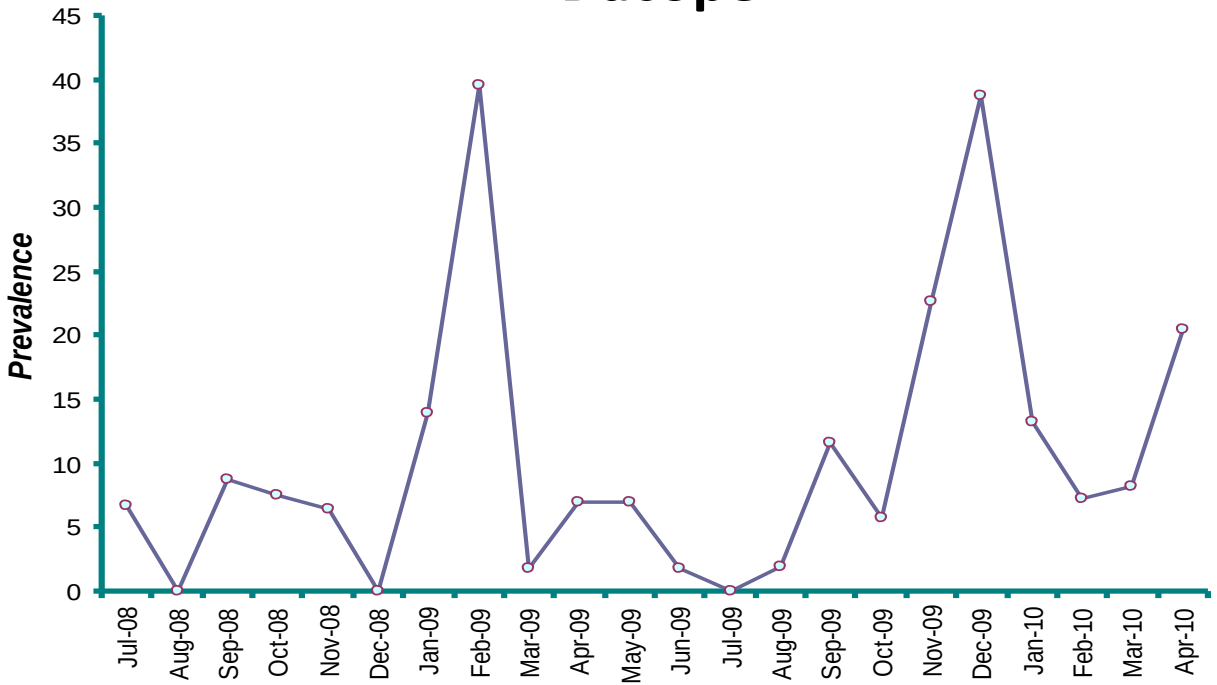
Seasonal patterns of (pre)eclampsia and gestational hypertension in pregnant women in Upazilla Health Complex, Dacope



- Average hospital prevalence: **9.28 % (95% CI: 7.46 – 11.12)**
- Sharp rise in cases in winter: 40%, 23% and 39% in Feb, Nov and Dec ’09, respectively

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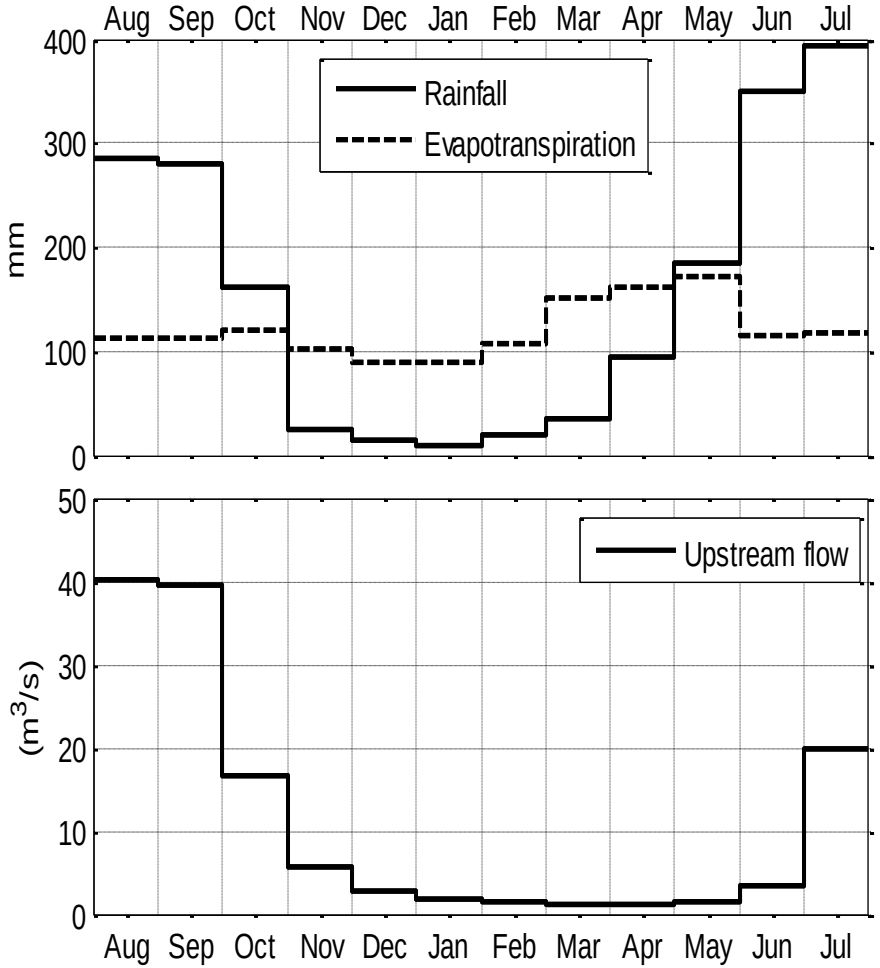
Seasonal patterns of hydrological fluxes in Khulna, including Dacope (Rahman et al., 2003)



Strong seasonality

Lower rainfall & upstream flow coincide with higher rates of (pre)eclampsia gestational hypertension

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Results of the case-control study

- Mean water sodium levels (mg/L) and estimated intake

Water source	n=755	Mean water sodium (SD)	Median water sodium	g/day with 2L intake	% of total* recommended
Rain only	1	66.0	-	0.1	7%
filter only	95	410.8 (410.0)	290.3	0.8	41%
pond only	231	374.3 (413.5)	221.3	0.7	37%
tubewell only	286	713.9 (533.0)	711.8	1.7	71%
Multiple sources	134	441.6 (625.5)	225.4	0.9	44%
All sources	-	516.6 (524.2)	425.0	1.1	52%

- **Recommended sodium in drinking water: 20 mg/L** (US EPA): equivalent to 0.04 g/day of sodium with 2L intake……2% of dietary goal
- WHO: sodium affects taste above 200 mg/L

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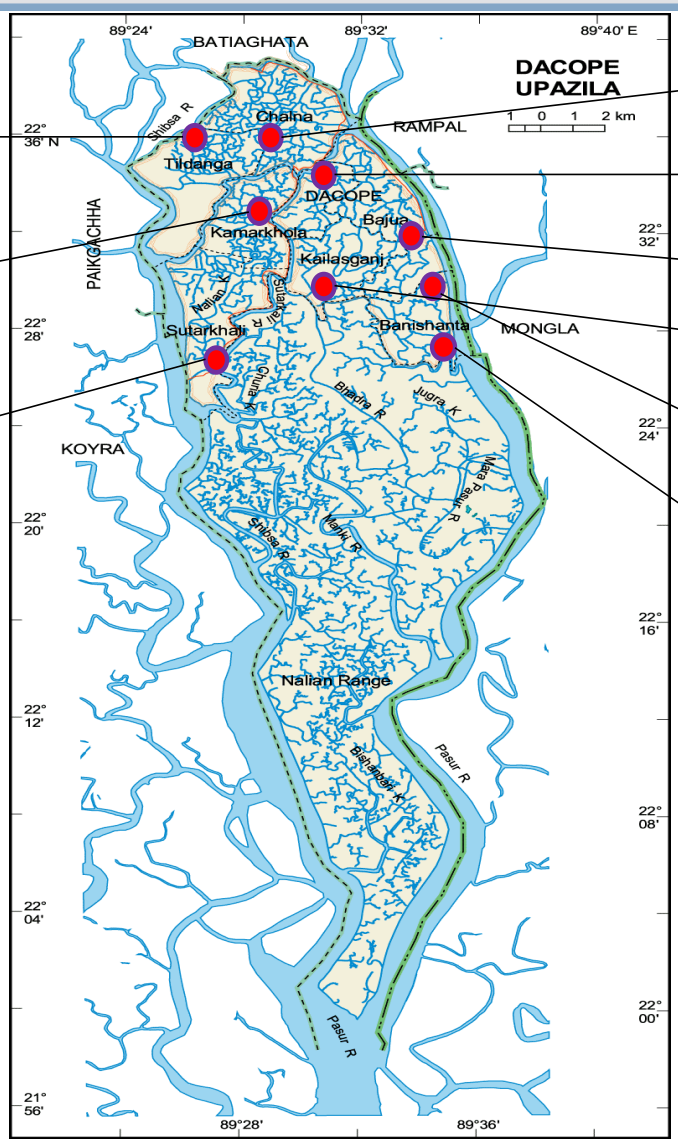
Mean water levels (mg/L) in Dacope



Mean Sodium: 518 mg/L

Mean Sodium: 595 mg/L

Mean Sodium: 537 mg/L

Mean Sodium: 611 mg/L

Mean Sodium: 429 mg/L

Mean Sodium: 416 mg/L

Mean Sodium: 554 mg/L

Mean Sodium: 448 mg/L

Mean Sodium: 326 mg/L

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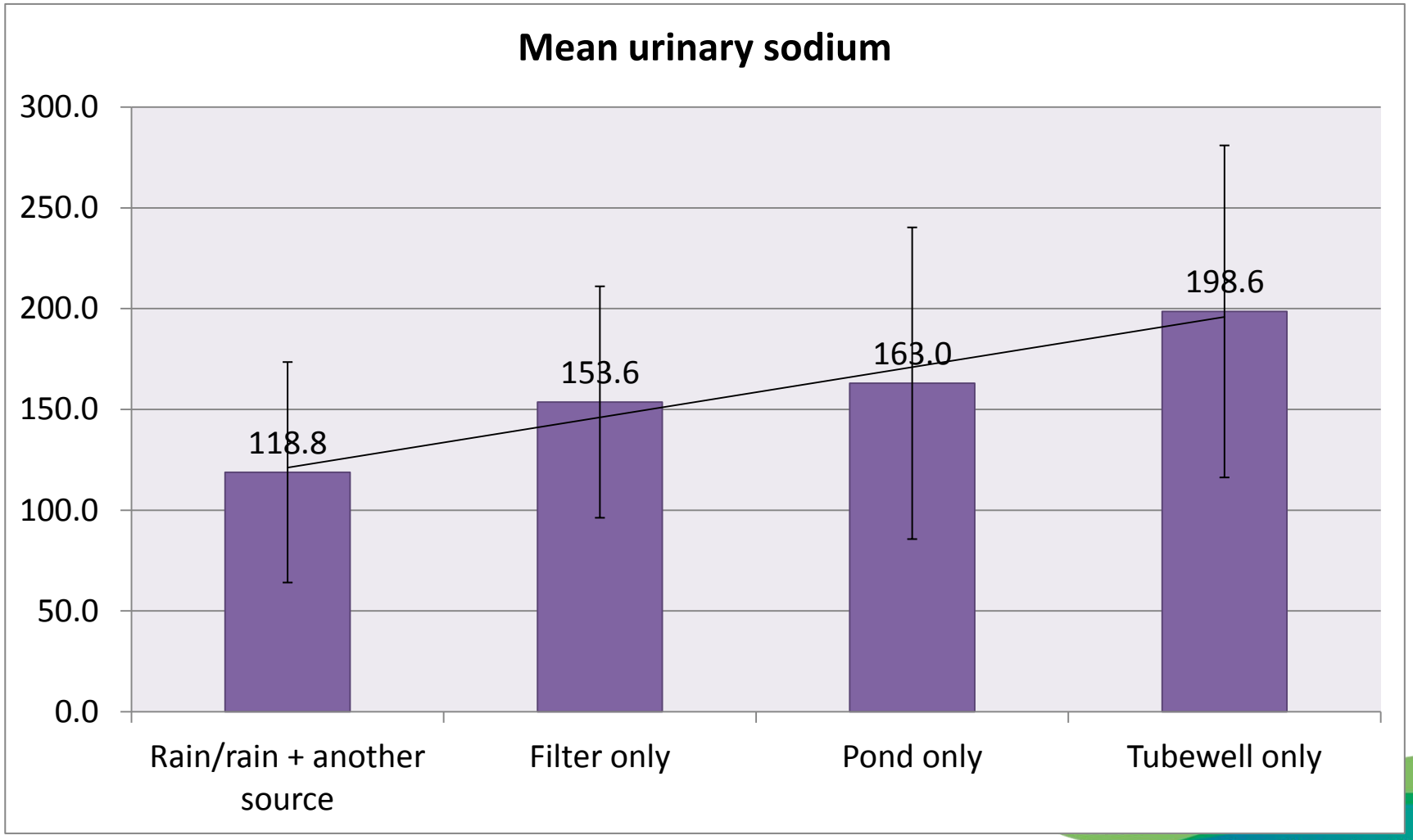
Mean urinary sodium (mmol/d) and water source (in controls)



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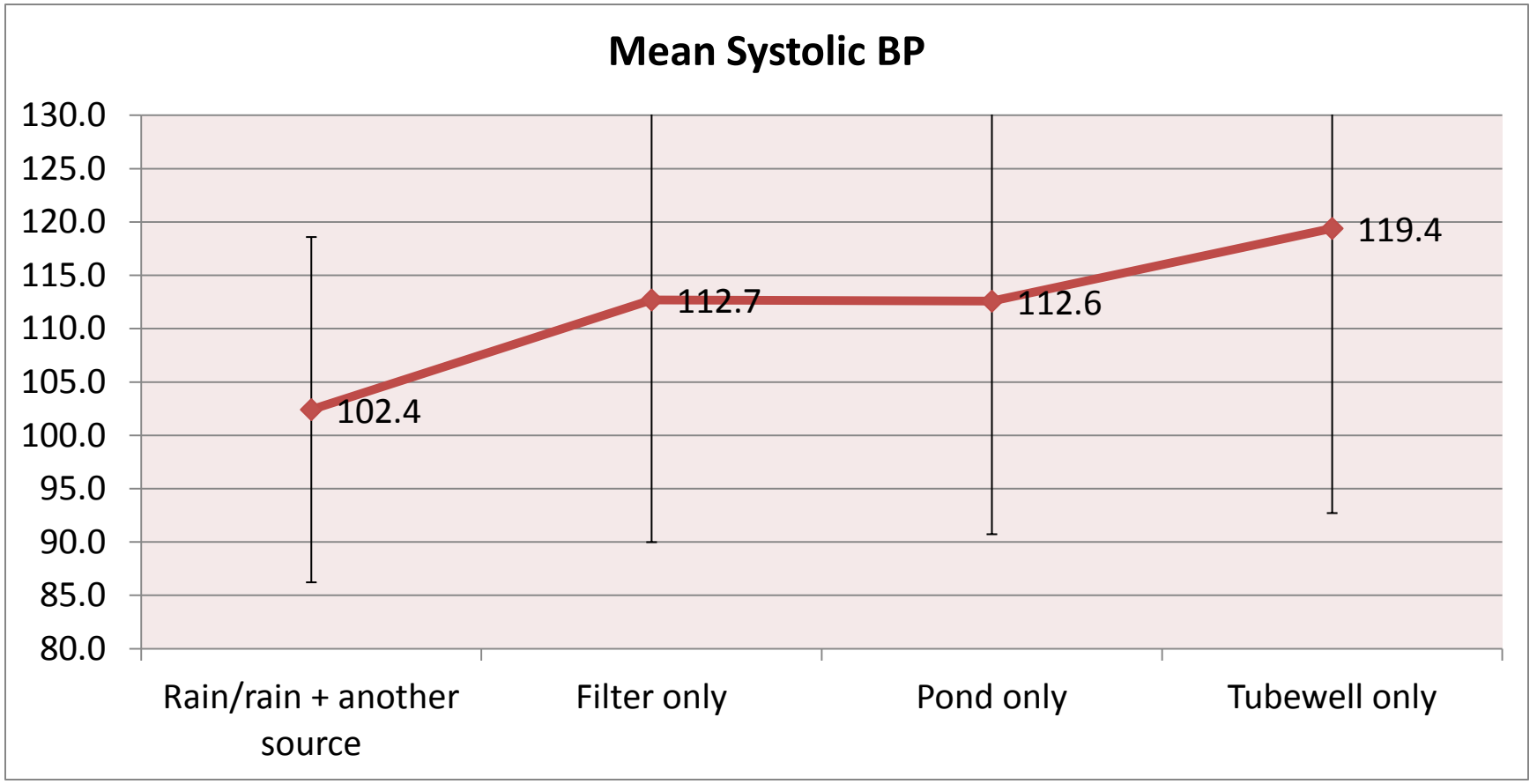
Mean systolic BP in relation to water source



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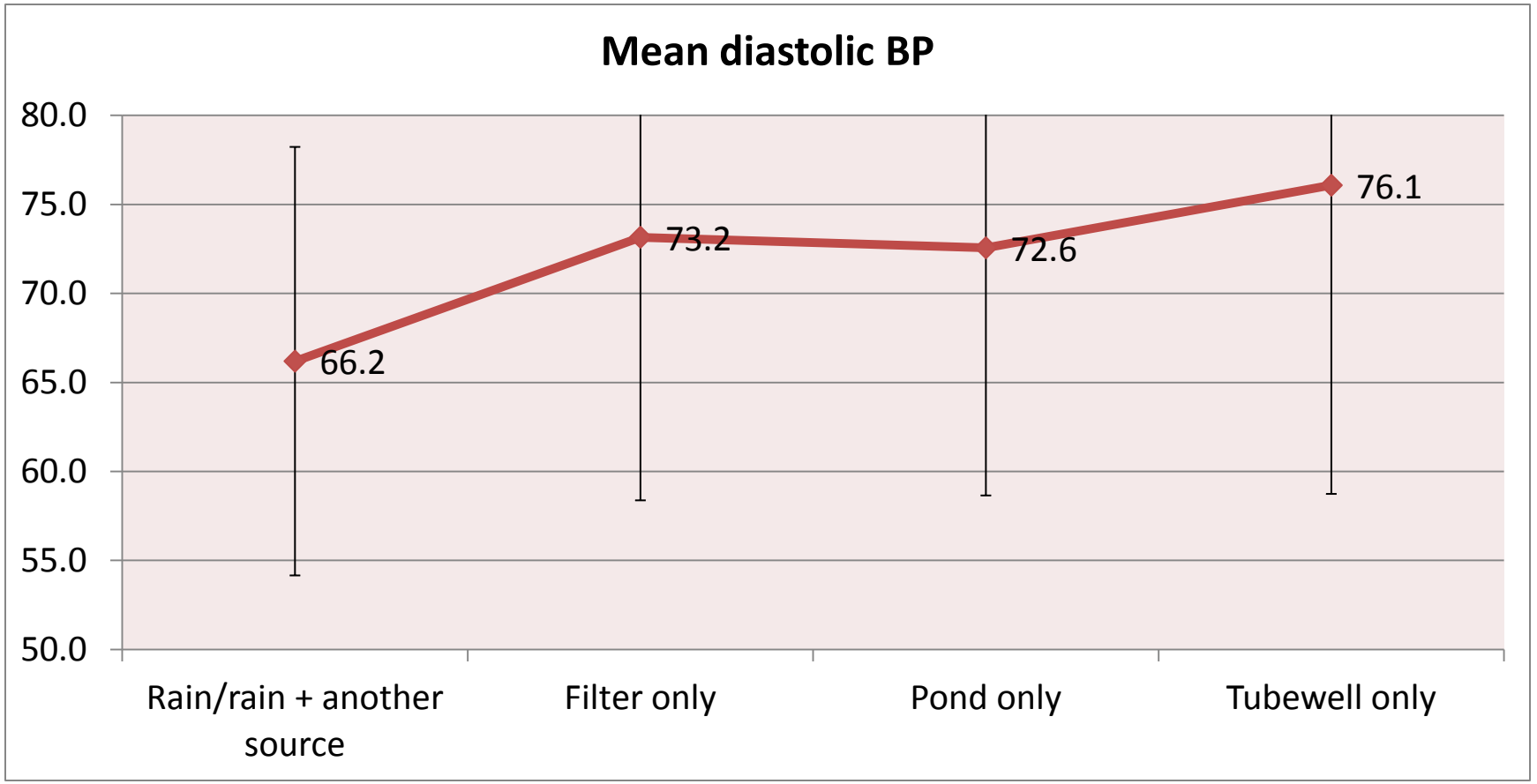
Mean diastolic BP in relation to water source



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Regression analysis

- Water source and the risk of (pre)eclampsia and gestational hypertension

Water Source	**Crude Odds Ratio (OR)**	**95% Confidence intervals**	**P-value**
Rain + another source	1.00	-	-
Filtered water	4.99	2.32 – 10.8	0.000
Pond water	4.38	2.16 – 8.87	0.000
Tubewell water	8.15	4.17 – 15.9	0.000
Water Source	**OR adjusted by age , parity and SES**	**95% Confidence intervals**	**P-value**
Rain + another source	1.00	-	-
Filtered water	5.15	2.37 – 11.2	0.000
Pond water	4.86	2.37 – 9.94	0.000
Tubewell water	7.98	4.05 – 15.7	0.000

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Regression analysis

- Water sodium and the risk of (pre)eclampsia and gestational hypertension

Water sodium mg/l	**Crude Odds Ratio (OR)**	**95% Confidence intervals**	**P-value**
Min to 300	1.00	-	-
300.01 – 600	2.73	1.70 – 4.40	0.000
600.01 – 900	3.65	2.30 – 5.80	0.000
900.01 - max	5.21	3.25 – 8.33	0.000
Water sodium mg/l	**OR adjusted by age, parity and SES**	**95% Confidence intervals**	**P-value**
Min to 300	1.00	-	-
300.01 – 600	3.36	2.07 – 5.60	0.000
600.01 – 900	4.35	2.61 – 6.94	0.000
900.01 – max	5.40	3.28 – 8.92	0.000

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Summary

- Current recommended salt intake set at 2 g/day (<85mmol/d) (WHO, 2002).
- Dacope population consuming unacceptably high levels from drinking water alone, depending on source.
- Tubewell - commonest source despite high sodium levels: scope for advocacy.
- Compared to rainwater, the adjusted risks of (pre)eclampsia and gestational hypertension were **significantly higher** for women who used filter water, pond water and tubewell water.
- Adjusted disease risks increased in a **significant dose-response** manner for **increasing quartiles of sodium concentrations** in drinking water.

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Summary

- Contributes to understanding the aetiology of (pre)eclampsia and gestational hypertension in coastal Bangladesh; useful for primary prevention.
- Provides an evidence base to create guidelines on sodium consumption.
- Inform policy makers about the urgent need to find sustainable solutions for the coastal populations
- These findings warrant further validation, for example, through a randomised control trial.
- Future studies should elucidate the biological basis for the association.

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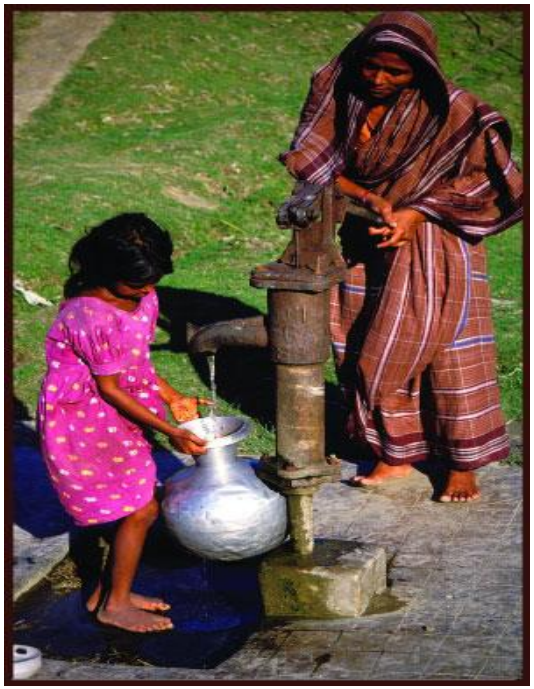
What can be done?

- Adaptation: promote alternative sources
  - Rainwater harvesting
  - Solar distillation
- Raise awareness

- Concerted effort by the local communities, the government, the civil society, the international community, health professionals, academics, and the private sector is needed to find solutions.



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