

Key uncertainties in net impacts of disease burden in Bangladesh due to the substitution of groundwater for alternative drinking water supplies

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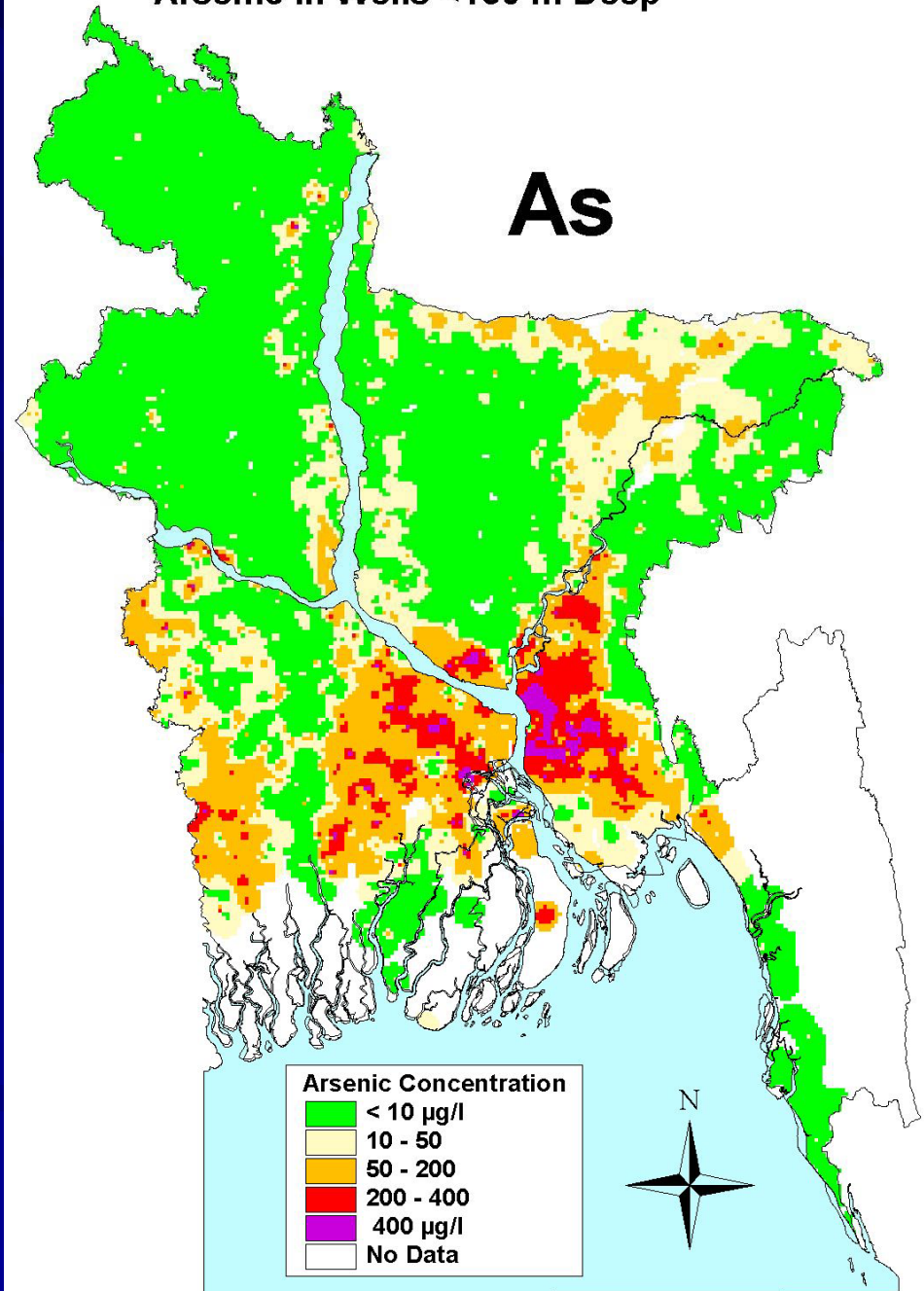
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Arsenic in Wells <150 m Deep

As



Average Arsenic Concentration in Bangladeshi Shallow (< 150 m) Wells

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"Arsenic Contamination and the Chemical Composition of Groundwater in Bangladesh"

based upon data collected during the "Groundwater Studies for Arsenic Contamination in Bangladesh" project during 1998 and 1999.

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Impact of tubewells: trade off with diarrhoeal disease

- Wells constructed since 1970s to reduce mortality due to diarrhoeal diseases
- Infant mortality dropped:
 - from 148 per 1000 live births in 1970-1975
 - to 59 per 1000 live births in 2000-2005
- Difficult to quantify impact of tubewells in reducing disease burden; however
- **CALCULATION OF IMPACTS ON DISEASE BURDEN MUST TAKE INTO ACCOUNT**
 - DIARRHOEAL DISEASE
 - ARSENIC-RELATED DISEASE BURDEN

Quantifying Impact of Mitigation Solely Involving Transfer of Water Supplies from Tubewells to Alternative Waters

■ Pathogenic microbes related disease burden

- Negative impact
- Independent of arsenic concentration of well waters

■ Arsenic-related disease burden

- Positive impact
- Strongly dependent upon arsenic concentration of well waters

Ideal Model

DALYs due to diseases related to arsenic exposure from drinking water

(POSITIVE IMPACT)

Disease Burden

Change in DALYs due to improvements in sanitation and treatment of pathogenic microbes

(POSITIVE IMPACT)

Change in DALYs due to higher assumed link between As concentration and As-related disease

(POSITIVE IMPACT)

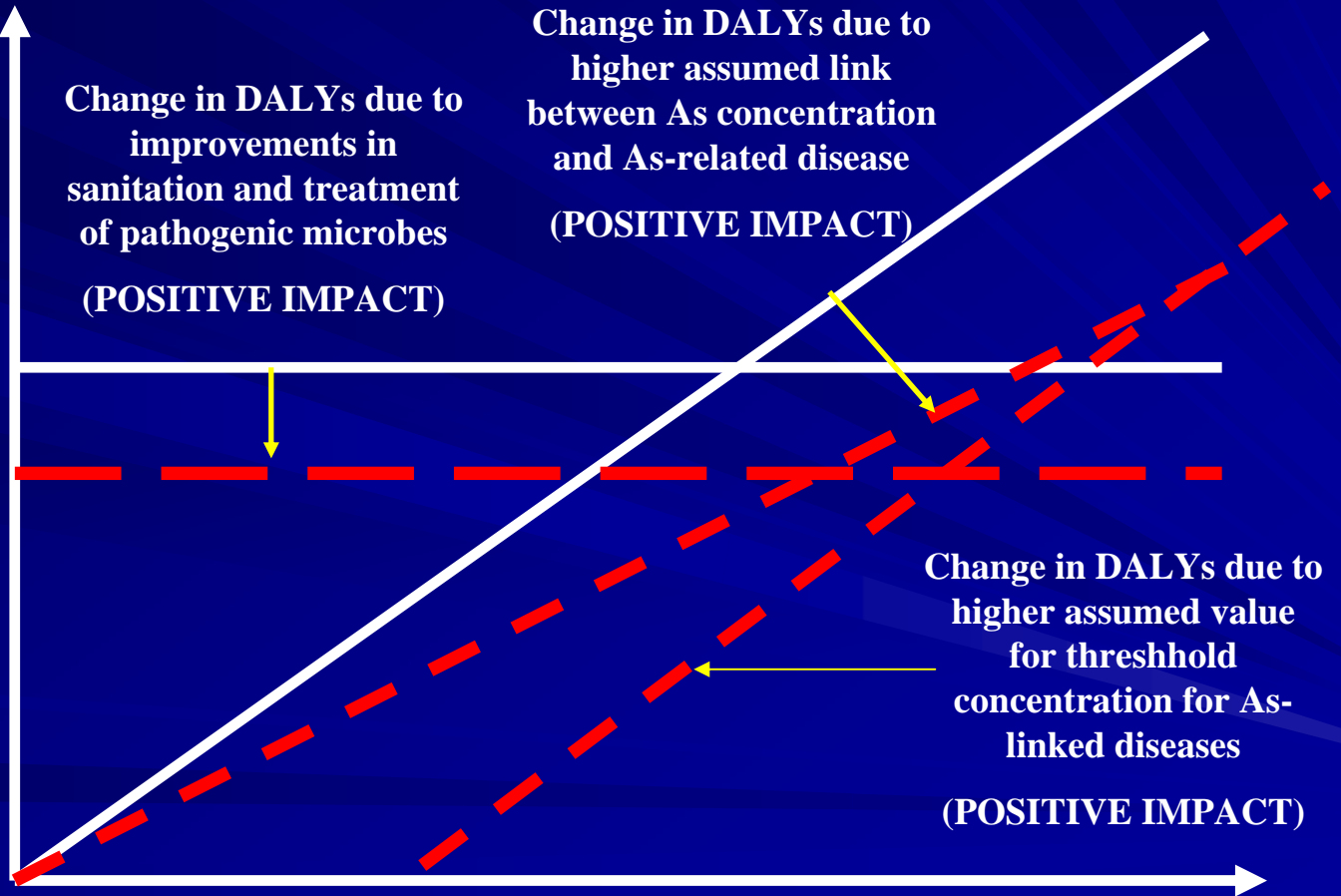
DALYs due to diseases related to pathogenic microbes

(NEGATIVE IMPACT)

Change in DALYs due to higher assumed value for threshold concentration for As-linked diseases

(POSITIVE IMPACT)

Arsenic Concentration in Groundwater



Necessary to determine level of uncertainty within parameters

- Unfortunately insufficient data available to produce linear dose-response relationships for arsenic exposed population
- However, Lokuge et al (2004) have produced model which compares mitigation to 10 ppb As and to 50 ppb As
- Important given current controversy over threshold values for arsenic in groundwater (Smith and Smith, 2004; Chakraborti, pers. comm.)

Model of Lokuge et al (2004)

- Calculation of number of deaths and Disability Adjusted Life Years (DALYs) in Bangladesh attributable to arsenic contaminated drinking water through:
 - Skin Cancer;
 - Tracheal, Bronchial and Lung Cancer;
 - Bladder Cancer;
 - Kidney Cancer;
 - Ischemic Heart Disease; and
 - Diabetes Mellitus
- DALYs: objective measure of one lost healthy life year due to death or incapacity from Global Burden of Disease study (Murray and Lopez, 1996)
 - Displayed as annual figures

Lokuge et al (2004) Method

Calculation of populations exposed to arsenic at 0-10ppb, 10-50ppb, 50-100ppb, 100-300ppb, 300-600ppb and >600ppb

Multiplication of overall disease burden and deaths in Bangladesh in the covered *sequelas* with fraction of population within exposure categories = *number of deaths and lost DALYs within each exposure category caused by diseases with a known link to arsenic*

Calculation of Population Attributable Fractions due to arsenic contamination at various exposure categories (stratified for cancers, unstratified for diabetes mellitus and ischemic heart disease), using epidemiological data from Taiwanese populations

Multiplication of PAFs with diseases and DALYs in each exposure category to give number of diseases attributable to arsenic

Calculation of trade-off between DALY and deaths saved due to arsenic mitigation and 20.8% increase in diarrhoeal disease for populations without access to adequate sanitation

Lokuge et al (2004) cont...

- Data on exposure levels taken from BGS study (Smedley and Kinniburgh (2002))
- Standardised Mortality Ratios (SMRs) for disease attributable to arsenic taken from studies on Taiwanese Populations (Smith et al (1992) and Tsai et al (1999))
- Average increase in diarrhoeal risk for populations without access to adequate sanitation taken as 20.8%, from Pruss et al (2002)
- Existing disease burden in Bangladesh from Global Burden of Disease 2002

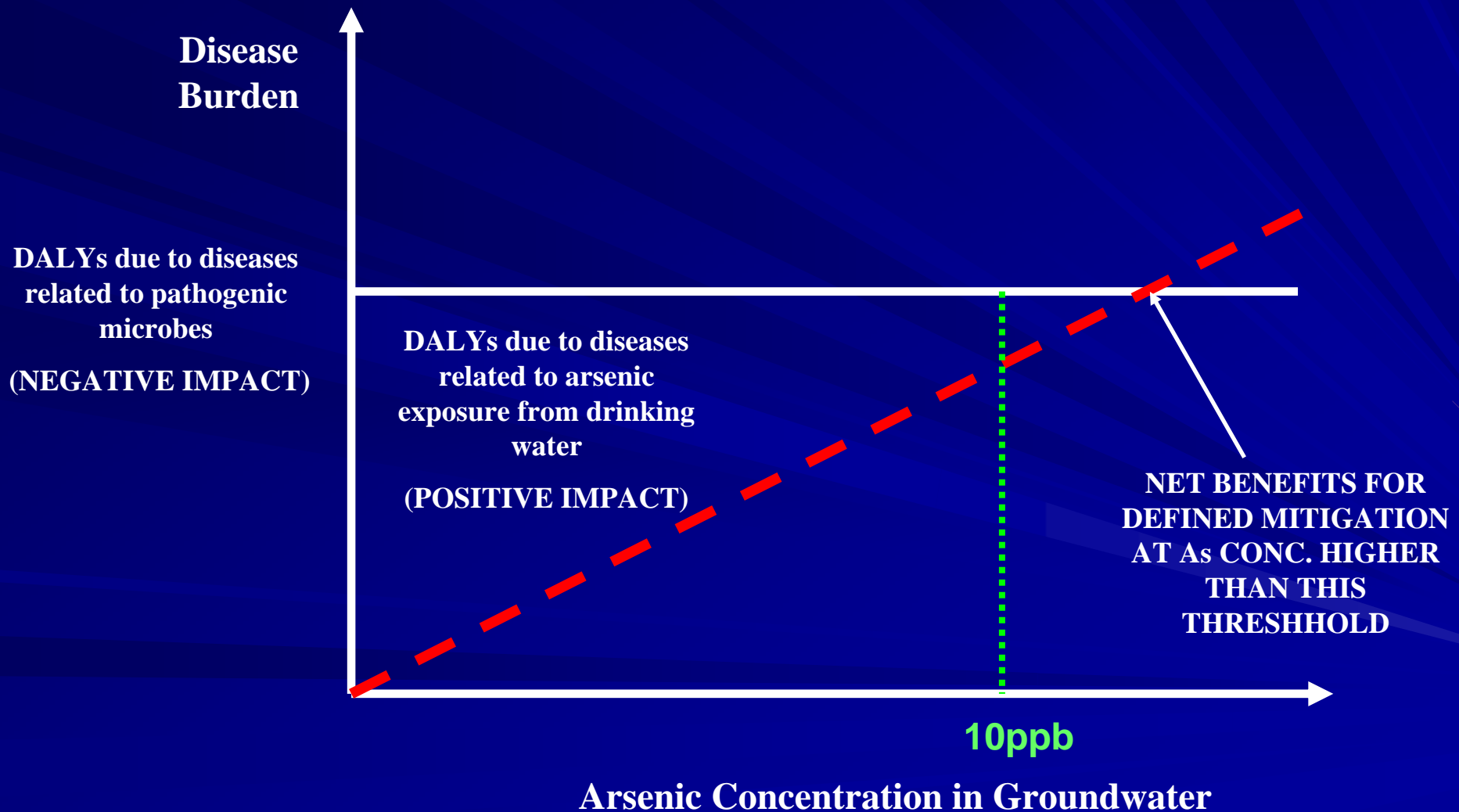
Adamson and Polya (2007)

- Attempt to determine level of uncertainty within Lokuge et al Model
 - Two papers published since 2004 by Navas-Acien et al which question the quality of the Tsai et al (1999)⁶ study, from which SMRs for Diabetes Mellitus and Ischemic Heart Disease were derived
- Of studies which relevant to the Lokuge et al model, Tsai et al (1999)⁶ rated most poorly for both diseases, e.g.:
 - No internal comparisons within study participants,
 - No adjustment for smoking, hypertension, lipids, BMI
 - Intensity of search not independent of exposure status
- Additionally:
 - Population structure updated to 2001 census of Bangladesh
 - Disease burden for Bangladesh only recently published – previously estimated from SEAR-D global sub-region, which was recognised by Lokuge et al as being non-representative of rural populations

Results using updated population and disease burden data

Pop. Intervened	Cancer threshold	Deaths	DALYs
> 10 μ g l-1	none	5,141	-12,281
> 10 μ g l-1	> 50 μ g l-1	4,156	-23,146
> 10 μ g l-1	> 100 μ g l-1	3,503	-30,461
> 50 μ g l-1	none	5,389	18,421
> 50 μ g l-1	> 100 μ g l-1	4,737	11,105

Results using updated population and disease burden data cont...



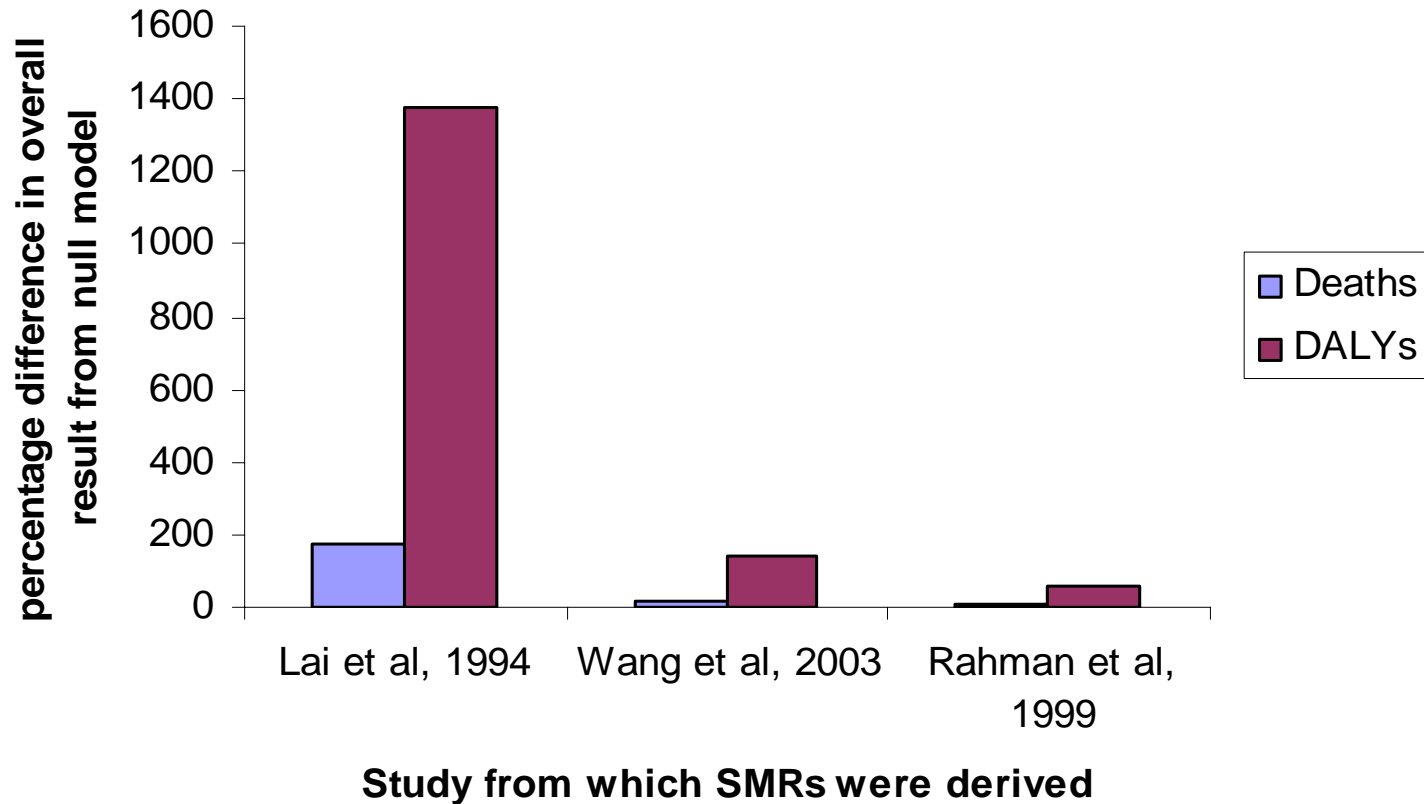
Comparison of mitigation to 50ppm and 10 ppm

Model		Population supplied with intervention	All those exposed to arsenic levels > 10 µg/L			All those exposed to arsenic levels > 50 µg/L	
Name	Description	Threshold for arsenic-related lung, bladder and kidney cancer	No threshold	>50 µg/L	>100 µg/L	No threshold	>100 µg/L
LQM	This study, parameter values as used by Lokuge where possible, otherwise as described in the text	Deaths	7777	6608	5826	7883	7065
		DALYs discounted at 3 %	28547	16077	7827	51823	43572
NULL	This study, NULL MODEL, parameter values as described in the text	Deaths	5064	4156	3568	5389	4801
		DALYs discounted at 3 %	-13580	-23146	-29264	18421	12302
N/DM 1	This study, NULL MODEL modified by SMRs for diabetes mellitus from Lai	Deaths	14441	13533	12945	13402	12813
		DALYs discounted at 3 %	163340	153774	147656	169592	163474
N/DM 2	This study, NULL MODEL modified by SMRs for diabetes mellitus from Rahman	Deaths	5385	4477	3889	5711	5123
		DALYs discounted at 3 %	-7514	-17080	-23199	24486	18368
N/DM 3	This study, NULL MODEL modified by SMRs for diabetes mellitus from Wang	Deaths	5908	5000	4412	6233	5645
		DALYs discounted at 3 %	2340	-7226	-13344	34341	28223
N/IHD 1	This study, NULL MODEL modified by SMRs for ischemic heart disease from Lin	Deaths	17902	16994	16405	18227	17639
		DALYs discounted at 3 %	128824	119258	113140	160824	154706
N/IHD 2	This study, NULL MODEL modified by SMRs for ischemic heart disease from Tseng	Deaths	22907	21999	21411	16927	16339
		DALYs discounted at 3 %	184341	174775	168656	146399	140281
N/IHD 3	This study, NULL MODEL modified by SMRs for ischemic heart disease from Wu	Deaths	5011	4103	3515	5336	4748
		DALYs discounted at 3 %	-14169	-23735	-29854	17831	11713

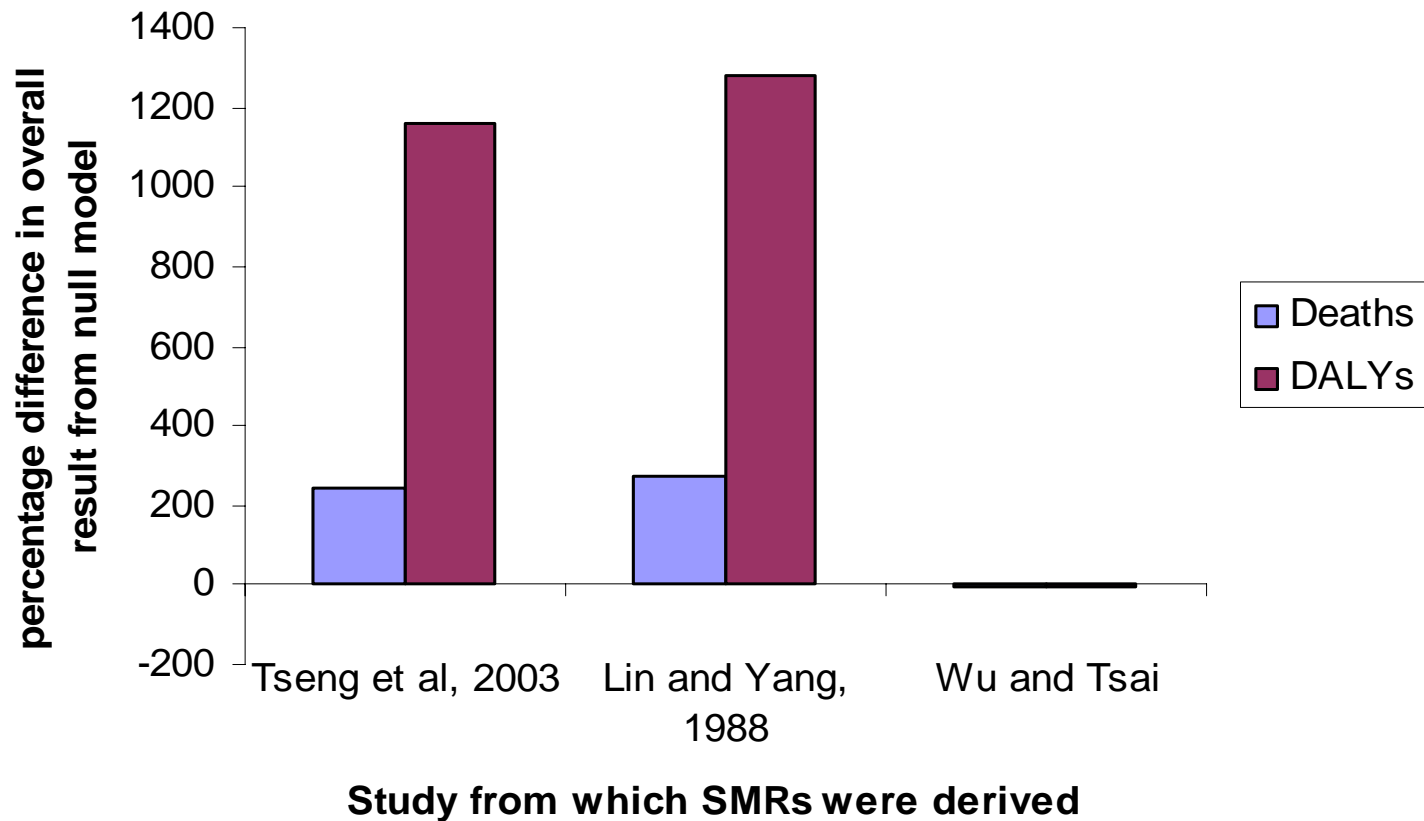
Navas-Acien et al (2005 and 2006)

- Relevant studies (i.e. lowest exposure category 300ppb or lower) rated most highly were Lai et al (1994) for Diabetes Mellitus and Tseng et al (2003) for ischemic heart disease
- These studies stratified exposure into 3 categories, whereas Tsai et al (1999) only compared 'exposed' (>300ppb) with 'unexposed'.

Model using SMRs from alternative studies for Diabetes Mellitus



Model using SMRs from alternative studies for Ischemic Heart Disease



Conclusions

- Navas-Acien studies have identified Diabetes Mellitus and Ischemic Heart disease as key uncertainties within the model, with very large errors
- Necessary for linear dose response relationships between arsenic exposure and arsenic-related diseases to be established, as
 - more exposure categories = greater risk exposed
- Controversy surrounding mitigation to 50 ppb vs 10 ppb renders reduction in errors more crucial
- Could be major consequences if models are used by policy makers without further work
 - N.B. degree of error only checked for two end-points, likely to be much higher if cancers are also taken into account!

Final Point

- Use of 20.8% in contention
- Used as a blanket value in Lokuge et al as quantity of water seen as important as quality, and household handling may be a major source of contamination (Esrey et al (1991), Hoque et al (1989)).
- Clearly this is not the case, as demonstrated by seminars given today at RGS 2007
- Studies currently ongoing to reassess this claim (see Clasen and Cairncross (2004) Refining the dominant paradigm)

References – Page 1 of 2

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