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Health benefits of biofortification

an *ex-ante* analysis of iron-rich rice and wheat in India

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Introduction

Introduction
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- What is biofortification?
- Breeding food crops for higher contents of essential micronutrients (vitamins & minerals)
- Why biofortification?
- Micronutrient malnutrition affects billions of people world-wide
- Biofortification is potentially cheaper than alternative interventions (fortification & supplementation)

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Introduction

- Why is iron deficiency bad?
- Functional outcomes of iron deficiency anaemia (IDA) are:
  - impaired physical activity
  - impaired mental development
  - increased maternal mortality
    - stillbirths due to maternal death
    - child deaths due to lack of breastfeeding

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Quantifying benefits

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Quantifying health benefits

- Health improvements result in reduced mortality or in reduced morbidity
- Morbidity can be weighted to be comparable with premature mortality
- The “burden” of a disease is then the
  - years of life lost (YLL) due to mortality
  - years lived with disability (YLD)
- Or: disability-adjusted life years (DALYs)
  - Burden = $DALYs_{lost}$ = YLL + YLD

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Quantifying health benefits

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More formally:

$$DALYs_{lost} = \sum_j T_j M_{ij} \left(\frac{1 - e^{-rL_j}}{r} \right) + \sum_i \sum_j T_j I_{ij} D_{ij} \left(\frac{1 - e^{-rd_{ij}}}{r} \right)$$

T = size of target group j
M = mortality rate due to IDA in target group j
L = remaining life expectancy for target group j
r = discount rate of 3 percent
I = incidence rate of disease i in target group j
D = disability weight of disease i in target group j
d = duration of disease i in target group j

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Current situation in India

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- Some prevalence rates used:

Target groups	Moderate IDA	Severe IDA
Children ≤ 5 yrs	27.5 %	3.2 %
Women ≥ 15 yrs	7.4 %	1.0 %

- IDA-related maternal mortality:
  5 % of total maternal mortality
- The current burden of IDA in India is
  0.2m YLL + 3.7m YLD = **4**m $DALYs_{lost}$

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Current situation in India

- Available interventions
  - Medical supplementation (iron pills)
  - Industrial fortification (enriched flour)
  - Food-based approaches (education)
- Biofortification
  - Wide potential coverage
  - Self-targeting if focussed on staples
  - Targeting of rural populations
  - Continuous benefit stream

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Potential impact
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Potential impact of biofortification

Assumptions used to calculate impact

	Iron-rich rice		Iron-rich wheat	
	Pessim.	Optimist.	Pessim.	Optimist.
Current *Fe* content	3 ppm		38 ppm	
Potential *Fe* content	6 ppm	8 ppm	46 ppm	61 ppm
Potential increase	100 %	167 %	20 %	60 %
Consumption share	20 %	50 %	30 %	50 %

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Potential impact of biofortification

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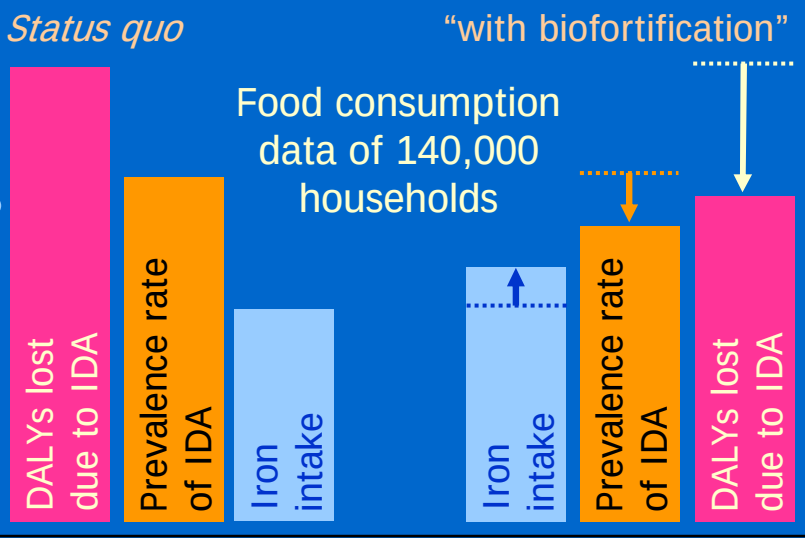

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Potential impact of biofortification

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New prevalence rates for moderate IDA

Target groups	Old	Pessimist.	Optimistic
Children ≤ 5 yrs	27.5 %	23.5 %	16.5 %
Women ≥ 15 yrs	7.4 %	6.5 %	3.0 %

Reductions in the burden of IDA in India

Biofortification of	Scenario	DALYs saved	Decrease of burden
Rice & wheat	pessim.	0.8 m	- 19 %
Rice & wheat	optimist.	2.3 m	- 58 %

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Evaluation
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Economic evaluation

- With only limited resources available “effectiveness” is a poor yardstick
- To “compete” with alternatives biofortification has to “pay off”
- Juxtaposing DALYs saved with R&D costs yields “Cost per DALY”
- The cost per healthy life year can be compared with other interventions

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Economic evaluation

- Annual costs for both iron-rich rice & wheat range from $ 0.2m - $ 1.6m
- The annual average over 30 years for both crops ranges from $ 0.3m - $ 0.6m
- **Only** the pills to reach 50% of all pregnant women and children aged 1-5 years with iron supplements would cost $ 5.2m **each** year

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Economic evaluation

- Cost-effectiveness of iron biofortification

Target crop	Rice & wheat	Only rice	Only wheat
	$/DALY		
Pessimistic scenario	3.53	2.44	6.01
Optimistic scenario	0.48	0.32	0.66

- Saving one healthy life year can cost as little as 32 Cents

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Economic evaluation

- The World Development Report 1993 classifies costs per DALY:
  - $ 1 - $ 3 = “most cost-effective”
  - < $ 25 = “remarkably low”
  - $ 50 - $ 150 = “highly cost-effective”
- Gillespie reports costs per DALY of iron fortification and supplementation in the range of $ 4.4 - $ 12.8
- This contrasts favourably with our results of $ 0.48 - $ 3.53

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Economic evaluation

- For comparing results with other interventions or to reach decision makers who are not familiar with DALYs
- Cost-benefit analyses can be carried out by attaching a $ value to one DALY
- In the pessimistic scenario biofortifying both crops has an IRR of 63% and a benefit-cost ratio of 142.
- In the optimistic case the IRR is 141% and the BCR is 1042.

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Economic evaluation

- Other studies of iron interventions, using different approaches, yielded results in the range of
  - BCR = 1.6-59 for supplementation
  - BCR = 5-200 for fortification
  - BCR = 19-79 for biofortification
- Again, this contrasts favourably with our BCR of 142-1042

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Conclusion

Conclusion

- Biofortification is potentially effective in reducing the burden of IDA in India
- Biofortification ranks amongst the “cheapest” micronutrient interventions, costing only $ 3.53 per DALY saved
- Where hidden hunger is wide-spread, breeding for micronutrient-rich crops is an economically viable intervention

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Conclusion

Conclusion

- This study provides valuable input for decision makers
- We further extended the use of “DALYs” to assess output of agricultural research
- We developed a new framework to analyse biofortification and iron def.
- And, as a first, we used representative national household data to generate the basis for this kind of impact analysis

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Thank you

for your attention!

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