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Potential impact and cost-effectiveness of Golden Rice in India: an ex-ante study

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Introduction

- Problem of VAD ✓
- Interventions to control VAD and their strengths & weaknesses ✓
- The present evaluation was undertaken to clarify the potential impact and the relative cost-effectiveness of Golden Rice
- India was chosen as case study because VAD is prevalent and research on GR takes place

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Methods

- GR is an agricultural product but common agricultural economics methods for impact assessment cannot be used
- Beneficiaries of GR have no purchasing power
- The benefit of GR is improved health
- How to measure health across target groups and different health outcomes?
- Namely night blindness, corneal scars, blindness, measles & child mortality

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Methods

- Counting VA deficient individuals neglects the severity of different health outcomes
- For premature mortality the years of life lost (YLL) can be counted
- In the other cases the years lived with disability (YLD) can be counted
- The severity of these health outcomes can be weighted relative to death
- Then the burden of a disease can be expressed in disability-adjusted life years (DALYs) lost

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Methods

- Burden = $DALYs_{lost}$ = YLL + $YLD_{weighted}$
- More formally:

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

- Comparing the burden with and without GR gives its impact in terms of a health gain
- How to relate the improved VA intakes to improved health outcomes?

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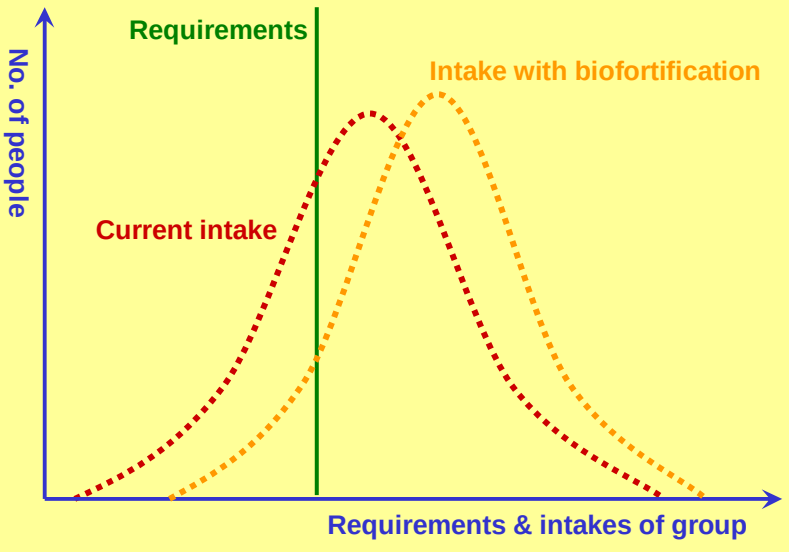
Methods



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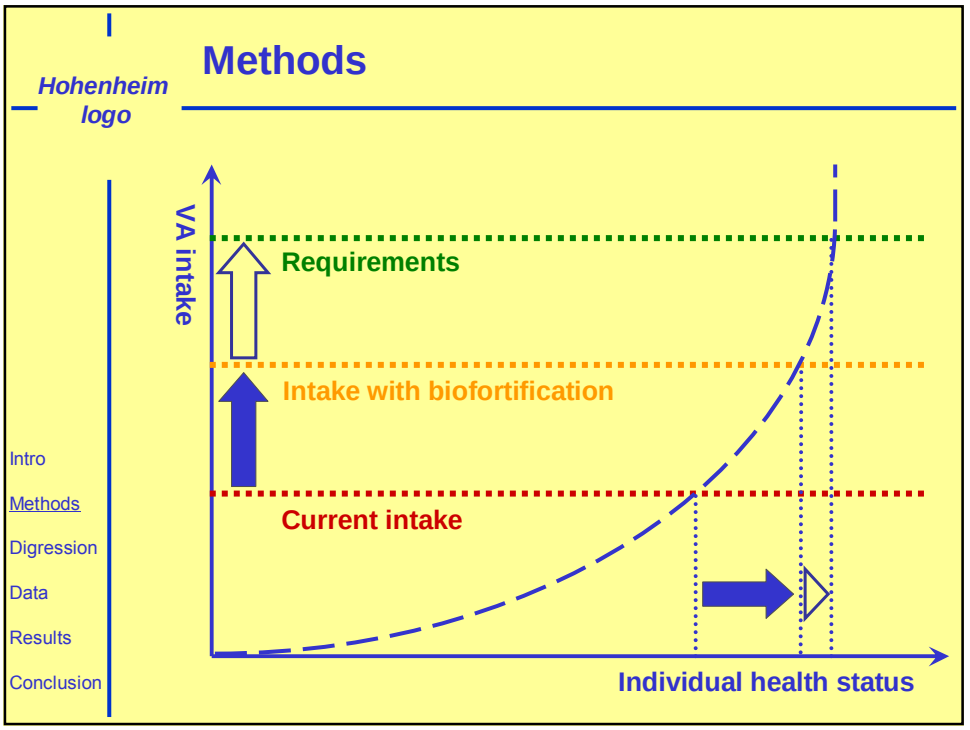
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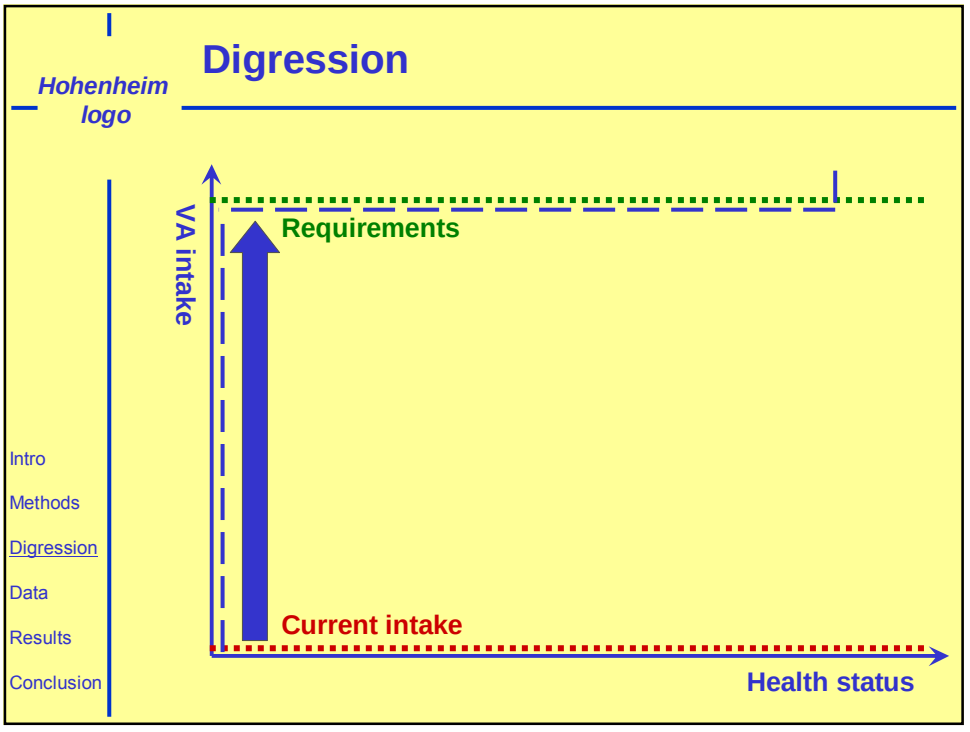
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	"Content" (µg/100g)	VA content (µg/100g)	Grams to reach 750 µg VA	Fat content (g/100g)
Golden Rice (SGR2)		233-1,033	72-321	0.5
Taken from Shiva (2000)		*Based on Gopalan et al. (1989), USDA (2004) and Erhardt (2005)*		
Cabbage	217	9	8,333	0.1
Jackfruit	54	15	5,000	0.1
Tomato, ripe	32	42	1,786	0.2
Orange	35	92	815	0.2
Radish leaves	750	221	339	0.4
Mango, ripe	500	229	1.5 fruits	0.4
Milk, cow	50-60	64	1,172	6.5
Egg, hen	300-400	420	4 eggs	13.3

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Methods

- Given the health gains expressed in DALYs the improvement relative to the overall disease burden can be derived
- The absolute number of DALYs saved can be juxtaposed to the overall R&D costs of GR to obtain a cost-effectiveness measure ($/DALY)
- To take account of the uncertainty surrounding ex ante analyses a scenario approach is used

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Data

	Disability weight	Duration (yrs)	Incidence (%)
Children ≤5 years			
Nightblindness	0.05	1.00	100% of 1.03
Corneal scars	0.20	64.40	10% of 0.02
Blindness	0.50	64.40	10% of 0.02
Measles (simple)	0.35	0.03	10% of 2.70
Measles (complications)	0.70	0.06	10% of 2.70
Under five mortality	(1.00)	64.40	3% of 9.30
Pregnant women			
Nightblindness	0.10	0.42	100% of 6.62
Lactating women			
Nightblindness	0.10	0.50	100% of 5.52

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Data

Impact scenario	Low	High
β-carotene content in GR (μg/g)	14	31
Post-harvest loss of β-carotene (%)	80	35
Conversion of β-carot. in GR into VA	6:1	3:1
Coverage of GR 15 yrs after release		
- government shops & schools (%)	20	100
- on the free market (%)	14.3	50
- in rice products (%)	10	50

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Scenario	Low impact		High impact	
	Years	Undis-counted (US$)	Years	Undis-counted (US$)
International R&D	2001-07	7.5 m	2001-07	3.3 m
R&D within India	2002-11	1.2 m	2002-09	0.8 m
Regulatory process	2003-12	2.5 m	2003-10	2.2 m
Release of GR	2012-13		2010-11	
Social marketing	2013-15	15.6 m	2011-15	30.7 m
Maintenance breeding	2013-29	2.1 m	2011-29	1.9 m
Total cost (discounted at 3%)	2001-30	21.4 m	2001-30	27.9 m
Average annual cost	2001-30	0.7 m	2001-30	0.9 m

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Results

Impact scenario	Low	High
Annual burden of VAD (DALYs lost)	2.3 million	
No. of lives lost due to VAD each year	71,600	
Reduction of the burden through GR	-8.8 %	-59 %
No. of children's lives saved through GR	5,500	39,700
Reduction of the burden through the consumption of coloured rice landraces	-0.1 %	-3.3 %

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Results

Impact scenario	Low	High
	US$/DALY	
r_{DALYs} = 3%, $r_{US\$}$ = 3%	**19.40**	**3.06**
r_{DALYs} = 0%, $r_{US\$}$ = 3%	4.76	0.74
r_{DALYs} = 10%, $r_{US\$}$ = 10%	103.5	14.76
World Bank benchmark (US$/DALY)	200	
WHO standard for valuing DALYs (US$)	620 - 1,860	
US$/DALY saved with supplementation	134 - 599	

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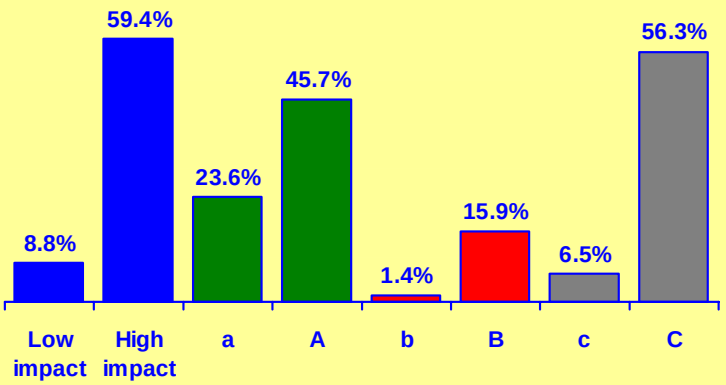
Results



a = low beta-carotene content, high coverage rate

b = low impact scenario for government channels only

c = low impact scenario with RDAs instead of EARs

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Results

- The efficacy of GR in closing the VA intake gap is higher for the poorest quartile as compared to the richest 25% of households
- In the predominantly rice eating regions of India, consumption of GR in the high impact scenario provides 99% of all individuals with their recommended dietary allowance (RDA)
- In the low impact scenario it ensures RDA sufficiency for 13.4% of children (compared to 8.4% for children in all India)

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Conclusion

- GR has the potential to be an effective & efficient intervention to fight VAD
- GR on its own will not eliminate VAD
- The inclusion of GR in more comprehensive public health strategies should be considered
- Other useful interventions are targeted VA supplementation, nutrition education & poverty reduction

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Conclusion

- Future research has to determine the exact size of crucial parameters like
  - the β-carotene content under field conditions
  - the magnitude of post-harvest losses of β-c.
  - the agronomic performance of GR
  - the acceptance of GR by consumers
- Issue of product dilution in informal seed systems needs to be solved (for export)
- The safety of GR will have to be tested and regulated

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Thank you

for your attention!