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Potential Impacts of Golden Rice on Public Health in India

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Introduction

- 140 million pre-school children & 7 million pregnant women suffer from vitamin A deficiency (VAD) worldwide
- Up to 3 million children die every year & many become blind
- The current intervention of choice is bi-annual medical supplementation with mega-doses of vitamin A (VA)
- Rising coverage rates are achieved

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Introduction

- Supplementation is resource intensive
  (funding, manpower, infrastructure, monitoring)
- Those most in need may not be reached
  (in remote areas or at the fringes of society)
- VAD is an essentially food-based problem
  but supplementation is a medical intervention
- A more sustainable approach would to be
  to improve dietary VA intake
- Income growth (via higher quality food)
  will not improve nutrition any time soon

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Introduction

- Rice-eating populations are at particular risk
  because milled rice does not contain
  beta-carotene (a precursor of VA)
- For the same reason it cannot be cross-bred
  into the endosperm of rice
- A genetic engineering approach was successful
  as a proof-of-concept (Golden Rice)
- The potential impact & cost-effectiveness
  of GR remains disputed
- In India VAD is prevalent & GR is researched

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Methods & data

- 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
- Cultivation/consumption needs to be linked to health outcomes to capture benefits
- 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 & data

- 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 & data

- 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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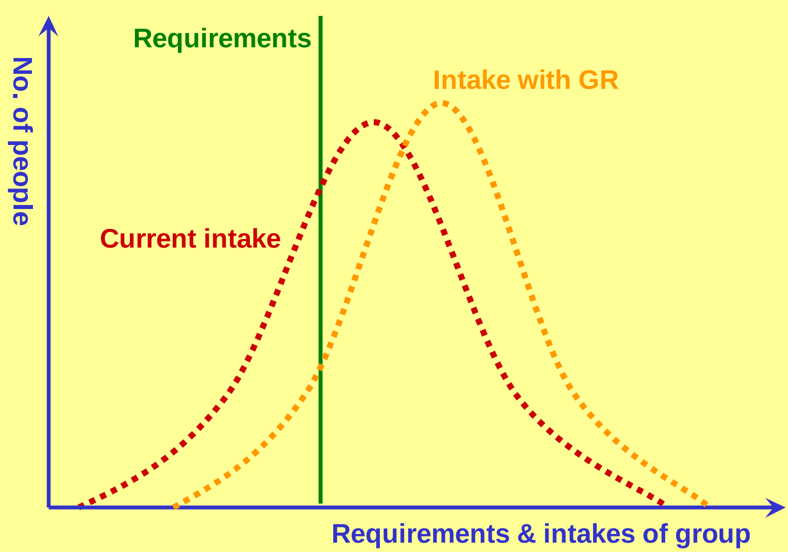
Methods & data



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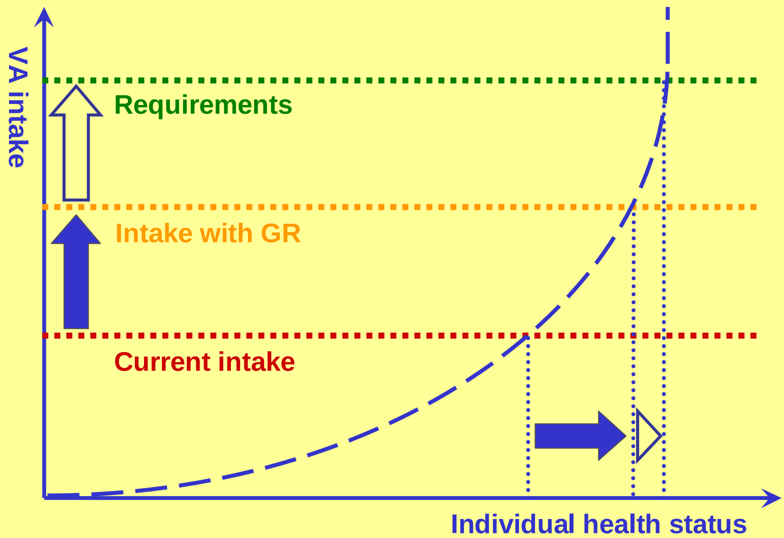

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Methods & data

- 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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Methods & 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
Average annual cost over 30 yrs ($)	713,000	931,000

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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

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Results

Impact scenario	Low	High
Cost-effectiveness of GR (US$/DALY)	**19**	**3**
World Bank benchmark (US$/DALY)	200	
WHO standard for valuing DALYs (US$)	620 - 1,860	
US$/DALY saved with supplementation	134 - 599	

- Results of different scenarios and various sensitivity analyses not reported here

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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 beta-carotene content that can be realised under field conditions
  - the magnitude of post-harvest losses of beta-carotene
  - the agronomic performance of GR-varieties
  - and the acceptability of GR by consumers
- The safety of GR for human consumption & the environment will have to be assessed and GR be regulated by national authorities

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Thank you

for your attention!