Optimization of diets for human health, low-cost and planetary health: a modeling approach

Prof Nick Wilson, Dr Christine Cleghorn, Dr Nhung Nghiem

BODE[3] Programme,
University of Otago,
Wellington, New Zealand

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Presentation Outline

- Background
- Modeling to optimize diets: health, low-cost, low GHGs etc
    - Methods & Results
- Modeling optimization of bread design
- Comparisons with other work
- Possible priorities for future research
    - Key metrics, land use, waste, modeling interventions
- Conclusions

Background

Health: Improving nutrition – key to NCD control

Food costs: Food security a challenge internationally – including for some groups in high-income countries

Sustainability: Climate change – a particularly serious (& growing) threat to human health & ecosystems (up to a third of greenhouse gas [GHG] emissions from agriculture if consider land use)

Objective

To identify foods and dietary patterns that are:

- healthy (meet nutritional guidelines)
- low-cost
- associated with low GHG emissions

Done to help inform policies available to governments (eg, nutrition guidelines, food labelling laws, taxes/subsidies on foods and food voucher policies)

Methods

Scenario development & linear programming (LP) to model 16 diets for NZ population

LP: mathematical technique allows the generation of “optimal solutions” eg, the lowest cost diet that meets guidelines for healthy nutrition

LP: used for decades in the nutrition domain, with growing recent consideration of cost & sustainability

Methods continued

The first grouping of dietary scenarios focused on achieving the lowest daily food cost (& meeting recommended nutrient levels).

The next grouping – achieving the lowest GHG emission profile.

Specific dietary patterns (Mediterranean-style and Asian-style) + scenarios with “familiar meals” fairly acceptable to most NZers.

Data inputs: nutrients in foods (NZ), food prices (NZ), food wastage (UK), & food-specific GHG emissions (UK & NZ data).

For more see: Wilson et al 2013. *PLoS ONE*

Results

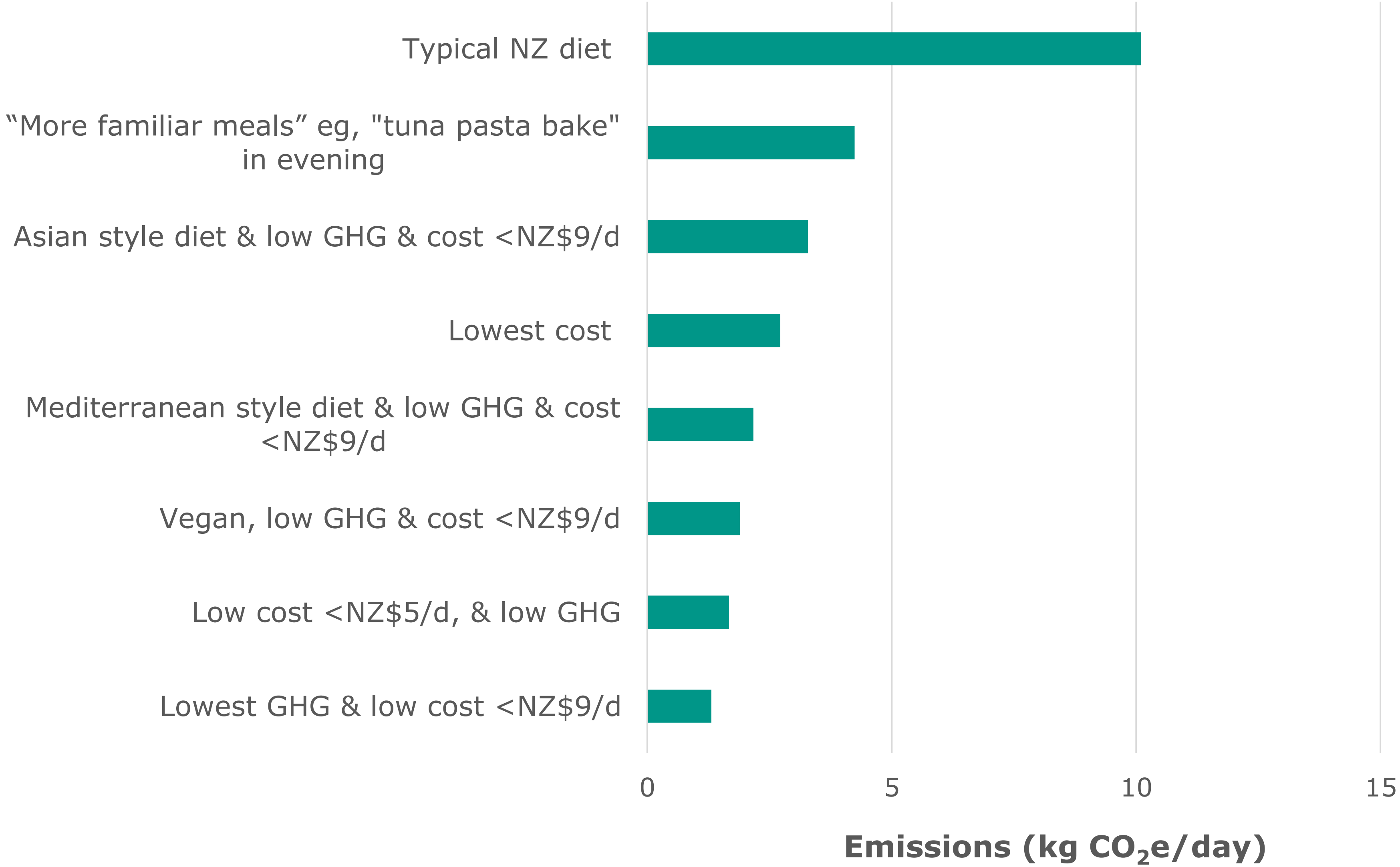
Low cost, low GHG, only 7 foods to provide all nutrients: oats (whole grain), powdered milk, carrots, kiwifruit, dried split peas, sunflower seeds, vegetable oil

Example of more realistic diet with minimum levels of some *required components* (17 foods):

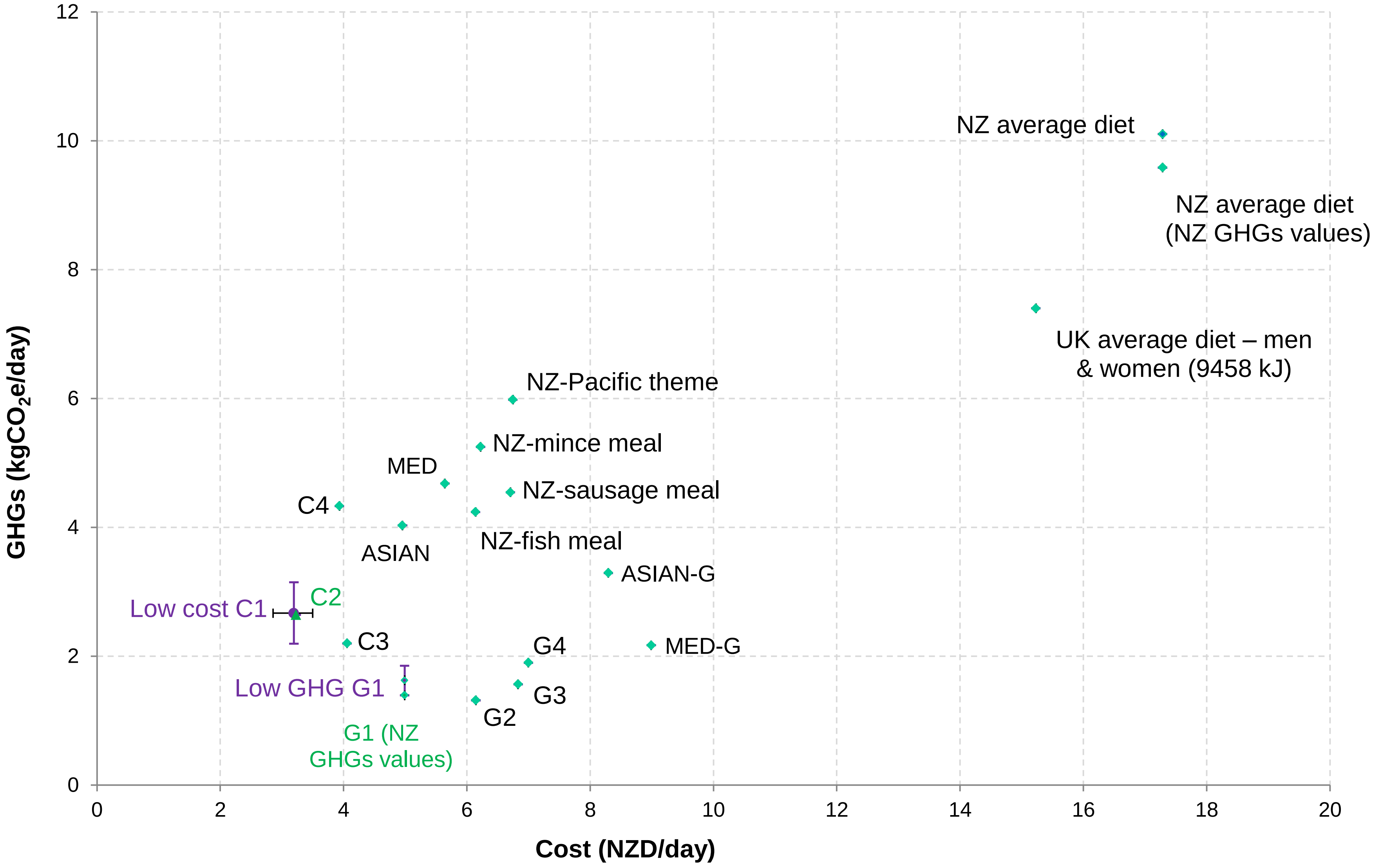
- ***Breakfast:*** porridge: oats (whole grain), powdered milk, sugar
- ***Lunch:*** sandwiches: wholemeal bread, margarine, peanut butter, cheese; apple
- ***Dinner:*** tuna pasta bake meal: tuna, pasta, tomatoes, salt, carrots, green peas, split peas, wholemeal flour, oil

Results: Dietary patterns & GHG emissions

[Derived from: Wilson et al 2013, *PLoS One*]



Results: Cost & GHG emissions per day of the various optimized daily dietary scenarios



Optimized diets: largely plant-based

Dietary pattern	Vegetarian/ vegan	Mainly plant, some meat
Lowest cost (4 diets)	4 diets (all milk)	-
Lowest GHG (4)	2 diets (milk) 1 diet vegan	1 diet (fish)
Asian/Mediterranean style & low GHG (2)	2 diets (milk)	-
"More familiar meals" (4) some required ingredients	-	4 diets had meat/fish (77g to 125g)

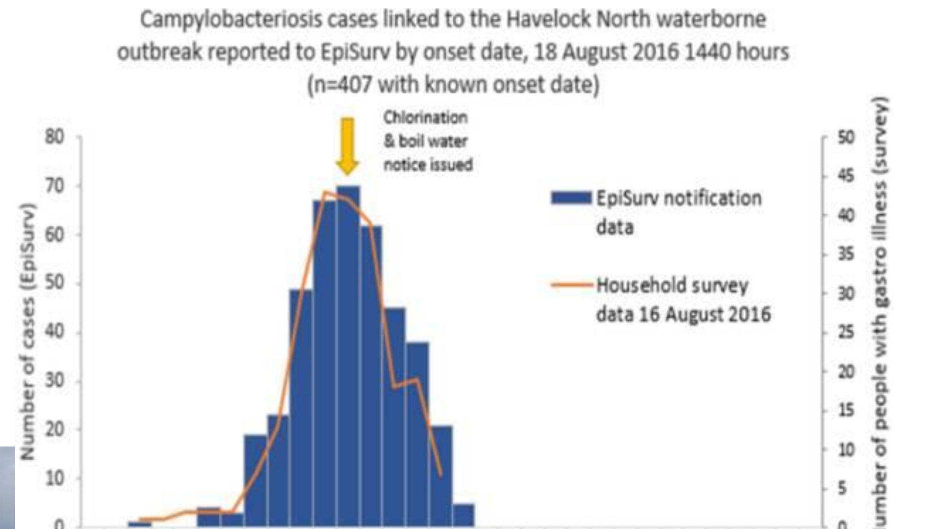
Examples of costs, GHGs & nutrient intakes

Nutrients / Scenario:	Lowest cost (C1)	Lowest GHG (G1)	Asian style	Mediterranean (MED)	NZ more typical (eg, mince meal NZ-M)
Emissions (kg CO_2e)	2.72	**1.67**	4.03	4.68	**5.25**
Price (<5 NZ$)	**3.19**	4.99	4.95	5.64	**6.22**
Fruit and vegetables (g)	63	80	500	912	249
Energy (≥ 11,450 kJ)	11,450	11,450	11,723	11,788	12,650
Saturated fatty acids (≤ 30 g)	6	18	5	13	**20**
Polyunsaturated fatty acids (≥ 13.1 g)	14	83	13	14	15
Protein (≥ 52 g)	124	98	109	100	133
Dietary fibre (≥ 30 g)	51	54	57	57	64
Sodium (≤ 2,300 mg)	475	237	1,523	1,670	**2,300**
Total sugars (g)	90	22	43	125	45
Potassium (≥ 3,800 mg)	3,800	3,800	3,800	3,800	3,800
Calcium (≥ 840 mg)	840	840	840	840	840
Iron (≥ 8 mg)	23	33	19	24	31
Zinc (≥ 12 mg)	18	21	15	15	24
Selenium (≥ 60 µg)	60	90	60	60	60
Vitamin A (≥ 625 and ≤ 3,000 µg RE)	625	625	1,700	625	625
Thiamin (≥ 1 mg)	2	6	2	2.1	3
Vitamin C (≥ 30 mg)	30	30	118	94	34
Vitamin E (≥ 10 mg)	11	78	11	14	11

Limitations

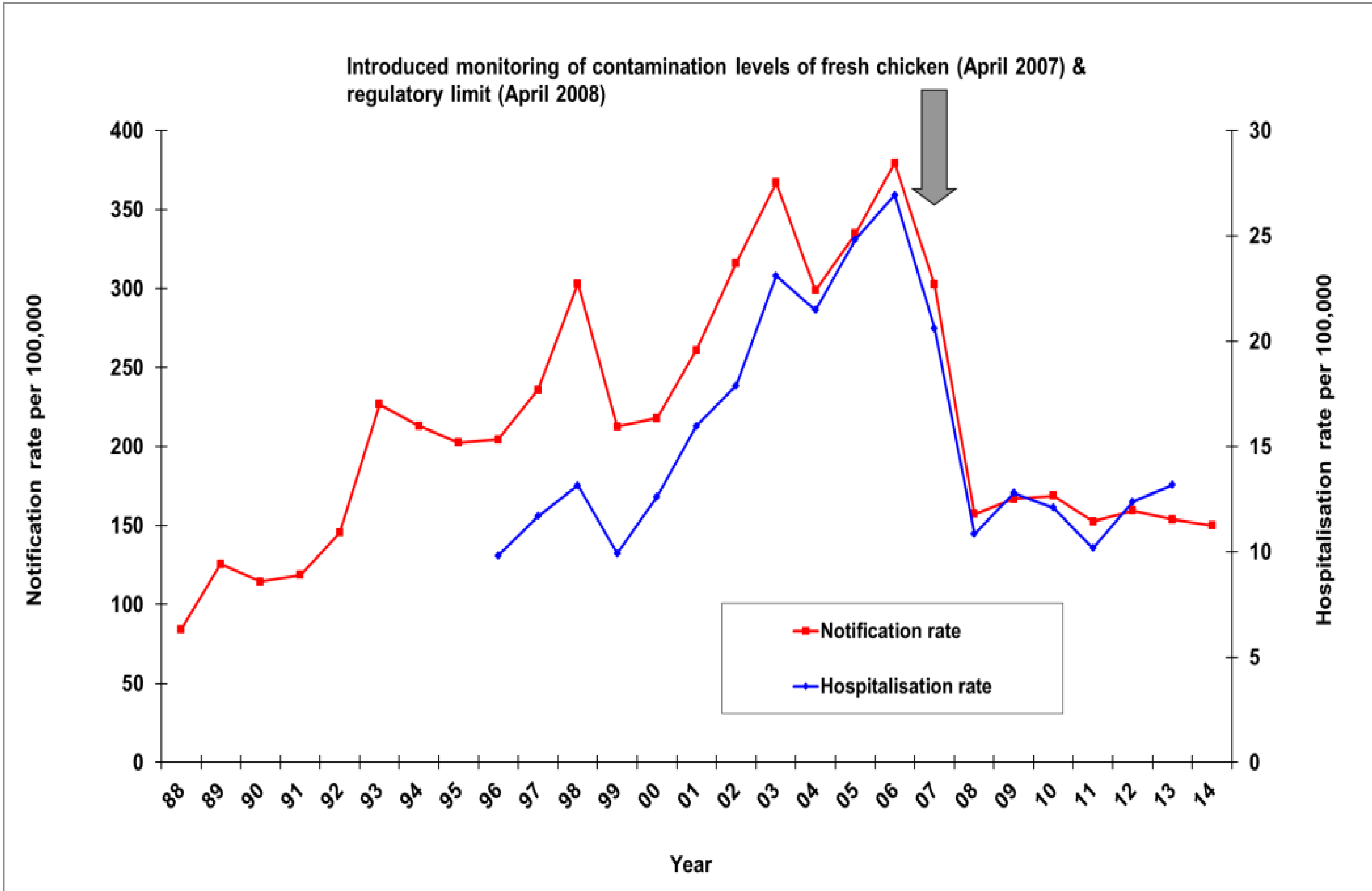
- Focus was on “optimal” vs smaller shifts from current diets
- Limited NZ data on GHGs & waste – so partial reliance on UK values
- Sustainability aspect limited to GHGs
- NZ food prices are distorted:
  - Subsidized irrigation
  - Farmers don’t pay for water pollution
  - No GHG taxes on agriculture (yet for NZ)

Unaddressed externalities, Example 1: In 2016 NZ had world's largest ever outbreak of waterborne campylobacteriosis (livestock faeces contaminated drinking water)



Example 2: Campylobacteriosis in NZ after regulation to reduce contaminated poultry meat

(Sears et al 2011, *Emerg Inf Dis*)



Example 3: Increased flooding risks from previously forested hill country now used for livestock grazing

Conclusions from this modeling

Identified optimal foods & dietary patterns that were healthy, low-cost & had low GHG emissions profile → nearly all vegetarian diets

Some limitations but patterns were consistent with other literature

Probably reasonably generalizable

It has informed our research – but only modest government interest to date

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RESEARCH ARTICLE Open Access

Designing low-cost "heart healthy bread": optimization using linear programing and 15-country comparison

Nick Wilson*, Nhung Nghiem, Sian Ryan, Christine Cleghorn, Nisha Nair and Tony Blakely

Abstract

Background: Bread is an important comp
also typically too much of other nutrients
the optimal design of low-cost "heart heal
15 countries.

Methods: Optimization using linear progr
range of minimal sodium levels. Then with
then dietary fiber, and then polyunsaturate
and comparison nutrient and price data c

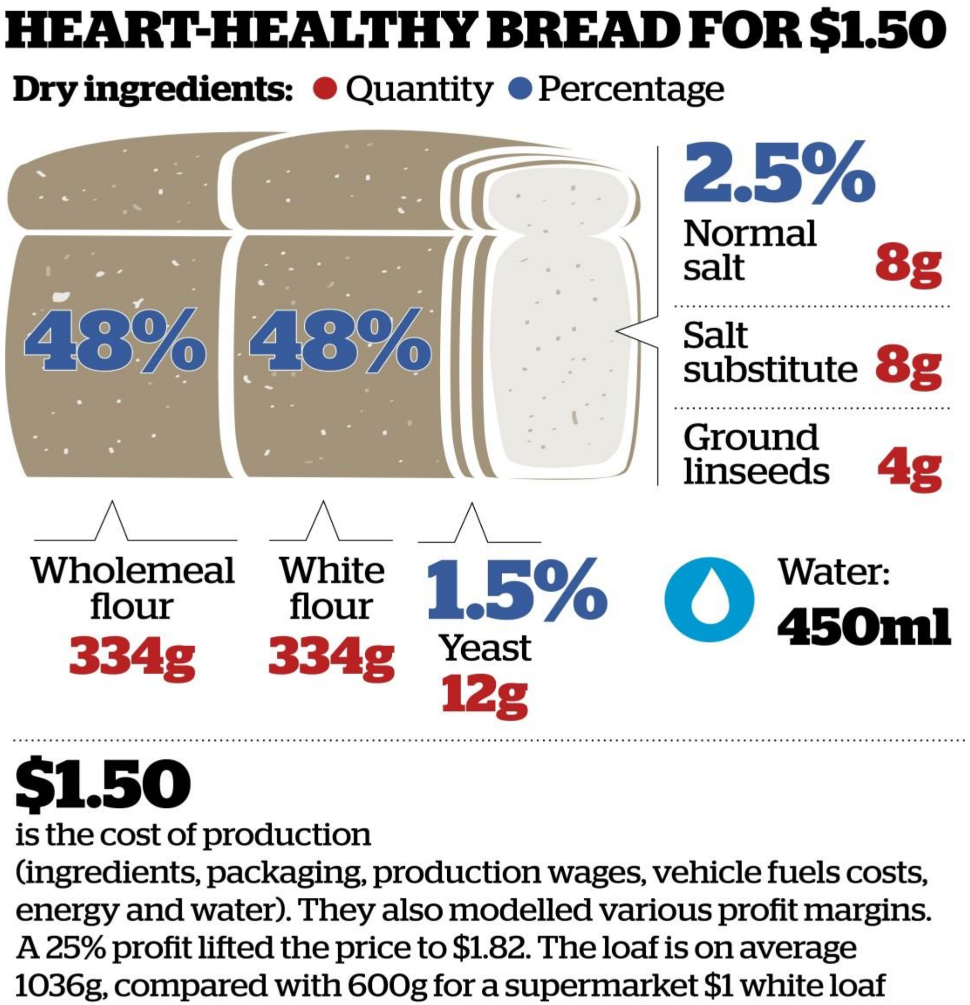
Results: The optimized loaf costing NZ$1.
three out of the eight heart health nutrien

Bread design optimization

- Optimization using linear programing focused on achieving set loaf prices and for a range of constraints (↓sodium, ↑ALA, ↑PUFAs, ↑fiber).
- The optimized loaf costing NZ$1.50 (US$1.02) in ingredients superior to commercial white loafs in 3/8 heart health categories.
- The optimized loaf that was high in linseed and cost NZ$3 (US$2.04), typically superior (6/8 categories) to commercial seed/nut loafs and lower cost.
- But does not include GHG emissions (as per Swedish bread [Sundkvist et al 2001])

Media coverage of these bread designs: suggested high public interest

NZ Herald **"Kiwi researchers design super-loaf"**



Comparisons with other work

- **Sustainability:** Consistent pattern of vegetarian or low-meat diets being more sustainable/lower GHG emissions
- **Health:**
  - General pattern of diets low in GHGs being healthier.
  - But health gains jeopardised if sugar is used to substitute for less meat/dairy
- **Cost:** Most studies suggest cost-saving/cost-neutral; but some that a sustainable diet is more expensive

Possible priorities for future research

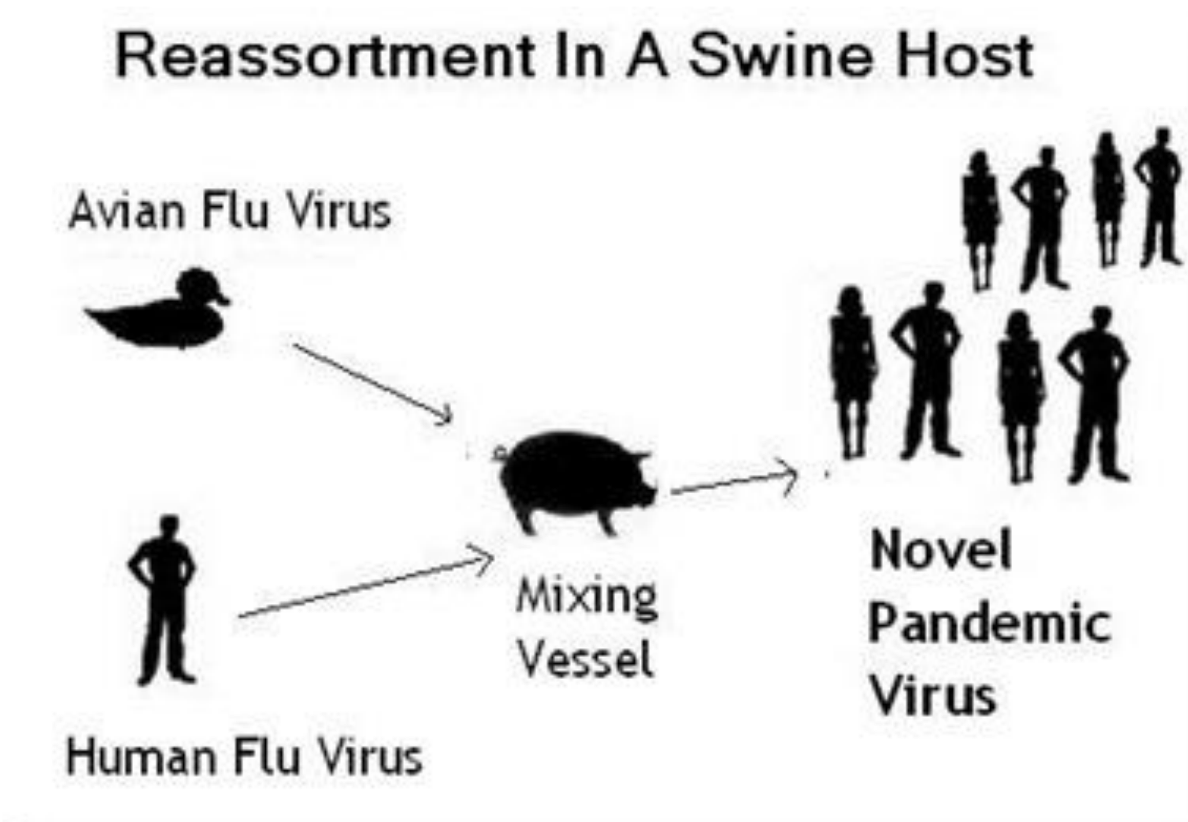
1) Improved GHG metrics for foods: food wastage, land use, water use

Eg, land use relates to:

- Biodiversity
- Water quality
- Timber production opportunities
- Carbon sequestration opportunities
- Flood protection (hill country)

Possible priorities for future research

2) Can zoonotic infectious disease risks be quantified? (Eg, pandemic influenza from poultry & pigs; campylobacteriosis from poultry)



Possible priorities for future research

3) Capturing antimicrobial resistance risks associated with livestock agriculture

4) Research/modeling interventions to achieve healthy & sustainable diets (eg, cost-effectiveness of dietary interventions)

Research on *existing* nutrition interventions – sustainability impacts?

- Mexico's "junk food" tax (GHG impact?)
- Soda taxes & plastic waste impacts?
- National nutrition guidelines that include sustainability (eg, Germany)
- Vouchers for farmers markets in USA (low-income families)
- Food labels – green stars

Modeling of *theoretical* interventions

- Taxes on ruminant meats & dairy products [Eg, Edjabou & Smed 2013; Briggs et al 2013]
  - Eg, tax of £2.72/t CO_2eq in UK averted 7770 deaths/y & reduced emissions & raised revenue
- Taxing ruminant agriculture (CH_4, NO_x) – planned for NZ

Conclusions

- Modeling studies and other research: possible to have foods and dietary patterns that are healthy, low-cost, & environmentally sustainable (all predominantly plant-based diets)
- Such research can inform personal decisions but also policies (food/agriculture taxes/subsidies, labeling interventions)
- Future work could improve the metrics (food waste & land use) & model cost-effectiveness of dietary interventions

Questions?