

National Academies

Maximizing Agriculture to Enhance Nutrient Composition to Better
Fulfill Dietary Recommendations



Human Biology Issues: Food Allergy

January 30, 2024

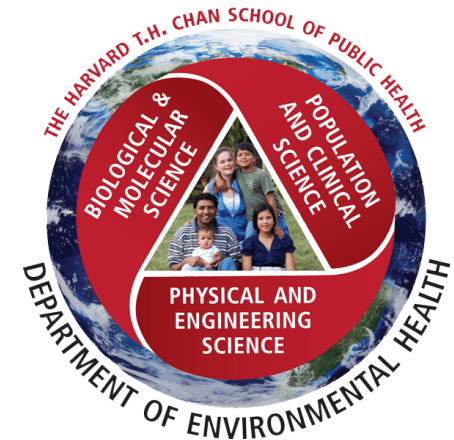
Kari C. Nadeau, M.D., Ph.D.

John Rock Professor of Climate and Population Studies

Chair, Department of Environmental Health

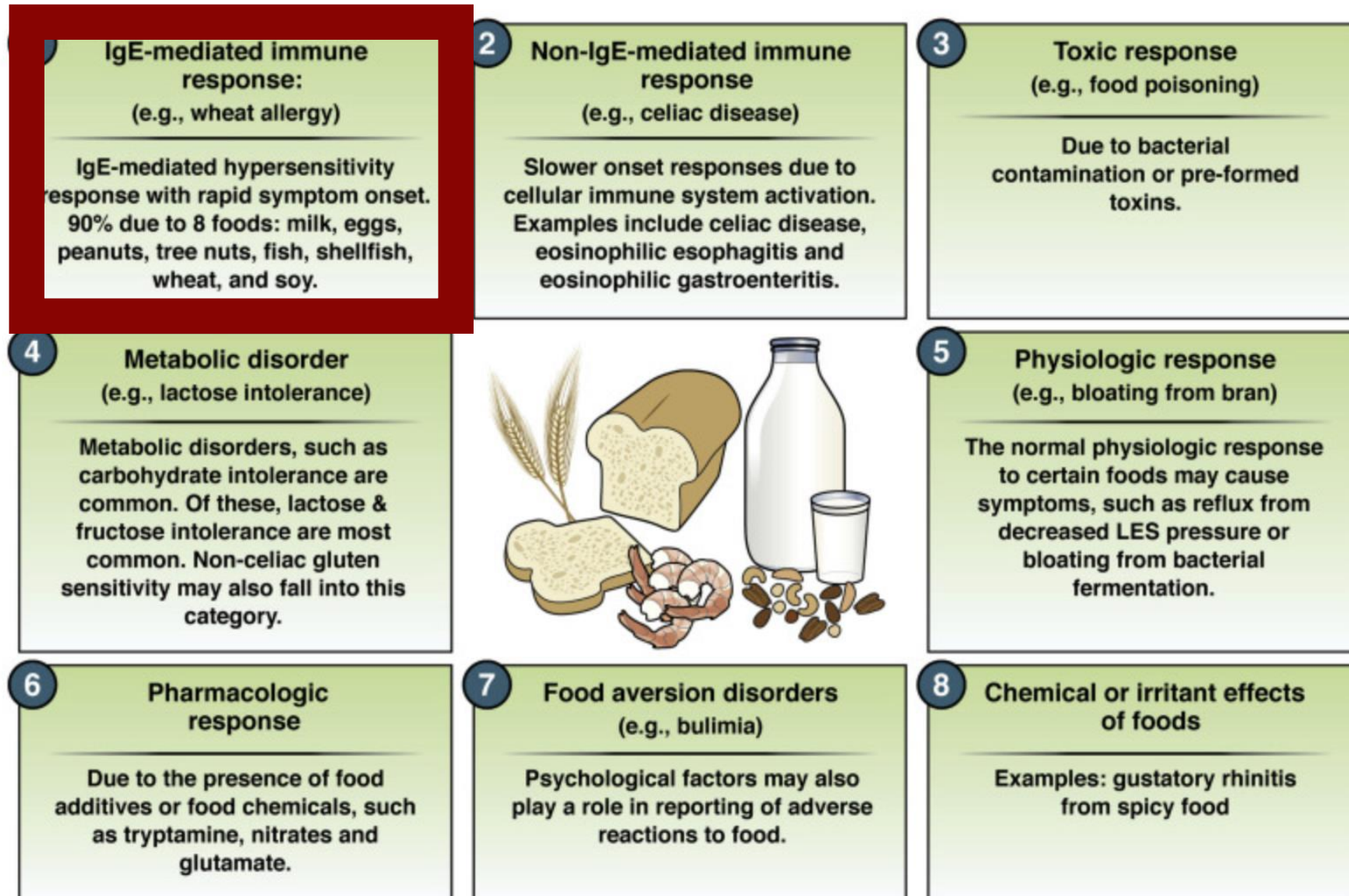
Interim Director, Center for Climate, Health, and the Global Environment

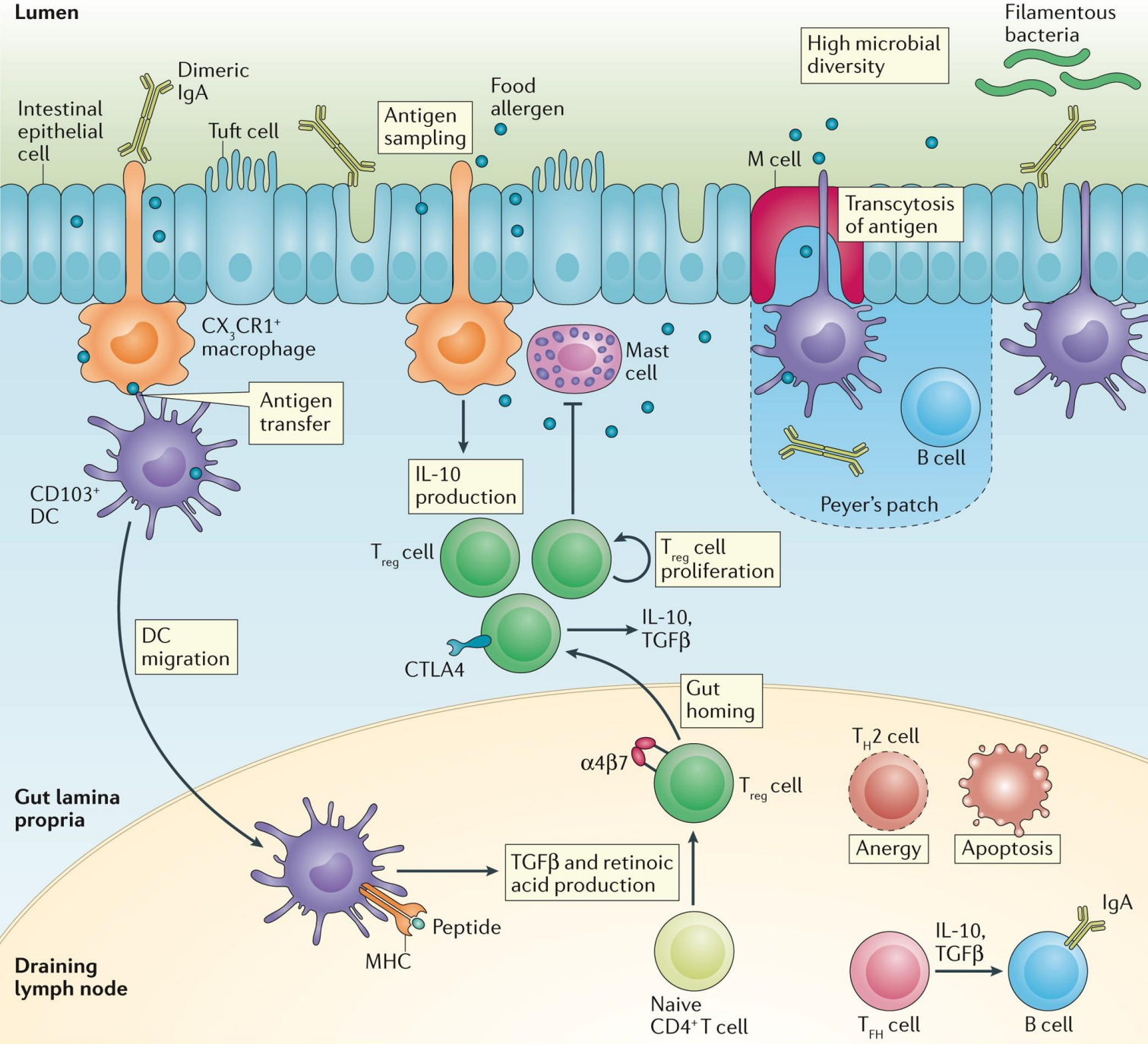
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HARVARD T.H. CHAN
SCHOOL OF PUBLIC HEALTH

Common causes of adverse reactions to food





Food allergy: immune mechanisms, diagnosis and immunotherapy

[Wong Yu](#), [Deborah M. Hussey Freeland](#) & [Kari C. Nadeau](#)

nature reviews immunology

There are many potential food allergens

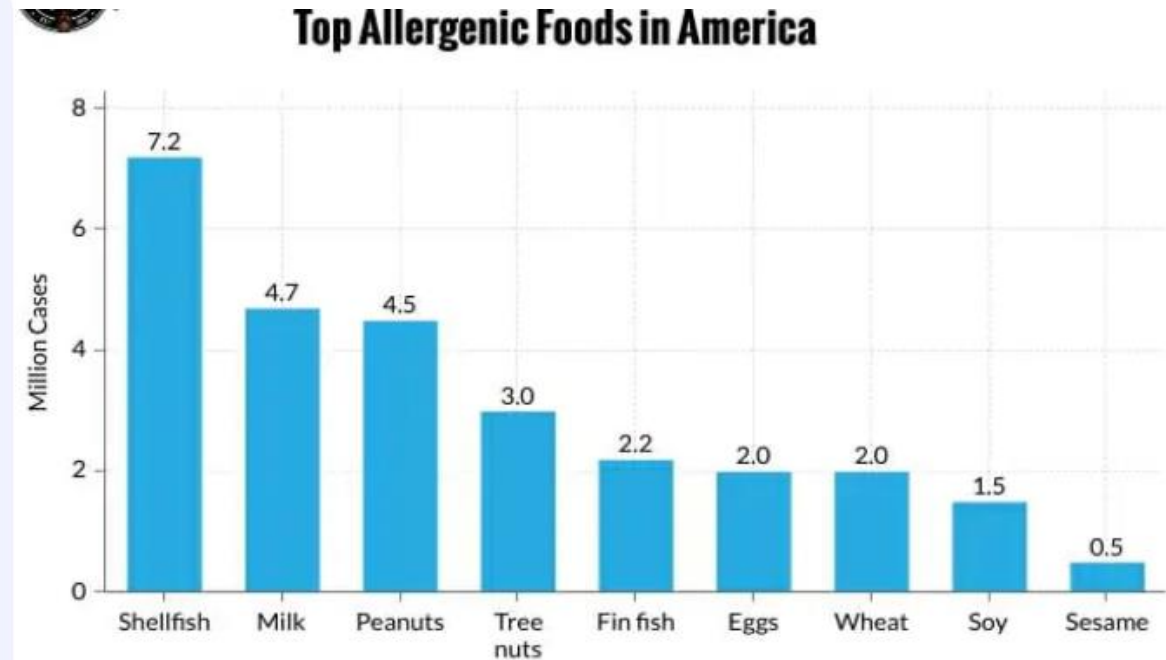
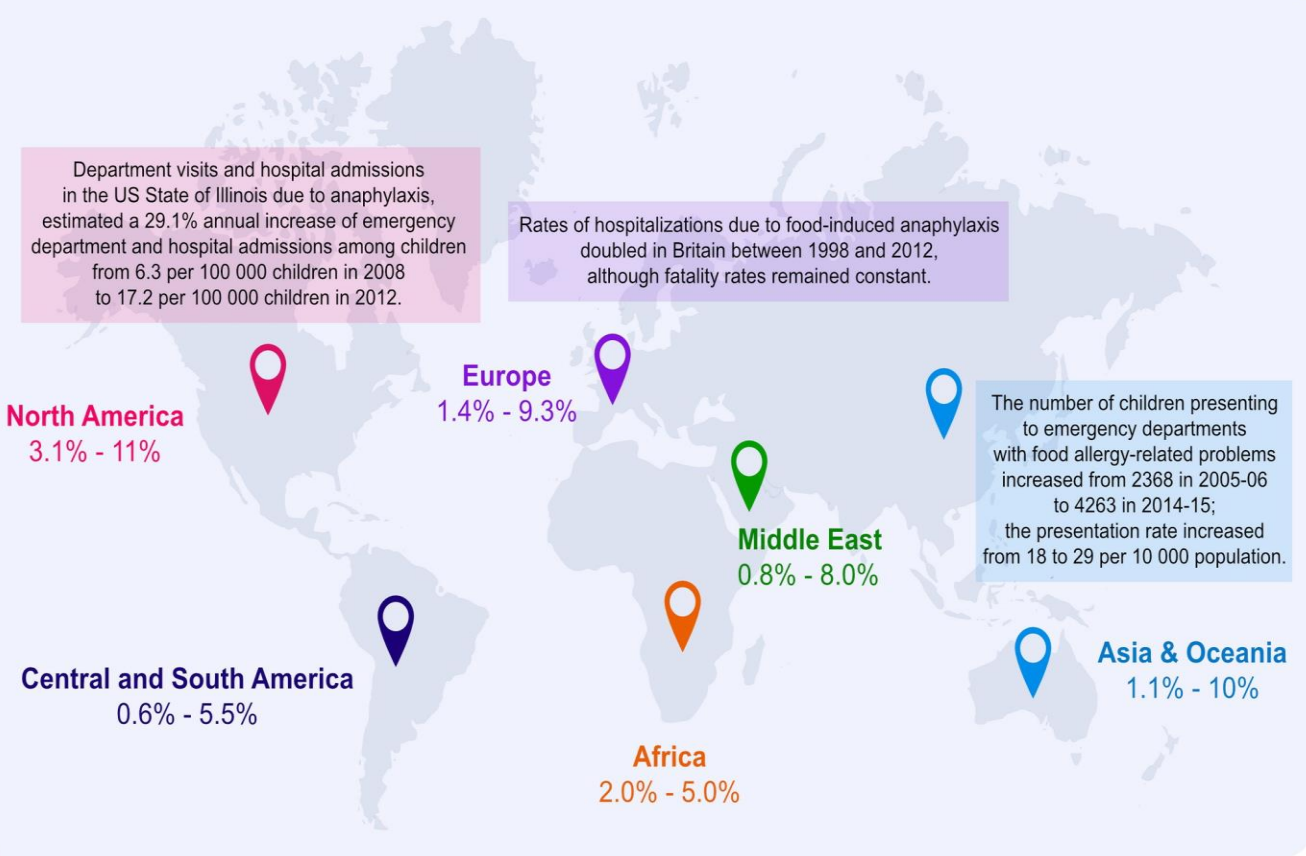
Initial activation is thought to occur through broken skin barrier, leading to Th2 allergy

Some proteins are associated with food allergy:

- shellfish
- milk
- egg
- connection with pollens (for ex/ fruit or nuts)
- tree nuts
- legumes
- seeds

(some are less frequent: for ex/ soy or almond)₃

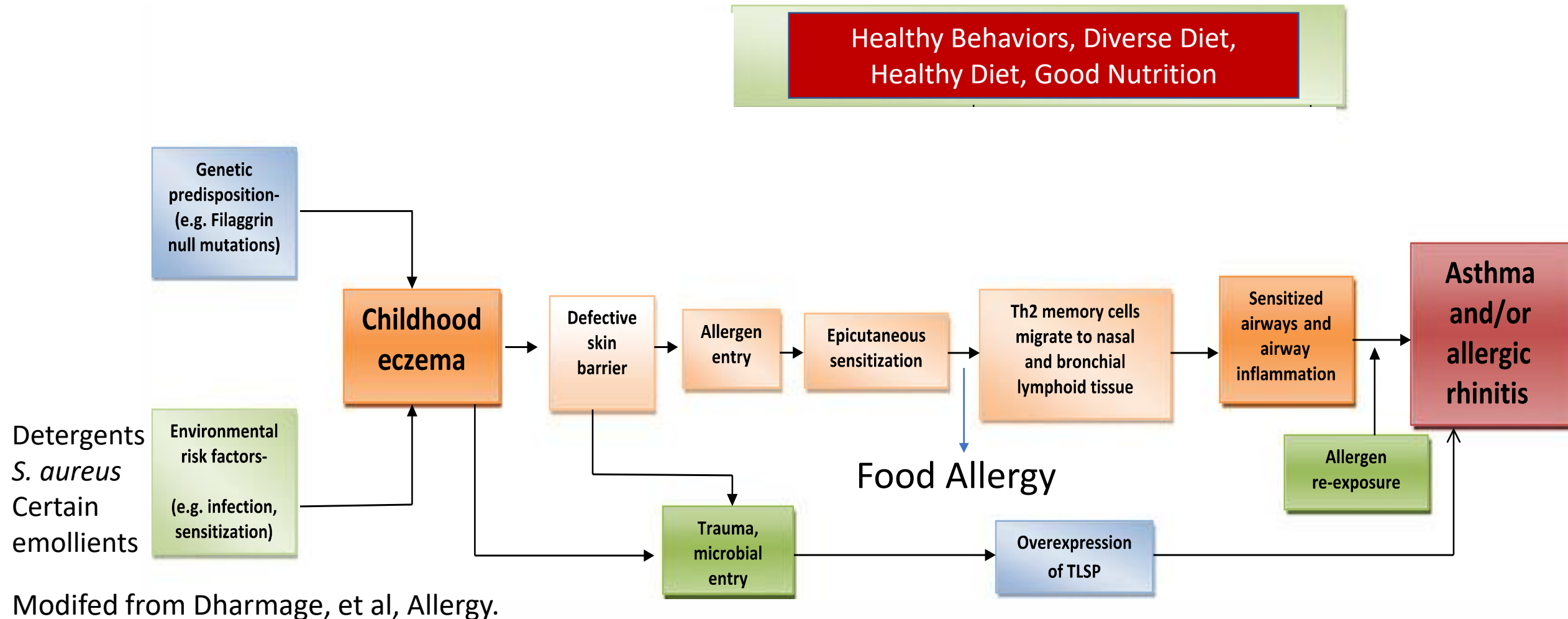
Epidemiology of Food Allergy



Warren and Gupta. Allergy. 2022 Oct;77(10): p. 2937-2948.

- Prevalence of food allergy varies globally. No epidemiological evidence to date suggests that plant-based diets have increased the risk of food allergy.
- Food allergy-associated hospitalization admission rates suggest that rates of FA has increased over the last few years

A proposed pathway to explain the atopic march from childhood eczema and the development of asthma and allergic rhinitis during the course of a lifespan



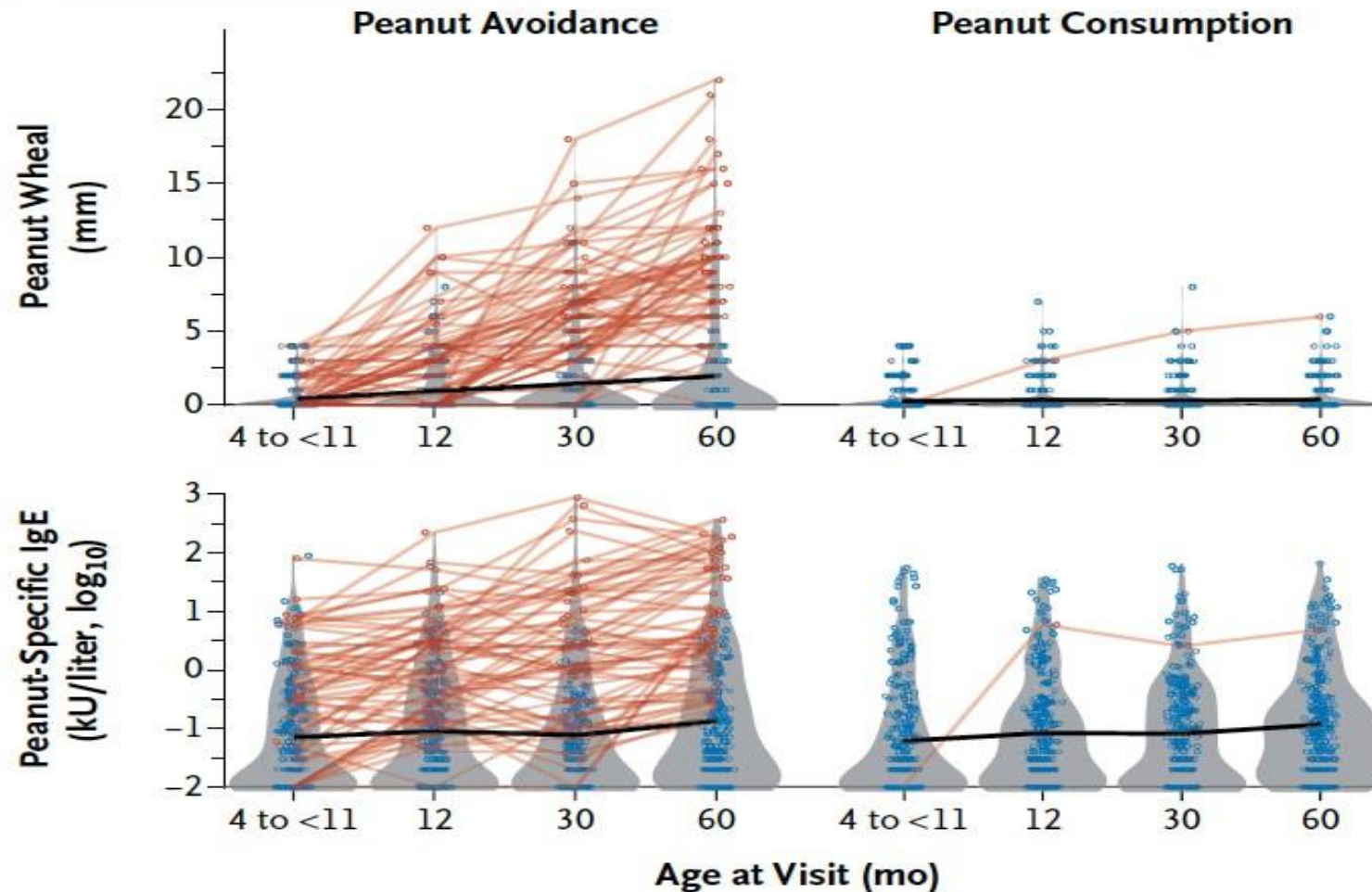
Brough HA, Nadeau KC, Sindher SB, Alkotob SS, Chan S, Bahnson H, Leung DYM, and Lack G. Allergy - Wiley. 2020.

With reference to: Bertelsen, et al. Allergy 2013. Savage, Matsui, Wood, Keet, JACI 2012. Tanzer, et al..Rothenberg, Oyoshi , PLoS. 2022

Nielsen, et al. Davis, Parsonnet, Boyd. Science Translational Medicine. 2019.

Tracking Prevention of Food Allergy

A Wheal Sizes and IgE Levels



In avoidance group:
Increase of specific IgE to peanut by 11% For each month of life during study

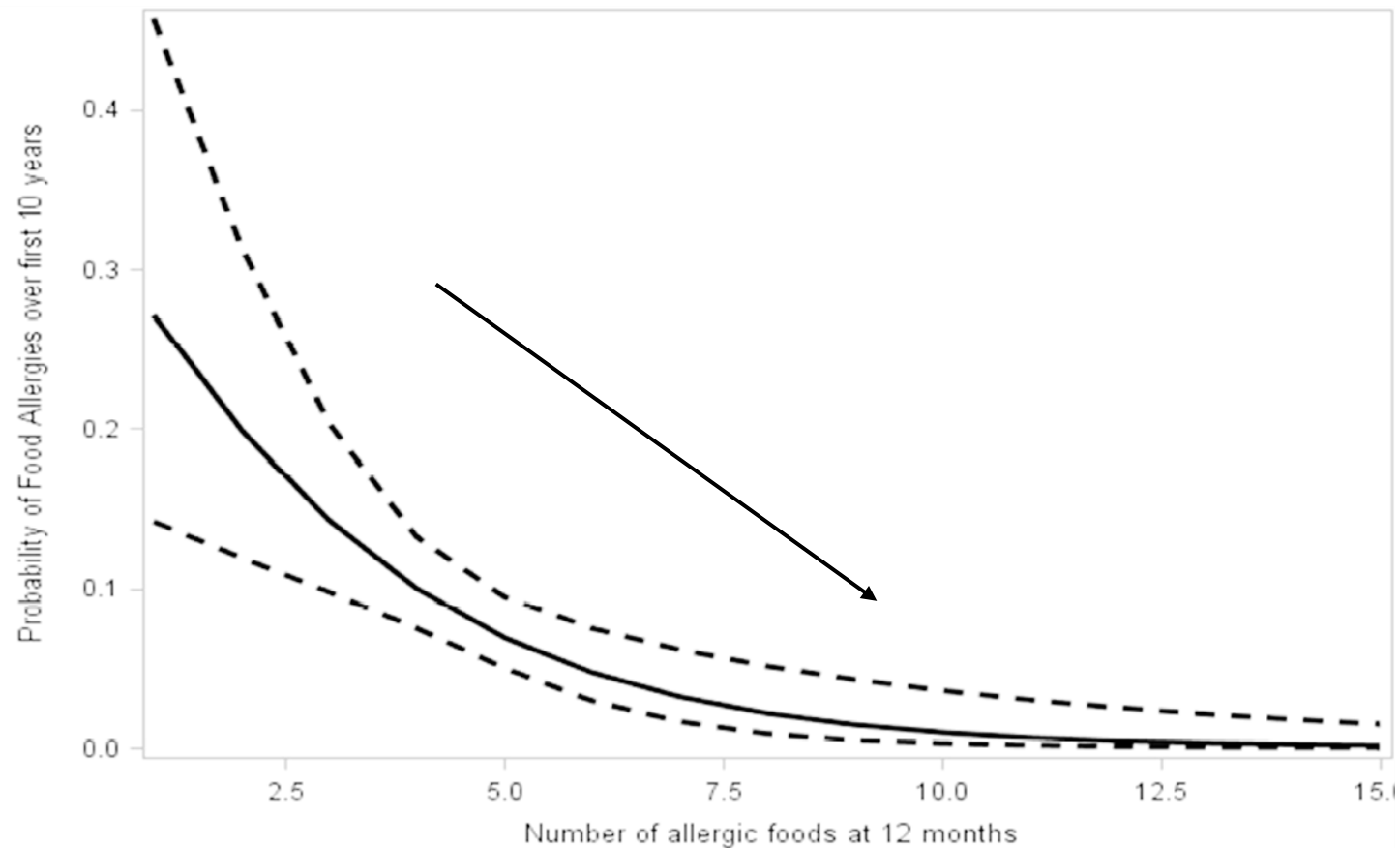
In consumption group:
No cross protection to egg

Multiple Food Allergen Approach-Diverse Diet

Different Measures of Dietary Diversity During Infancy and the Association With Childhood Food Allergy in a UK Birth Cohort Study

Multivariable Analysis

- 96% reduction in food allergies over the first 10 years of life with the consumption of 8 allergenic foods by 12 months of age*



*Adjusted for presence of eczema and age of introduction of solid foods

Ultra processed foods –possible association with increased risk of food allergy?

Note: Ultra-processed foods are made mostly from substances extracted from foods, such as fats, starches, added sugars, and hydrogenated fats. They may also contain additives like artificial colors and flavors or stabilizers. Examples of these foods are frozen meals, soft drinks, hot dogs and cold cuts, fast food, packaged cookies, cakes, and salty snacks.

Allergic symptoms such as asthma, eczema, and wheezing have been correlated with a poor diet and the excessive consumption of ultra-processed foods (UPFs).

It is hypothesized that UPFs contain more allergens than their less-processed counterparts.

> [Pediatr Allergy Immunol](#). 2018 Aug;29(5):504-511. doi: 10.1111/pai.12911. Epub 2018 May 29.

Associations of ultra-processed food and drink products with asthma and wheezing among Brazilian adolescents

B Melo ¹, L Rezende ², P Machado ³, N Gouveia ², R Levy ²

> [Thorax](#). 2017 Mar;72(3):206-212. doi: 10.1136/thoraxjnl-2016-208375. Epub 2016 Dec 20.

Cured meat intake is associated with worsening asthma symptoms

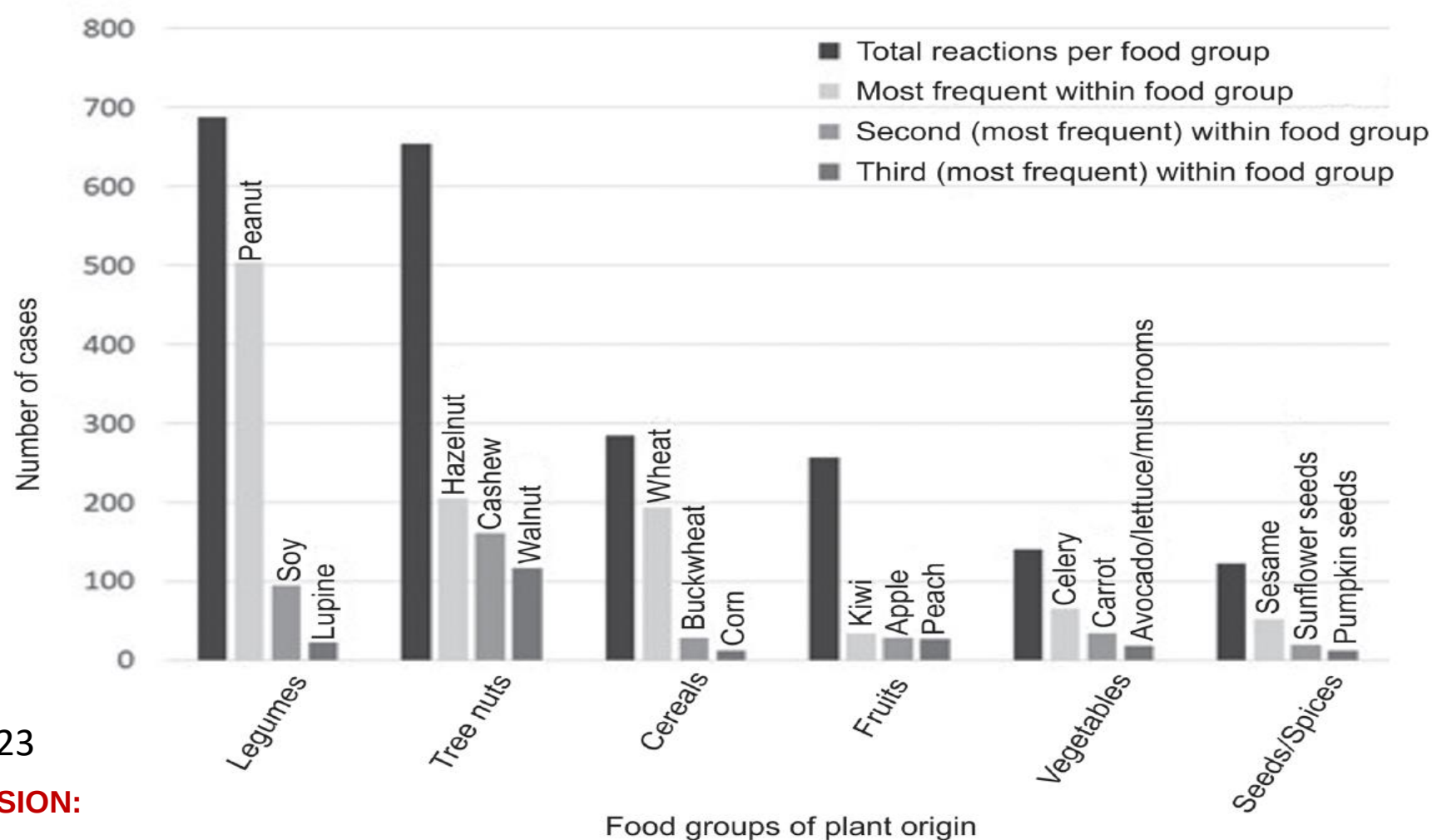
Sicherer S.H., Sampson H.A. Food Allergy: A Review and Update on Epidemiology, Pathogenesis, Diagnosis, Prevention, and Management. *J. Allergy Clin. Immunol.* 2018;141:41–58.

Vegan diets from an allergy point of view – Position paper of the DGAKI working group on food allergy

Imke Reese¹, Christiane Schäfer², Barbara Ballmer-Weber^{3 4}, Kirsten Beyer⁵, Sabine Dölle-Bierke⁶, Suzanne van Dullemen⁷, Uta Jappe^{8 9}, Sabine Müller¹⁰, Sabine Schnadt¹¹, Regina Treudler¹², Margitta Worm⁶

Food	Protein source and other ingredients	Special features
Plant-based drinks	Isolates from soy, pea, oats, rice, cashew, almond, hazelnut, coconut, hemp seeds	High risk due to short gastric residence time, insufficient denaturation, highest risk of anaphylactic reactions
Yogurt substitutes	Soy, peanut, oats, cashew, coconut, tapioca starch	Longer gastric residence time, less frequent anaphylactic reactions
Cheese substitutes	Isolates and concentrates from soy, lupine, pea, cashew	Longer gastric residence time, less frequent anaphylactic reactions
Egg substitutes	Soy, pea, white lupine, broad bean, aquafaba, linseed, banana, tapioca starch	Substitute for the functional properties of eggs in vegan cooking and baking
Spreads	Sunflower seeds, pumpkin seeds, lupine, lentil, hemp seeds	As an alternative to cream cheese or cold cuts
Meat substitutes	Isolates and concentrates from soy, pea	Highly concentrated protein
Fish substitutes	Isolates and concentrates from soy, wheat, mushrooms, algae	Highly concentrated protein, they also frequently contain additional <i>novel foods</i> to imitate the taste of fish
Other highly processed foods	Tofu, tempeh, seitan, miso	Less frequent anaphylactic reactions

The most frequent triggers or groups of triggers in confirmed anaphylaxis



Reese, et al. 2023

CONCLUSION:

- **Milk substitutes.** If the avoidance of cow's milk is necessary or aimed at, the consumption of calcium enriched soy drinks and calcium-enriched soy products as substitutes for cow's milk is recommended.
- From an allergological, gastroenterological, and immunological point of view, dietary patterns characterized by high food diversity and minimally processed foods are preferred.

Review

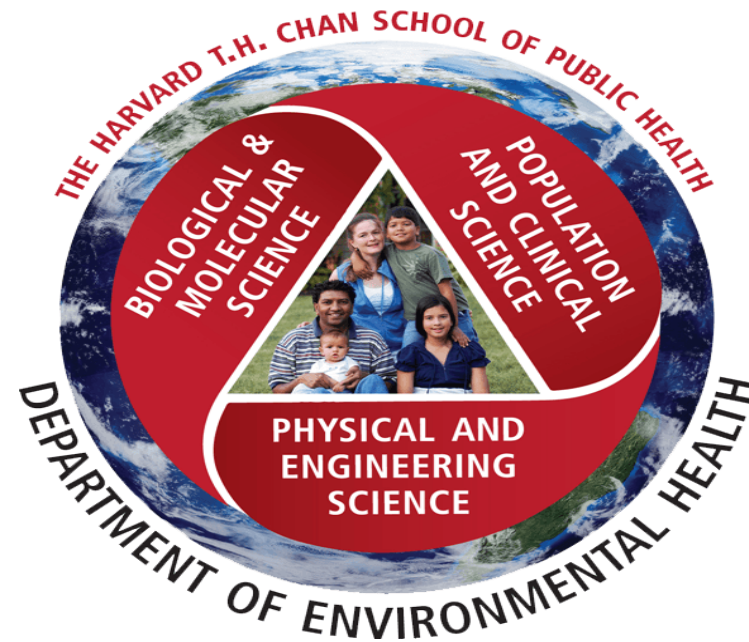
Early Introduction of Novel and Less-Studied Food Allergens in the Plant-Based Era: Considerations for US and EU Infant Formula Regulations

Carina Venter ^{1,*} , Raanan Shamir ²  and David Mark Fleischer ¹

- **Do fortified plant-based infant formulas, compliant with FDA regulations and EFSA (European) guidelines, support adequate infant growth?**
 - Plant-based formulas supplemented with amino acids and micronutrients to comply with FDA regulations and EFSA guidelines, evaluated in sufficiently powered growth studies, can support adequate growth in infants
- **Are plant-based infant formulas suitable for the management of cow's milk allergy (CMA)?**
 - *Currently available plant-based infant formulas are suitable for the management of CMA*
- **Does feeding with novel plant-based infant formulas increase the risk of food allergies to the food allergens they contain?**
 - An early introduction and continuous intake of food allergens are more likely to prevent food allergies than increase their risk
- **Does feeding infants plant-based food allergens in early life increase the risk of allergic and severe allergic reactions?**
 - Early introduction of food allergens in young infants is safe.

Thank you

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Back up

Nutritional values and selected allergenic structures of selected legumes and relevant nuts for estimation of possible risks for cross-reactive allergic reactions (*based on 100 g ready-to-eat final product*) according to Allergome

Food	Energy (kilocalories) [fat in g, carbohydrates in g, protein in g]	Important allergenic structures	Notes (focus allergy/food form)
Fenugreek <i>Trigonella foenum-graecum</i>	366 [6.4/48.3/23.0]	7S vicilin: Tri fg 1: 2S albumin: Tri fg 2 7S globulin: Tri fg 3 Bet v 1-like: Tri fg 4	No WHO/IUIS documentation yet Note: is increasingly used in usual spice quantities
Peanut <i>Arachis hypogaea</i>	599 [48.4/7.48/29.78]	7S vicilin: Ara h 1 + isoforms 2S albumin: Ara h 2/Ara h 6/Ara h 7 + isoforms	Peanut products are available in many variants (roasted, defatted, as flour, or as oil), resulting in significantly differing macronutrient contents.
Peanut roasted	630 [52.95/9.28/26.94]	11S globulin: Ara h 3	
Peanut flour defatted flour	349 [0.55/30.65/52.50]	Profilin: Ara h 5 Bet v 1-like: Ara h 8 + isoforms LTP: Ara h 9/Ara h 16/Ara h 17 + isoforms Oleosins: Ara h10/Ara h 11, Ara h 14/Ara h 15 + isoforms	
Peas, ripe-flour <i>Pisum sativum</i>	316 [1.51/44.0/24.1]	7S vicilin: Pis s 1 + isoforms 7S vicilin/Convicilin + isoform: Pis s 2 LTP + isoform: Pis s 3 Profilin: Pis s 5 Bet v 1-like: Pis s 6	Pis 1 and Pis 2 – together with isoforms probably the main allergens
Chickpea, dried <i>Cicer arietinum</i>	337 [5.9/44.0/19.0]	7S vicilin: Cic a 1 2S albumin: Cic a 2S ilbumin LTP: Cic a 3 11S globulin: Cic a 6	Chickpea flour contains 20% protein, twice as much as wheat flour
Lentil, dried ripe <i>Lens culinaris</i>	307 [(1.6/40.5/23.4)]	7S vicilin: Len c 1 + three isoforms LTP: Len c 3 + isoform No 2S albumin or Bet v 1 homolog described so far	
Lupine, grist <i>Lupinus species</i>	356 [8.7/13.0/43.0]	7S vicilin: Lup a 1/Lup an 1 major allergen, cross-reaction between peanut and lupine. LTP: Lup an 3 + isoform Bet v 1-like: Lup a 4 Profilin: Lup a 5 + isoform 2S albumin: Lup an delta conglutin	Based on the sequence homologies of lupine products, a similar allergenic potency for birch pollen allergen can be assumed for patients as with soybean
Soybean, dried <i>Glycine maxima</i>	386 [18.3/6.3/38.2]	Hydrophobic protein: Gly m 1 Defensin: Gly m 2 Profilin: Gly m 3 + isoforms Bet v 1-like: Gly m 4 + isoform 7S vicilin: Gly m 5 + isoforms 11S globulin: Gly m 6 + isoforms Seed biotinylated protein: Gly m 7 2S albumin: Gly m 8	Soy products are available in many variants (roasted, defatted, as flour, or as oil), resulting in significantly differing macronutrient contents.
Soybean, roasted	431 [24.0/6.1/50.0]		
Soy protein (TVP)	291 [1.5/7.0/50.0]		

Nutritional information is based on the German Federal Food Code 3.02 [12] and is part of the Prodi/Optidiet nutrition software. TVP = textured vegetable protein.

Food	Energy (kilocalories) [fat in g, carbohydrates in g, protein in g]	Important allergenic structures	Notes (focus allergy/food form)
Cashews <i>Anacardium occidentale</i>	590 [42.2/30.5/20.6]	7S globulin: Ana o 1 , 11S gGlobulin: Ana o 2 2S albumin: Ana o 3 (f443, major allergen),	Basic ingredient for cashew processing (for example, cheese alternatives, drinks, and snacks).
Cashew flour, de-oiled <i>Anacardium occidentale</i>	356 [2.0/41.8/39.6]	Bet v 1-like isoform	
Hazelnut, natural <i>Corylus avellana</i>	664 [63.3/6.0/16.3]	PR-10: Cor a 1 and additional 10 isoforms Profilin: Cor a 2 + 2 isoforms	37 known allergen structures, of which 12 are documented at WHO/IUIS, but 2 are inhalant allergens. Various isoforms are known.
Hazelnut, roasted <i>Corylus avellana</i>	685 [(6.7/5.4/14.8)]	LTP: Cor a 8 + isoform 11S globulin: Cor a 9 + isoform 7S vicilin: Cor a 11 + isoform 2S albumin: Cor a 14 + isoform 7S globulin: Cor a 16	

Nutritional values and selected allergenic structures of selected relevant seeds, oilseeds, and wheat for estimation of possible risks for cross-reactive allergic reactions (*based on 100 g ready-to-eat final product*) according to Allergome

Food	Energy (kilocalories) [fat in g, carbohydrates in g, protein in g]	Important allergenic structures	Notes (focus allergy/food form)
Psyllium <i>Plantago ovata</i>	271 [7.0/3.5/16.0]	Pla o without further characterization	Note the significantly different nutrient profile compared to psyllium husks.
Psyllium husks <i>Plantago ovata</i>	222 [0.7/12.0/2.3]		
Hemp seeds, shelled <i>Cannabis sativa</i>	611 [48.0/16.0/25.0]	Profilin: Can s 2 (identified as an aeroallergen) LTP: Can s 3 + isoform (identified as an aeroallergen, not a food allergen). Can s 4: Oxygen Evolving Enhancer Protein 2 (identified as an aeroallergen). Can s 5: Bet v 1-like (identified as an aeroallergen)	Hemp seeds should preferably be used shelled. Unprocessed and unshelled hemp seeds must be pre-processed by heat to avoid the antinutritive substances.
Hemp seeds, unshelled <i>Cannabis sativa</i>	461 [32.0/2.2/21.0]		
Hemp seeds, roasted <i>Cannabis sativa</i>	560 [44.0/12.0/33.0]		
Linseed, whole <i>Linum usitatissimum</i>	498 [37.0/7.7/22.0]	2S albumin: Lin u 1	Observe EU Regulation on consumption restriction
Sesame, raw <i>Sesamum indicum</i> ; Synonym (old): <i>Sesamum orientale</i>	593 [50.4/10.2/50.4]	2S albumins: Ses i 1 + isoform, Ses i 2 + isoform, 7S vicilin: Ses i 3 + Isoform Oleosins: Ses i 4, Ses i 5 + isoforms 11S globulin: Ses i 6 + isoform 11S globulin: Ses i 7 + isoform	

Food	Energy (kilocalories) [fat in g, carbohydrates in g, protein in g]	Important allergenic structures	Notes (focus allergy/food form)
Wheat grain <i>Triticum aestivum</i>	301 [1.8/59.6/11.7]	Profilin: Tri a 12 and isoforms LTP: Tri a 14 + isoforms Omega 5 gliadin: Tri a 19	Over 100 described allergen structures (including amylase inhibitors, gliadins, glutenins, serine protease inhibitors, thiol reductases); 15/28 allergens already documented at WHO/ IUIS as food allergens.
Gluten	395 [4.0/7.0/81.0]		
Seitan (<i>Triticum aestivum</i>)	115 [1.7/1.8/22.4]		

Reese, et al. 2023