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Genetic modification technology for nutrition and improving diets: an ethical perspective

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Genetically modified (GM) techniques to improve the nutrition and health content of foods is a highly debated area riddled with ethical dilemmas. Assessing GM technology with a public health ethical framework, this paper identifies public health goals, the potential burdens of the technology, and areas to consider for minimizing burdens and ensuring beneficence, autonomy, and little infringements on justice. Both policymakers and food producers should acknowledge local food environments and the agricultural context of each community in order to effectively prepare communication strategies and equitably distribute any proposed GM food intervention.

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Introduction

Agricultural production increasingly involves modern technology in order to meet growing quantity and quality global food demands [1]. One such form of new production is biofortification, or the process by which the nutritional quality of food crops is improved by adding nutrients or other health promoting properties through agronomic practices, conventional plant breeding, or modern biotechnology such as genetic modification [2,3]. Genetically modified (GM) foods with an increased micronutrient level, one type of biofortification, are foods whose genetic composition is altered in a way that does not occur spontaneously in nature. As a result, GM foods have sparked intractable debates in recent decades.

Many ethical issues arise with the production, use and consumption of GM technology when applied to foods [4••]. Beyond eating a diverse diet to deliver quality nutrients, should GM technology be used as a public health strategy to improve nutrition? Is the approach sustainable? What are the known and unknown health risks in both producing and consuming such crops, and do they outweigh potential nutritional benefits? What information should consumers expect to receive if they eat GM crops? What are the long-term social and economic costs and trade-offs of GM technology?

This paper draws on significant empirical evidence from the literature to try and answer these questions. In particular, the 'Ethics Framework for Public Health,' developed by Kass [5], serves as a tool to help stakeholders consider the ethical implications of programs with public health goals, such as GM foods in some circumstances. The use of Kass' framework (Figure 1) is not intended to answer all the ethical questions that may arise with GM technology, as its evidence base continues to evolve. Because public health promotes and protects health through social approaches, GM technology and its aims to improve population wellbeing warrant a careful analysis of ethical implications.

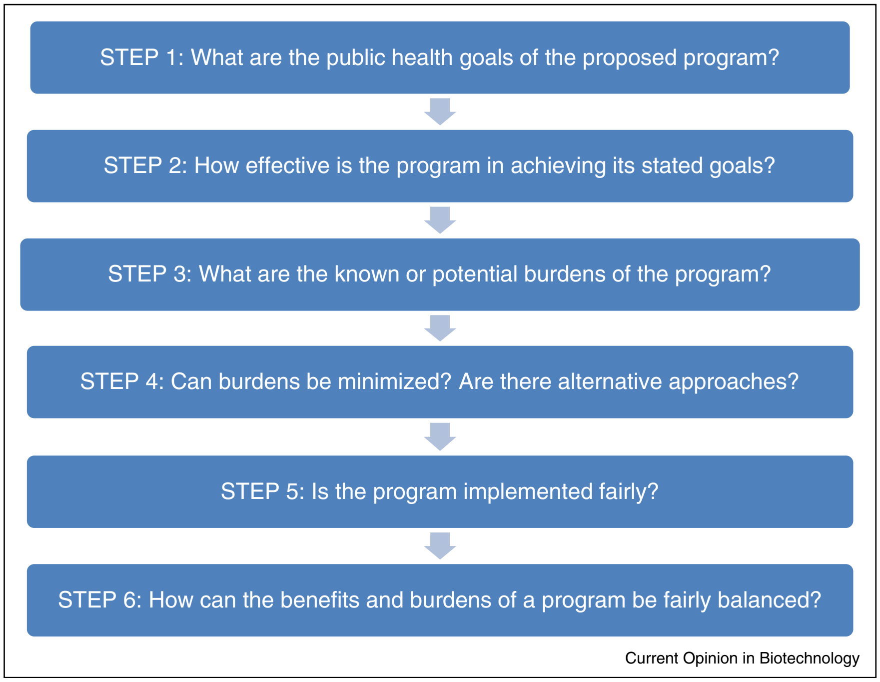
What are the public health goals of GM technology and are they being met?

Second generation GM crops are those which are bred to improve quality traits such as nutritional quality or processing traits. Alternatively, first generation GM crops are farmer-oriented, and aim to improve agronomic (quantity) traits. One goal of second generation GM crops is to address micronutrient deficiencies in rural populations. Most commonly, staple crops are bred to increase the nutritional content of Vitamin A, zinc, and iron. Golden Rice is one such example, described in Box 1.

It is important to note other second generation GM crops, which reflect public health goals that are different from biofortified crops or first generation GM crops: they aim to either increase consumption and reduce food waste or promote health/prevent disease (Table 1). Crops bred with sensory properties increase certain characteristics, such as taste, texture, or aesthetic appeal which can contribute to reducing food waste — an area of growing concern in food security and public health.

GM crops bred with quality traits to either promote health or prevent disease are also known as 'designer crops' [6•].

Figure 1



Ethics framework for public health. Source: Kass (2001).

One example on the market in the United States is Plenish® a high oleic soybean that has zero *trans* fat with a high amount of monounsaturated fat. As a public health measure that ultimately gave such crops as Plenish® more market potential, the Food and Drug Administration (FDA) issued a rule in 2006 that required all food production companies to display *trans* fat content in packaged foods on the Nutrition Facts label [7]. This regulatory change has raised consumer awareness and demand for reduced *trans* fat products.

Box 1 The complications of Golden Rice

Golden Rice is one example of a GM crop which was developed to produce beta-carotene, a precursor of vitamin A, in the grain of rice (Golden Rice Project, URL: http://Goldenrice.org). Ex ante studies have shown that Golden Rice can be a cost-effective strategy to achieve a public health goal–alleviating vitamin A deficiency (VAD) [25,27]. Although Golden Rice was initially developed over a decade ago, a complex regulatory framework for GM crops has significantly bottlenecked public rollout [28–30]. Agronomic properties, such as yield potential, and the opposition to GM technology itself, are two main constraints [21••]. During the period in which Golden Rice has been in the R&D stage, other public health initiatives in the Philippines have helped to decrease the prevalence of VAD in the country, with rates falling from 40.1% in 2003 to 15.2% in 2008 [21••]. Strong public ethical opposition to the technology reflects delays in research and implementation as seen in 2013 when activist organizations destroyed Golden Rice field trials in the Philippines [31]. In 2002, the Philippines was the first country in Asia to approve GM commercial crop cultivation. As of October 2016, Golden Rice is still awaiting release.

GM technology is also a tool to help address food security [8]. In some cases, first generation crops such as Bt eggplant are projected to increase income generation by improving yields and decreasing the necessity to invest in costly insecticides [9]. This can have potential indirect benefits on nutrition if additional income garnered from this 1st generation crop is spent on nutrition-direct interventions. An additional step in the consideration of GM as an ethical production technique reflects the fact that many of these crops were developed to provide global health *beneficence* by decreasing health disparities, particularly for the more vulnerable populations [4••,10]. Many crops bred for nutritional (quality) traits are still in the research and development (R&D) phase [11•], so assessing success in achieving the desired public health goal has yet to be determined. Delineating the public health goals of GM crops inform other ethical points of the framework and enhance the argument that GM technology should be assessed on a case-by-case basis. De Steur *et al.*, in this issue, provides insight on this claim by offering *ex ante* assessments on cost-effectiveness and the potential efficacy of GM [12,13].

What are the known or potential health burdens of GM technology?

Maleficence, or inflecting harm, is a potential burden of any new food production technique. Maleficence is of heightened concern with GM technology, particularly because research has yet to determine the extent to adverse