frontiers FOR YOUNG MINDS

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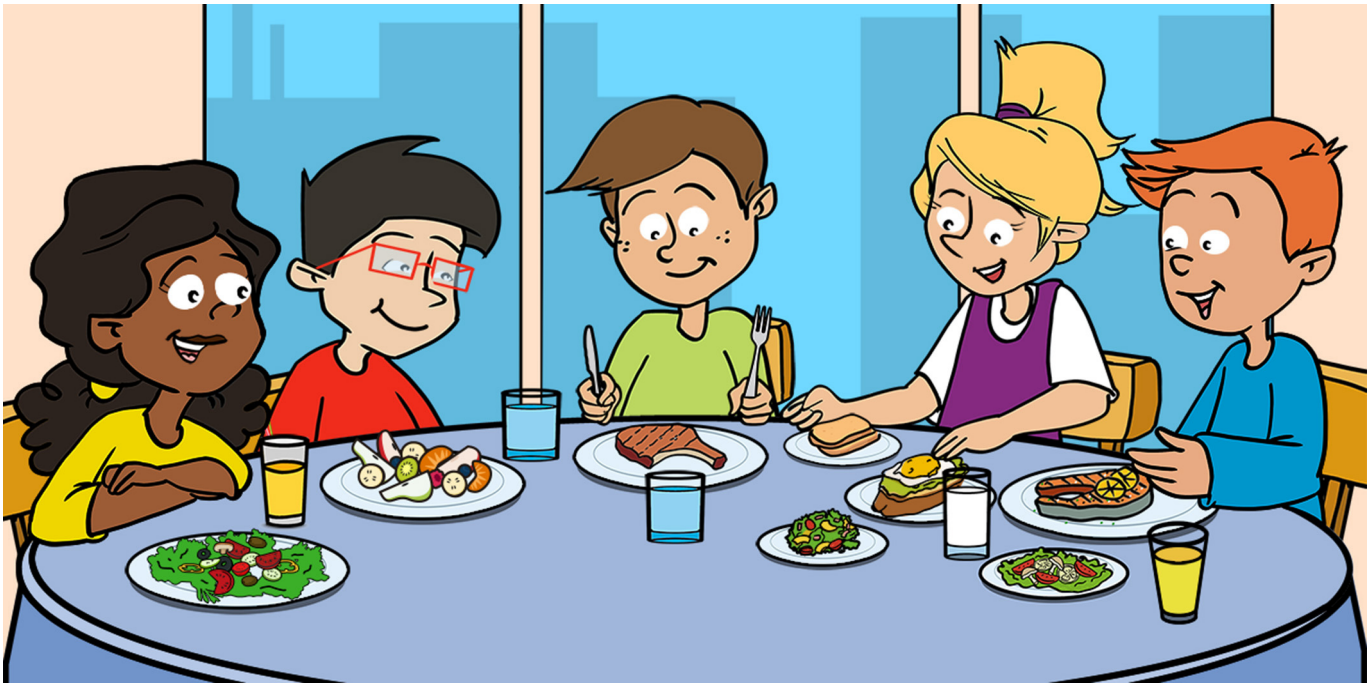

CAN PERSONALIZED NUTRITION IMPROVE PEOPLE'S DIETS?

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YOUNG REVIEWERS:

ETHAN
AGE: 15

SOPHIA
AGE: 13

Each person differs in physical characteristics such as eye color, but also in likes and dislikes. These differences are due to our genes and our environments, including what we eat. What we eat affects our health, and each of us has individual nutritional needs. This is the basis for the idea of personalized nutrition. In our research study, called the Food4Me Study, we tested whether personalized nutrition advice helped over 1,600 people to eat healthier diets. We collected information about each person, including what they ate, and we collected samples of saliva to examine their genes. We gave each person either the usual advice about healthy eating (such as "eat more vegetables") or advice that was personalized based on the individual's characteristics. After 6 months, we discovered that people who received personalized nutrition advice improved their diets more than people who received the typical healthy eating advice.

WHY WE ARE ALL DIFFERENT

Each of us is different. Some people are tall while some are short, some have brown eyes and others blue eyes. We also differ in our likes and dislikes. These individual characteristics make up what is called our **phenotype**, and our phenotypes help to make us the individuals that we are. Differences between individuals are due to a combination of genes and environment, including what people eat. Each of us has small but noticeable differences in our **genes**. The overall pattern of these gene variations is called our **genotype**. For example, height is influenced by hundreds of genes, but is also influenced by what we eat. In general, people are taller when they have been well-nourished at every stage of their development, starting in the womb through their late teens or early twenties, when most people reach their adult heights.

PHENOTYPE

The characteristics of each person including e.g., height, eye color, and behaviors.

GENES

A piece of DNA that provides the information to make a protein. Each of us has more than 20,000 different genes.

GENOTYPE

Small gene variations that are specific to each person.

Identical twins share the same genotype because they come from the same fertilized egg. However, although they have the same exact genes, identical twins are not completely identical. Do you have any friends who are identical twins? If so, can you tell who is who? Twin pairs tend to become less alike as they get older—and not just because they choose to wear different clothes or to style their hair differently! The differences are the result of interactions between each twin's environment (including what they eat) and their genotype, and this combination influences their phenotype.

PERSONALIZED NUTRITION: DO WE ALL NEED TO EAT THE SAME FOODS TO BE HEALTHY?

The ability to eat a wide variety of foods is one of the reasons why humans have been so successful as a species. What we eat affects how well we grow and develop and, of course, our health. Based on the foods that can be grown or found locally, traditional cuisines differ considerably in different parts of the world. So, it seems that people can be healthy without eating the same foods. However, each of us has our own specific nutritional needs because of our genotypes and other individual characteristics. So, some of us would benefit from eating more (or less) of certain foods.

Most of us eat too many sugary, salty, and fatty foods. We would be healthier if we changed what we eat. Although health experts give us excellent advice on healthy eating patterns, this general advice has not been very effective in helping people change their eating behaviors. **Personalized nutrition** is designed to provide dietary advice based on each individual's characteristics [1]. Because it is specific to each individual, we thought that maybe personalized nutrition advice would help people to make appropriate changes to their diets. For example, the genotype of some people indicates that they are

PERSONALIZED NUTRITION

Information about an individual that is used to provide dietary advice specific to that person.

especially sensitive to eating a lot of salt. These people might benefit more from cutting down on salt than other people would. Others might benefit from making certain dietary changes to help them to keep a healthy body weight.

With help from a team of colleagues in several European countries, we set out to test our personalized nutrition idea in a project called the Food4Me Study. In this study, we wanted to find answers to three main questions. First, we wondered whether personalized nutrition is more effective than the usual "one-size-fits-all" dietary advice, when it comes to helping people improve what they eat. We also asked about the best way to develop personalized nutrition advice. Last, we asked whether the internet would be a good method for delivering personalized nutrition advice to lots of people.

OUR DIETARY STUDY

DIETARY STUDY

A special kind of experiment in which researchers investigate how what we eat affects our health and wellbeing.

To answer these questions, we ran a big **dietary study** involving more than 1,600 adults from seven European countries (Figure 1). How did we get enough people to join the Food4Me Study without creating a huge amount of work for the research team? We used the internet! We used posters, radio advertisements, and interviews with senior scientists to encourage people to go to the Food4Me website if they were interested in joining the study. Interested people were asked to fill in online questionnaires to provide information about themselves. We used their answers to identify those people who were suitable for the study [2].

RANDOM ALLOCATION

A process by which people are assigned to experimental groups so that, on average, each group is similar at the start of the experiment.

INTERVENTION

A deliberate change in people's diet to help answer a scientific question.

Next, we placed the participants randomly in one of four groups, in a process called **random allocation**. Random allocation ensured that the people in each group were very similar at the start of the study. Each group was given a different dietary treatment (our **intervention**). People in the control group (group 0) were given the usual healthy-eating advice, for example to eat at least five portions of fruits and vegetables each day. People in groups 1–3 were all given personalized nutrition advice. However, the information used to create the personalized nutrition advice differed for each of these groups. For group 1, we based the advice on an analysis of what each individual ate at the start of the study. For group 2, we used their starting eating pattern plus information on their body measurements, such as waist circumference and blood test results. Finally, for group 3, we based the advice not only on what they ate at the start of the study and their phenotype, but also on their genotype, which we assessed by looking at their saliva. We gave personalized advice based on five genotypes that are known to influence the links between what people eat and their health. For example, we looked at a certain genotype of the gene used to produce a protein called **apolipoprotein E**, which gives people a greater risk of developing heart disease and dementia. People with this genotype would benefit from eating less

APOLIPOPROTEIN E

A blood protein that helps transport cholesterol and other fats. A variant of the gene for apolipoprotein E gives some people a greater risk of developing heart disease and dementia.

Figure 1

Over 1,600 individuals from seven European countries were included in the Food4Me Study.

Figure 1

saturated fat, the "unhealthy" fat found in high amounts in foods like sausages and cakes. For each person in groups 1–3, we provided personalized advice designed to help them make dietary changes that were directly relevant to them and that would hopefully improve their long-term health.

To find out whether people in personalized nutrition groups 1– 3 made bigger improvements in their diets than those in group 0, we collected information on what each person ate at the start of the study, and again 6 months later. Study participants helped us with this by filling in detailed food-frequency questionnaires on the Food4Me website. These questionnaires asked them how often they ate over 150 different common foods and drinks, such as fruits and vegetables, cheese, yogurt, and fizzy drinks, and how much of each these foods they ate. We could then then determine whether our advice helped people improve their diets by eating more healthy foods and less unhealthy foods. The data participants provided was analyzed automatically by computer, which saved a huge amount of time and effort compared with paper forms [2].

WHAT DID WE DISCOVER IN THE FOOD4ME STUDY?

At the end of the Food4Me Study, we found that our participants' eating habits improved, which was good news. However, there were bigger improvements for people in groups 1–3 than in group 0. The improvements were similar in groups 1, 2, and 3, which told us that the specific dietary information given to each group was not as

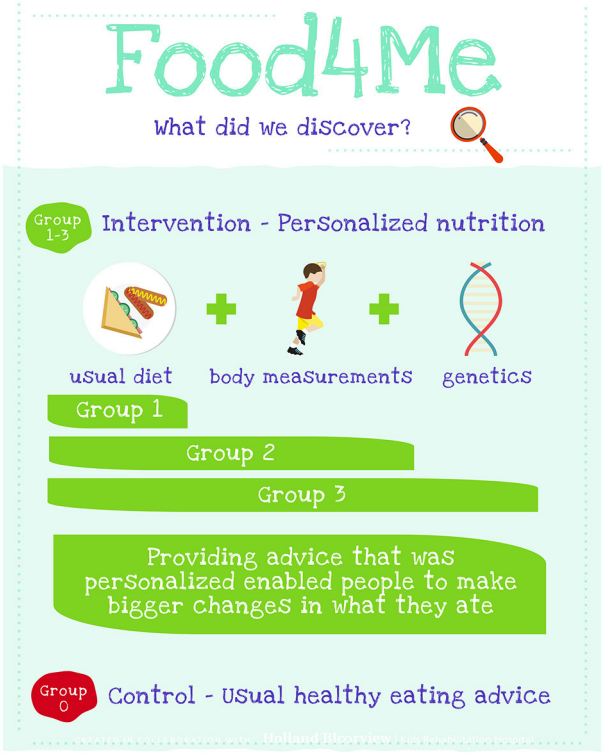

Figure 2

Summary of discoveries in the Food4Me Study. Our intervention made deliberate changes to dietary advice to see if it improved eating habits. The personalized advice given to Group 1 was based on each participant's diet at the start of the study; Group 2 was based on their diet and their phenotype, and Group 3 was based on their diet, phenotype and genotype. These three groups were compared with the control group, which was given general advice on healthy eating.

important as the fact that the advice was *personalized* [3]. Personalized dietary advice helped people to make bigger dietary changes than when the advice was not personalized (Figure 2). The Food4Me Study also showed that it was very practical to use the internet to deliver personalized nutrition advice to lots of people who lived in different countries [3].

COULD PERSONALIZED NUTRITION IMPROVE EVERYONE'S HEALTH?

What we eat really matters. Alongside being physically active and not smoking, healthy eating habits are one of the most important ways to stay healthy throughout our entire lives. However, most people ignore healthy eating advice. This can eventually lead to a wide range of health problems, such as obesity, heart disease, and diabetes. Could we use what we have discovered in the Food4Me Study to improve *everyone's* eating habits and help all people stay healthy? Well, it is clear that personalized nutrition advice helped people to make bigger improvements in their diets than non-personalized advice did [3], and other studies have discovered this, too [4].

Although Food4Me was a rather large study involving more than 1,600 people in seven European countries, to improve the health of *everyone* in Europe, we would need to deliver personalized nutrition

advice to hundreds of millions of people! This is an enormous challenge, because we would need to collect and analyse genotypes and dietary information for each person in the population. However, in the Food4Me Study, we developed computerized systems called **algorithms** that make it much easier to make personalized nutrition advice available to everyone. We have seen that people across Europe are keen to use personalized nutrition advice and that they are happy to use the internet to get this information. The next big challenge is to scale up the Food4Me approach and test it on many more people, to see if it can potentially help us all develop healthier eating habits.

ALGORITHMS

A set of rules used by a computer used to carry out calculations or to solve complex problems.

ORIGINAL SOURCE ARTICLE

Celis-Morales, C., Livingstone, K. M., Marsaux, C. F. M., Macready, A. L., Fallaize, R., O'Donovan, C. B., et al. 2016. Effect of personalized nutrition on health-related behaviour change: evidence from the Food4Me European randomized controlled trial. *Int. J. Epidemiol.* 46:578–88. doi: 10.1093/ije/dyw186

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

ETHAN, AGE: 15
Hi! my name is Ethan. At my regional science fair, I won Best Junior Project, Best Biology Project, Gold Medal, and a qualification to the Canada-Wide Science Fair, where I achieved a bronze medal. I have also been a finalist at the InspoScience Canada IRIC. Besides, I enjoy debating, having won the title of national champion and second speaker this past year, and public speaking. I am an avid writer, being published for my poems, short stories, and argumentative articles.

SOPHIA, AGE: 13
My name is Sophia, I am 13 years old. I live am Brazilian and love to play with my friends and watch videos on the internet.

AUTHORS

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Katherine M. Livingstone is a senior research fellow in the Institute for Physical Activity and Nutrition at Deakin University in Australia. She completed her Ph.D. in nutrition at the University of Reading in the UK. Katherine leads personalized nutrition research to improve the diets of adults. She is passionate about understanding how our biology and behaviors influence our food choices and our health, so that we can design more effective dietary interventions and healthy-eating policies. Katherine's research was funded by a National Health and Medical Research Council Investigator Grant.

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John C. Mathers is Professor of Human Nutrition at Newcastle University in the UK. In addition to teaching students about nutrition and health, he carries out research on nutrition and aging and on the risk of age-related diseases. He was one of the founding members of NuGO—the European Nutrigenomics Organization—that has pioneered the use of modern molecular methods for studying how what we eat affects our health. John is also interested in finding better ways, such as using digital and personalized approaches, to help people eat better diets and to improve their health. *john.mathers@newcastle.ac.uk