Amerta Nutrition
e-ISSN: 2580-1163 (Online)
p-ISSN: 2580-9776 (Print)
Zulfa et al. | Amerta Nutrition Vol. 7 Issue 2SP (December 2023). 283-292

RESEARCH STUDY
English Version
OPEN ACCESS

Exploring Knowledge of Gene-Based Nutrition Services among Indonesian Nutritionists

Gambaran Pengetahuan Ahli Gizi tentang Pelayanan Gizi Berbasis Gen di Indonesia

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ARTICLE INFO

Received: *29-08-2023*
Accepted: *31-12-2023*
Published online: *31-12-2023*

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DOI:
10.20473/amnt.v7i2SP.2023.283-292

Available online at:
https://e-journal.unair.ac.id/AMNT

Keywords:
Nutritionist, Nutritional genomics, Gene-based nutrition services, Knowledge

ABSTRACT

Background: Individuals possess unique genes that influence their susceptibility to diseases and their response to dietary interventions. The emergence of nutritional genomics has made it possible to identify disease predispositions and mitigate risks through gene-based dietary guidance. Consequently, understanding gene-based nutrition services is crucial for nutritionists, as it facilitates the integration of genetic insights into dietary recommendations.
Objectives: This study aims to evaluate the familiarity of dietitians in Indonesia with gene-based nutrition services.
Methods: Employing a qualitative approach with a phenomenological orientation, this study was conducted in DKI Jakarta, Jawa Barat, Jawa Tengah, Jawa Timur, and DI Yogyakarta. Purposive sampling was employed, involving a total of seven nutritionists. Data were gathered through in-depth interviews conducted both in person and online via Zoom meetings. Thematic analysis was carried out utilizing Nvivo 12.0.
Results: The knowledge of nutritionists regarding nutritional genomics is limited. While they could explain fundamental concepts, their understanding lacked depth. Similarly, their comprehension of gene-based nutrition services was restricted, leading to uncertainties about their role in such services. Nutritionists generally expressed positive attitudes towards gene-based nutrition services, recognizing their significance and advocating for their provision by relevant agencies. There was a strong interest among nutritionists in offering gene-based nutrition services and a willingness to expand their understanding of nutritional genomics.
Conclusions: The knowledge of nutritionists regarding gene-based nutrition services remains insufficient. There is a need for nutritionists to undergo training, attend seminars, and enhance their understanding of nutritional genomics in academic settings.

INTRODUCTION

The nutritional genomics field, especially the prevention and treatment of degenerative diseases has increasingly developed over the last two decades[1–5]. Nutritional genomics is a science that studies gene responses to food or diet for early identification of possible changes in food intake. Nutritional genomics is divided into two scientific disciplines, namely Nutrigenomics and Nutrigenetics[6]. The application of nutritional genomics has been supported by technology. This can help health workers accurately predict the risk of Non-Communicable Diseases (NCDs) and provide nutritional recommendations in accordance with individual genetic variations for early disease prevention[7–9]. In Indonesia, nutritional genomics is a new science and it needs to be developed.

Nutritionists need to understand nutritional genomics as it provides information regarding how nutrition and genotype interact with phenotype[5]. Increasing knowledge about gene-based nutrition regarding diet and lifestyle choices is expected to change the level of susceptibility to disease and increase an individual's health[10]. The development of nutritional genomics significantly affects disease prevention and control. Thus, nutritionists need to apply and integrate nutritional genomics into their practice[11]. However, the implementation of gene-based nutrition services is low[12-13]. The development of gene-based nutrition services in Indonesia faces some challenges such as low trust in genetic technology, lack of knowledge about the role of genetics in chronic disease, and concerns about Direct-To-Consumer (DTC) testing related to the ethics of

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genetic testing, test reliability, scientific validity, clinical utility, and efficacy of this new technology[13].

The main challenge in gene-based nutrition services is limited knowledge and confidence about genetics and nutritional genomics[11]. A study concerning genetics and nutrigenomics conducted in the United Kingdom (UK) reported low levels of knowledge (mean knowledge score 56.3%), low engagement (mean number of activities taken 20.0%– 22.7%) and low trust (mean trust score 25.8%–29.7%)[11]. Another study at Ankara Hospital, Turkey revealed that the majority of nutritionists did not have adequate knowledge of nutrigenetics[14]. Moreover, other studies reported that nutritionists still need to develop their skills and knowledge in genetics and diet-gene interactions to better implement nutritional genomics in their practices[15]. In Indonesia, the implementation of nutritional genomics science has been adapted to the existence of a genetic examination service for individuals following a diet that suits their health condition as offered by some companies such as Prodia, Kalbe, Nalagenetics, and Cordlife[16]. However, studies concerning the knowledge and roles or involvement of nutritionists regarding nutritional genomics or gene-based nutritional services in Indonesia have not been available so far.

Studies concerning nutritionists' knowledge of gene-based nutritional services and nutritional genomics science as well as their application to dietetic practice have not been conducted. Therefore, this present study tries to identify nutritionists' knowledge about gene-based nutrition services in Indonesia, knowledge about the science of nutritional genomics and gene-based nutrition services, and nutritionists' views on gene-based nutrition services.

This study aims to determine nutritionists' in-depth knowledge of nutritional genomics science and gene-based nutrition services as well as their views regarding gene-based nutrition services. It focuses on the definition of nutritional genomics, nutrigenetics, and nutrigenomics; diseases related to the interaction of nutrition and genes; and the application of this knowledge in dietetics practice in hospitals. This is to find out the extent of their knowledge about nutritional genomics science which will be needed for intervention in the gene-based nutritional services. Besides, it deeper examines nutritionists' knowledge about gene-based nutrition services mechanisms, the role of nutritionists, examples of services, and the advantages and disadvantages of gene-based nutrition services. In terms of nutrition experts, it focuses on their interest in gene-based nutrition services and their expectations and suggestions for the development of gene-based nutrition services.

METHODS

This qualitative study used a phenomenological approach. Data were collected by conducting in-depth interviews both offline and online with the help of Zoom Meeting apps. This study involved 2 informants from DKI Jakarta, 1 informant from West Java, 1 informant from Central Java, 1 informant from East Java, and 2 informants from DI Yogyakarta. This study was conducted in February - July 2023. The determination of the informant used a purposive sampling technique with predetermined inclusion and exclusion criteria. The inclusion criteria were nutritionists working in a hospital for at least 1 year, have a Bachelor's degree/equivalent, staying at the research location, and have never provided gene-based nutrition services. Meanwhile, the exclusion criteria were not willing to participate in this study. The sample size reached saturation level consisting of seven informants.

The researcher selected informants from the results of the Qualtrics online survey. Those who filled out the online survey completely were selected based on the inclusion criteria, namely 86 informants who were grouped by province. They were selected using a spinner wheel and then the selected informants were contacted via WhatsApp. Before participation, they signed the informed consent containing information related to the objective of the study, willingness to participate, data confidentiality, interview procedures, and benefits or compensation. Then, the researcher designed the schedule for the interview. This study has obtained ethical clearance from the Alma Ata University ethics commission (No: KE/AA/IV/101155/EC/2023).

This study examined themes related to knowledge about nutritional genomics science, gene-based nutrition services, and gene-based nutrition services among nutritionists in Indonesia. The first theme focuses on the definition of nutritional genomics, the definition of nutrigenetics and nutrigenomics, diseases related to the interaction of genes and diet, types of genes affecting disease susceptibility, and the application of this science in dietetic practice. The second theme focuses on the informant's knowledge about gene-based nutrition services in Indonesia covering mechanisms, service providers, and the role of nutrition experts. The last theme focuses on informants' views about the importance of gene-based nutrition services, interest in gene-based nutrition services, and suggestions for the service.

Data analysis used thematic analysis. Data were reduced using Nvivo 12 software, presented with short descriptions or narrative text, and concluded and verified using triangulation examination techniques. The triangulation covered source triangulation by interviewing nutritionists who provide gene-based nutrition services.

RESULTS AND DISCUSSION

Informant Characteristics Data

This study involved 7 informants from five provinces. The characteristics of the informants are presented in Table 1. The majority of the informants were aged 30 years with an age range of 24 - 48 years. All informants are female. In terms of educational background, it is dominated by bachelor's degrees (S1). Concerning the type of institution, the majority of informants are from Type B Hospitals and they have worked as nutritionists for 8 years with a range of 2 - 25 years.

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Table 1. Characteristics of Informants

Province	Age	Gender	Education	Type of institution	Length of work
DKI Jakarta	24	Female	S1	Type B Hospital	2 years
DKI Jakarta	31	Female	S1	Type B Hospital	9 years
Central Java	28	Female	S1	Type C Hospital	5 years
DI Yogyakarta	48	Female	D4	Type A Hospital	25 years
East Java	26	Female	S1	Type B Hospital	4 years
West Java	28	Female	D4	Type B Hospital	4 years
DI Yogyakarta	28	Female	S1	Type B Hospital	5 years

The key informant in this study was one informant as presented in Table 2. The key informant is a female nutritionist aged 26 years who provides gene-based nutrition services and has a Bachelor's degree. The key informant has worked at gene-based nutrition service providers for 1 year and has worked as a nutritionist for 4 years. The key informants stay outside the research area but her workplace, namely the nutrigenetic service providers located inside the research location so her responses are relevant.

Table 2. Characteristics of the key informant

Province	Age	Gender	Education	Type of institution	Length of work
Banten	26 years	Female	S1	Nutrigenomics Service Provider	4 years

Theme 1: Knowledge of Nutritional Genomics *Science*
Description

The majority of the informants had insufficient knowledge about the nutritional genomics science. Most of them (5 out of 7 informants) stated that they had forgotten and they all did not study this science deeply so they did not have much information about it as indicated by the following statement.

"I think, I've kind of forgotten" (IF 1, 24 years old, S1)

"Incidentally, my hospital doesn't have it, so my friends and I don't really understand nutrigenomics, we're not too familiar with it either." (IF 2, 31 years old, S1)

This result is in line with Serkan Yilmaz et al., (2021) that t most nutritionists in Ankara Hospital, Turkey did not have enough nutrigenetic knowledge[14]. Most of the informants admitted that they had forgotten it as they did not provide gene-based services. It is in line with Collins et al., (2013) that low involvement of nutritionists results in a low knowledge level[11].

Source of Knowledge

Nutritionists do not get much information and knowledge about nutritional genomics science. The majority of the informants (5 out of 7 informants) gained this knowledge while studying, but there were only a few classes on nutritional genomics. Other informants (2 out of 7 informants) gained knowledge about this science by attending seminars. A previous study by Wright (2014) concerning self-confidence and education in the science of nutritional genomics revealed that a lack of training and an unsupportive environment resulted in poor knowledge and a lack of confidence in the field of nutritional genomics[17]. This is in line with the following statements.

"*In S1, it's only one or two credits."* (IF 2, 31 years old, S1)

"This science is new and not many people know about it. I once heard about it in a nutrition congress." (IF 4, 48 years old, D4)

The key informant stated that the college did not offer nutritional genomics classes. She learned about it from another nutritionist when she wanted to become a nutritionist who provides gene-based nutrition services. It is in line with Mariette Abrahams et al., (2018) that nutritionists seek knowledge about nutritional genomics through communication with each other and the wider scientific community[18]. The statement of the key informant is as follows:

"When I was in college, nutritional genomics classes didn't exist yet. So I have to learn about the genes and how to provide the counselling from a nutritionist or a specialist." (KI, 26 years old, S1)

Definition of Nutritional Genomics

The majority of informants (6 out of 7 informants) define nutritional genomics science according to their understanding. They define it as a science related to genes and nutrition. However, none of them mentioned about nutrigenomics and nutrigenetics. Some informants (4 out of 6 informants) said that the output of this science related to nutritional needs can be different for each individual depending on their genes. It can be seen from the following statement.

"As far as I know, it is about the study of genes, yes, about genomics, genomics and nutrition in relation to health, body health." (IF 4, 48 years old, D4)

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"As far as I know, nutrition genomics is related to the food or nutrition intake and genes. Well, each person has different genes, so it depends on the person. The genes will influence our nutritional needs," (IF 5, 26 years old, S1)

This is in line with Elsamanoudya et al., (2016) that the nutritional genomics science is a two-way relationship between nutrition and the human genome (nutrigenetics and nutrigenomics). Nutritional genomics defines gene expression and metabolic responses which possibly influence individual health conditions and disease susceptibility[19].

Scope of Nutritional Genomics Science

All informants agreed that nutritional genomics is related to the concept of individuals having different responses and some of them (4 out of 7 informants) exemplified the fat metabolism of different individuals. It is in line with Sharma et al., (2017) that nutrigenomics will help in evaluating individual nutritional needs based on the individual's genetic profile (personalized diet) and curing and preventing chronic diseases such as that dietary cholesterol has an inhibitory effect on the transcription of the β-hydroxy-β-methyl-glutaryl-CoA reduction gene[20]. Most informants (5 out of 7 informants) provided examples of different weight loss. It is in line with a previous study by Alsulami et al (2020) that some Single Nucleotide Polymorphisms (SNPs) have a relationship with obesity and the effect of the interaction between SNPs and a high protein diet on changes in body weight[1]. Some informants (3 of 7 informants) stated that the efficacy of different diets and disease susceptibility as indicated by the following statement.

"Every person is different. So, it is not certain if A consumes certain grams of fat then A will have Coronary Heart Disease (CHD). It's different depending on each person's metabolic genes. Some people have a good metabolism. They eat a lot of fatty foods but they are not fat and they have normal lab results. On the other hand, other people who eat the same foods with the same portion can get weight gain and have a high cholesterol level, Low-Density Lipoprotein (LDL), and high Blood Pressure (BP)." (IF 5, 26 years old, S1)

"When a person wants to lose weight, automatically we recommend a diet menu for weight loss using the same technique and the results turn out to be different where person A can get one to two kilos a month, but it does not work for person B." (If 6, 28 years old, D4)

"There is no relationship with diabetes, a person's blood glucose is normal but in another person, it can increase. So that's the relationship with Diabetes Mellitus (DM). Each person is different (explains with hand movements). I'm sorry, I don't really know it deeper" (IF 3, 28 years old, S1)

Definition of Nutrigenetics

Some informants (4 out of 7 informants) defined nutrigenetics quite precisely. However, they could not provide examples of nutrigenetics. They define nutrigenetics as the science that explains how genes influence an individual's nutritional needs. This is in line with Elsamanoudya et al, (2016) that nutrigenetics is the science of identifying gene variants associated with differences in response to nutrition and linking gene variations with disease[19]. Nutrigenetics identifies how an individual's genetic composition responds to various nutrients[5]. Uthpala et al, (2020) state that nutrigenetics explains how genes influence diet[21].

"So, it's about nutrigenetics, a person's nutrition is influenced by their own genes. That's why the nutritional adequacy level for women and men are different, because gene xx and gene xy are different, that's my analogy." (IF 1, 24 years old, S1)

Definition of Nutrigenomics

Most of the informants (5 out of 7 informants) could not correctly define nutrigenomics. They tried to guess it but it's incorrect.

"Nutrigenomics is the same, almost the same with (nutrigenetics), that's what I know." (IF 7, 28 years old, S1)

Nutrigenomics is the science that studies nutrients affecting gene expression in the body. Uthpala et al, (2020) define nutrigenomics as how the diet works on genes and changes gene expression which is prominent in non-communicable diseases like cancer[21].

Diseases Associated with Nutritional Genomics

All respondents stated that Diabetes Mellitus (DM) is associated with the interaction of genes and nutrition. It is in line with Phillips (2013) that Calpain 10 (CAPN10) is the first DM susceptibility gene identified. Other studies tried to confirm the association between DM risk and the TCF7L2 gene SNP (rs7903146)[22]. Most informants (6 of 7 informants) mentioned heart diseases and obesity (4 of 7 informants). It is in line with Henuhili (2010) that the Fat Mass and Obesity (FTO) gene is responsible for obesity[23]. Muhammad (2021) explained that the isoflavin daidzein and genistein compounds can reduce LDL-cholesterol levels, and inhibit the production of pro-inflammatory cytokines, cell adhesion protein, iNos, and oxidation of Low Density Lipoprotein (LDL) which positively prevents cardiovascular disease[5]. Two out of seven informants mentioned hypertension and one informant mentioned cancer. Muhammad (2021) stated that good vitamin D status can improve life rates in patients with colorectal and breast cancer[5].

"Maybe, it's related to genes, heart disease, diabetes, cancer, obesity, that's it." (IF 4, 48 years old, D4)

"Yes, hypertension. DM (pointing) is the same as diabetes mellitus." (IF 1, 24 years old, S1)

Knowledge of the Type of Genes Influencing Disease Susceptibility

All informants could not specifically mention the types of genes influencing the interaction of nutrition and genes. Three out of seven informants expressed that they knew certain types of genes related to a person's disease susceptibility, but did not remember the name of the gene.

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"I cannot memorize the type of gene because I got it a long time ago when I was in college. But, I remember that fat is related to lipoproteins, if I'm not mistaken, there are many types. That's what I remember. For diabetes, I don't know it well because I only remember about the heart." (IF 5, 26 years old, S1)

Application of Nutritional Genomics in Hospitals

All informants have not applied this knowledge in their workplace using actual procedures. This is in line with Abraham et al (2019) that the application of gene-based nutrition services throughout the dietetics profession is low[13]. Some informants (4 out of 7 informants) stated that the application can be done by providing education about gene-related diseases during counseling.

"It has not been according to the procedure because the gene examination has its own procedure. If I'm not mistaken, the examination is available." (IF 5, 26 years old, S1)

"I once said it to a patient who asked me why it was so difficult me to lose weight. So after investigating, her parents were obese, including her mother, herself, and her children. I explained that if she had the obesity gene, there was a carrier gene for having an excess nutritional status. That's it." (IF 1, 24 years old, S1)

Theme 2: Knowledge of Gene-Based Nutrition Services
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Gene-Based Nutrition Service Mechanism

All respondents only knew a little about gene-based nutrition services. They did not know the mechanism of gene-based nutrition services in detail. They stated that this service had special laboratory tests. Only two out of seven informants stated that the examination used saliva samples. It is in line with Angeline Fanardy (2020) that one of the examinations used saliva samples[24].

"I don't know the details, but as explained in brochures, there is a genetic check using what is that, it uses saliva samples. It is sent to a lab for analysis. The results will show the gene type including the explanation." (IF 7, 28 years old, S1)

Informants stated that they knew the mechanism for gene-based nutrition services using saliva samples and the results were then interpreted. Then, the outpatient will receive counselling regarding food recommendations, dietary restrictions, and disease susceptibility based on the results of the lab as indicated by the following statements.

"What I know is after taking a sample for the test, then the client needs to wait for the result. They are informed about the counseling, not a more consultation, it is linked to the results of the gene examination." (IF 2, 31 years old, S1)

"It's more like counseling that is more directed towards each individual depending on their genes, so taking a gene sample, then checking the results of the genes. The clients are then informed about the food restrictions and food recommendations. I think that's all." (IF 2, 31 years old, S1)

"For example, if you want to find out the gene, there is a separate test. So, it's like a medical check-up, but it focuses on the gene. Later, the results of the test will be interpreted as to which gene is a bit problematic. Thus, the client can know the risk of contracting disease, that's right?" (IF 5, 26 years old, S1)

"Gen-based nutrition services are when patients come for outpatient treatment, there can be in-depth interviews and tests." (IF 3, 28 years old, S1)

Gene-based nutrition services include laboratory tests using saliva samples or buccal swabs. Sample processing uses Polymerase Chain Reaction (PCR) or microarray. Each provider provides the gene test results differently depending on their panel. Some providers do not provide genetic-based meal plans and only provide general meal plans. Some also do not provide information about a person's susceptibility to certain disease risks. They collaborate with partners such as clinics, hospitals, and nutrition service platforms. Clients can get this service through collaborating partners or directly from the provider via the website and Instagram.

"The method uses saliva and buccal swab, and the processing uses PCR microarray and others." (KI, 26 years old, S1*)*

"Currently, we are the providers who provide the tests. Clients can buy the test to find out the results of their DNA on the panels offered. So far, it's more about the report, and consultation. The consultation is now with a clinical nutrition specialist as well and for the meal plan, we have a meal plan but it is not appropriate for those who have a genetic condition/. It's more about the amount of calories in one day, the recommended amount of certain ingredients, etc." (KI, 26 years old, S1)

"My workplace has not been able to map the disease susceptibility, like for example, the percentage of increasing cancer susceptibility. Actually, now we are developing it but haven't launched it yet. But it could be one of the parameters for the world of genomics or for other health conditions." (KI, 26 years old, S1)

"We have two types of models, namely B to B and B to C. B to B, we are with business partners, either to several companies or other nutrition providers like Sirka. We also developed a website and Instagram account for our direct selling. Interested people can also contact us directly. We are currently developing a clinic so that direct purchases can also be made directly or via our partners." (KI, 26 years old, S1)

"Here, we have partners such as clinics or hospitals." (KI, 26 years old, S1)

This is in line with Mitchell (2016) that gene-based nutrition services are currently provided through a consumer model. People can find a service provider company on the internet, apply for a test kit, do the swab, and return the test kit to the company. Then, they can use the test results to improve their eating habits. All nutrigenomics services require three distinct steps, namely, genetic testing and interpretation, disease susceptibility assessment, and a consultation session with

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a nutritionist to get dietary recommendations based on genetic test results[25].

Source of Information

Some respondents got information about gene-based nutrition services from Instagram, gene-based nutrition service providers, and gene-based nutrition service brochures. This is in line with the results of a previous study that nutritionists received the most information about gene-based nutrition services from nutritionists and social media[26] as indicated by the following statements.

> *"I don't know about the service mechanism in detail, but I know some from brochures."* (IF 7, 28 years old, S1).
> *"I know about the saliva from Instagram."* (IF 6, 28 years old, D4)
> *"I've heard from some hospitals that provide nutrigenomics services."* (IF 2, 31 years old, S1)

Benefits of Gene-Based Nutrition Services

All respondents believed that gene-based nutrition services were useful for realizing personalized diets, preventing disease, and being general diet alternatives that have not been successful. This is in line with Renzo et al, (2019) that personalized nutrition can explain the molecular and cellular effects of nutrition on individuals. This will allow nutritional interventions according to individuals' physiological, genetic, ethnic, cultural and economic background[27]. Besides, Ferguson et al, (2016) showed that personalized nutrition was more effective in preventing chronic disease compared to general diet recommendation[28]. Delmi (2019) revealed that a person can be diagnosed before they get sick, allowing doctors to determine a person's genetic predisposition to disease and take preventative and curative measures by changing diet and avoiding foods that cause the disease[6].

"Specifically, each individual has their own nutritional needs. What is circulating now is more global where balanced nutrition or RDA for certain ages are made equal (scratching the back of the head), while individuals have different genes (holding the nose). So, nutrigenomics may be more specific to each individual." (IF 2, 31 years old, S1)

"So you don't have to wait to get sick or feel the symptoms, you can already know, for example, from that gene, you already know that there is a problem with metabolism. The gene interpretation will show the relation to certain disease susceptibility. For example, the metabolism of carbohydrates or fat. It's very likely to find out when eating certain foods like junk food, will lead to Coronary Heart Disease (CHD). That means the client will know as early as possible so that it doesn't happen, it doesn't pass the curative period. It's more preventive." (IF 5, 26 years old, S1)

"Yes, that's specifically for patients, mainly about nutritional services, for example, providing a diet or nutritional counseling in accordance with diet, the heart condition. In terms of heart or diabetes, there is no proof. In terms of nutrigenomics, it is more specific to each individual, maybe it's better." (IF 2, 31 years old, S1)

Advantages and Disadvantages of Gene-Based Nutrition Services

Based on the results of the interview, all respondents agreed that the test has advantages, namely specific dietary interventions, accurate diet targets, a higher percentage of diet success, practical and easy-to-use tools, and application of a good lifestyle. It is in line with Angeline Fanardy (2020) that nutrigenomic examination was comfortable, non-invasive, and fast[24].

"Knowing the genes and matching them with the nutrigenomics will be better for the future, well, diseases can emerge later if they don't match." (IF 2, 31 years old, S1)

"Maybe it will be more efficient in the future, I mean our intervention will have a higher level for success." (IF 7, 28 years old, S1)

"Basically, the tool is available, it is considered practical and easy to use." (IF 1, 24 years old, S1)

No informant stated that this service could be carried out at home. Key informants expressed that this service was practical and could be done at home. Tools will be sent to the client to take samples, then the client will be guided on how to take, store, and send samples.

"So, we can guide clients in carrying out the swab at home. We guide them including everything that must be paid attention to and how to take the sample. The sample must be closed tightly and put in Hazard plastic. Then, it can be sent back to us." (KI, 26 years old, S1)

The majority of informants (5 out of 7 informants) expressed the disadvantages of this service such as being expensive and limited available in certain areas. Jacus et al, (2021) revealed that cost considerations are a critical dimension that must be addressed before implementing gene-based advice in nutritional practice[29].

"I read some articles that the service is quite expensive." (IF 5, 26 years old, S1)

"It's still limited, I think the community isn't familiar with it. Even, not all health services can optimally provide nutrigenetic services." (IF 3, 28 years old, S1)

One of the informants revealed that this service could not be covered by insurance. Besides, the key informant was hesitant to state that this examination could be covered by insurance as indicated by the following statements.

"*BPJS (Social Security Agency) does not cover this service because the budget is quite high. For other insurance, it depends on the level, for example for higher ranks, the insurance services are more numerous. But it depends on the insurance agency whether to cover it or not."* (KI, 26 years old, S1)

"Of course, people have problems with the price, but if the price is quite affordable, everyone can afford it. Or maybe it can be covered by any insurance, then it can be a preventive measure." (KI, 26 years old, S1)

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Knowledge of Gene-based Nutrition Service Providers

Most informants were unable to provide examples of the service provider. Only three out of 7 informants) knew the provider's partner hospital or clinic. In Indonesia, gene-based nutrition services were initiated by Kalbe in 2018. Thus, socialization about this service must be improved. Other studies conducted in 2023 revealed that many nutritionists were not familiar with gene-based nutrition services, namely 48 percent[26].

"In Indonesia, I only found Prodia, but I don't know about other places." (IF 3, 28 years old, S1)

The Role of Nutritionists in Gene-Based Nutrition Services

Some informants (4 out of 7 informants) doubted their role in gene-based nutrition services. This is in line with Abraham et al (2018) that the perceived obstacles to expanding the nutritional genomics practices were associated with skepticism among the dietetics community[18]. Informants argued that nutritionists could play a role in interpreting food and collaborating with clinical nutrition specialists. Clinical nutrition specialists have the responsibility to interpret the results of the nutrigenomic examination. Mitchell (2016) reported that nutritionists will work together with health care practitioners such as doctors and genetic counselors[25].

"It might become an alternative. Our understanding of food ingredients is better than doctors. So, it might be an alternative for collaboration. If the doctor doesn't explain the foods affecting genes, then nutritionists can provide it including the alternative menus. Maybe a doctor can explain and provide intervention, while the nutritionist can provide alternative applications for nutrigenomics." (IF 7, 28 years old, S1)

In practice, nutritionists can play a role in gene-based nutrition services by providing consultations regarding gene results to clients as stated below.

"It can be both, so if you want to read it, you can hear it from the clinical nutrition specialist and from a nutritionist." (KI, 26 years old, S1)

Theme 3: Nutritionists' Perspectives of Gene-Based Nutrition Services

All respondents showed positive to gene-based nutrition services and they believed that its existence is important. Gene-based nutritional services are expected to reduce the prevalence of degenerative diseases whose prevalence is increasing. A study by Sharma et al, (2017) revealed that nutrigenomics would help in the recovery and prevention of chronic diseases[20]. It is in line with Justine Horne et al, (2016) that respondents considered Personal Nutrigenomics Testing (PNT) a positive contributor to advancing the dietetics field[30].

"In my opinion, it is important for the future because prevention is better than cure. For example, if people know how genes receive nutrition and what their body needs, the prevalence of diseases such as CHD (coronary heart disease), diabetes, and others can be reduced." (IF 5, 26 years old, S1)

Almost all informants (6 out of 7 informants) wanted their workplace to provide gene-based nutrition services. Other respondents whose hospitals had collaborated with laboratories providing nutrigenomic tests also wanted to be able to provide nutrigenomic tests independently, so the costs could be cheaper.

"Yes, that's better. "It should be because I think it's better for the hospital services." (IF 6, 28 years old, D4)

"Yes, I want it because independently, the costs will be cheaper." (IF 7, 28 years old, S1)

On the other hand, the key informant argued that the gene-based nutrition service providers in Indonesia are extension providers, so the possibility of hospitals providing this service independently is still difficult. Angeline Fanardy (2020) stated that after taking the samples, Nutrigenme Indonesia would send the samples to a laboratory in Canada for analysis using the microarray technique[24] as stated below:

"Yes, in Indonesia, most of the providers are collaborating with other partners, yes, they provide it, but we are like the extension seller, that's our condition." (KI, 26 years old, S1)

All respondents were interested in providing gene-based nutrition services so they need to prepare themselves by studying as they are not ready to provide gene-based nutrition services now. This is in line with Jacus et al, (2021) that further training and learning are needed to equip nutritionists to provide dietary advice based on genetic information[29]. Besides, it is in line with Christopher Samia Cooper (2015) that nutritionists need to have more experiences in genetics and diet-gene interactions in order to feel confident and comfortable implementing nutritional genomics into practices.[15]

*"I am interested, but I need to study more." (*IF 3, 28 years old, S1)

Providers need to prepare many things to provide gene-based nutrition services. Based on the results of interviews, informants stated that the institutions need to prepare training, facilities and infrastructure, promotions, and costs to provide this service. S. Nacis et al, (2021) reported that further training and learning will equip nutritionists to provide dietary advice based on genetic information. Besides, cost and ethical considerations need to be addressed before integrating gene-based nutrition services[29] . Here's the statement:

"Actually, training, training for health workers. Yes, as nutritionists, we need to be trained first." (IF 4, 48 years old, D4)

"Maybe we also have to work together with related agencies and installations, for example, a lab for taking samples, infrastructure, mm (pause) maybe it's more about funds too, funds, infrastructure and

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cooperation between various parties such as directors, labs outpatient unit, that's all." (IF 3, 28 years old, S1)

"It is promoted to people who are interested in nutrigenomics. For example, if they don't know about it, they won't be interested. That's the promotion." (IF 5, 26 years old, S1)

Informants expected that gene-based nutrition services could further develop. Most of them (5 out of 7 informants) want training and seminars on nutritional genomics science and gene-based nutritional services. Some argue that such materials need to be included in college curricula to improve Human Resources (HR) for nutrition experts in the field of gene-based nutrition services. This is in line with Justin Horne et al, (2016) that nutrition students will be the right target for education about nutritional genomics science. Thus, the integration of nutrigenomics as a component of university-level training can help bridge this knowledge gap and further advance the field[30]. Inserting nutrigenomics education into dietetics curricula will help alleviate concerns about nutritionists' limited knowledge of nutrigenomics as stated below.

"Yes, training, we want to know the scope of the study, the materials, and the practices. Maybe, there should be special training." (IF 6, 28 years old, D4)

"The first is from human resources, the health workers. Even the distribution of knowledge related to nutrigenomics and nutrigenetics is needed to develop this service. It must be for all graduates, D3, D4, and S1 even S2." (IF 5, 26 years old, S1)

CONCLUSIONS

Nutritionists still have a low level of knowledge about nutritional genomics. They are unfamiliar with gene-based nutrition services and only have brief and basic information about the service. Nutritionists have positive perceptions of gene-based nutrition services. They consider this service important and want their agency to provide this service. However, they are not ready to provide this service and hope that the agency can provide training for them. Besides, equal distribution of knowledge about gene-based nutrition services in universities can help produce nutritionists who can provide gene-based nutrition services in Indonesia.

ACKNOWLEDGMENTS

The author highly appreciates the supervisor for guiding the implementation of this study and the participation of all participants in this study. Besides, the author appreciates the thesis group, entitled "Involvement, Self-Confidence, and Knowledge of Nutritionists about Gene-Based Nutrition Services in Indonesia: A Mixed Method Study."

Conflict of Interest and Funding Disclosure

This author declares that there is no conflict of interest in this study. This study was partly funded by the Ministry of Research, Technology and Higher Education under the Master's Thesis Research (PTM) grant scheme.

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