A Pilot Study on Sensemaking of Consumer Micronutrient Tests: Sufficiencies, Deficiencies, and Barriers to Improvement

Zilu Liang
liang.zilu@kuas.ac.jp
Kyoto University of Advanced Science
Kyoto, Japan

Nhung Huyen Hoang
2023md05@kuas.ac.jp
Kyoto University of Advanced Science
Kyoto, Japan

Thilini Savindya Karunarathna
2021m647@kuas.ac.jp
Kyoto University of Advanced Science
Kyoto, Japan

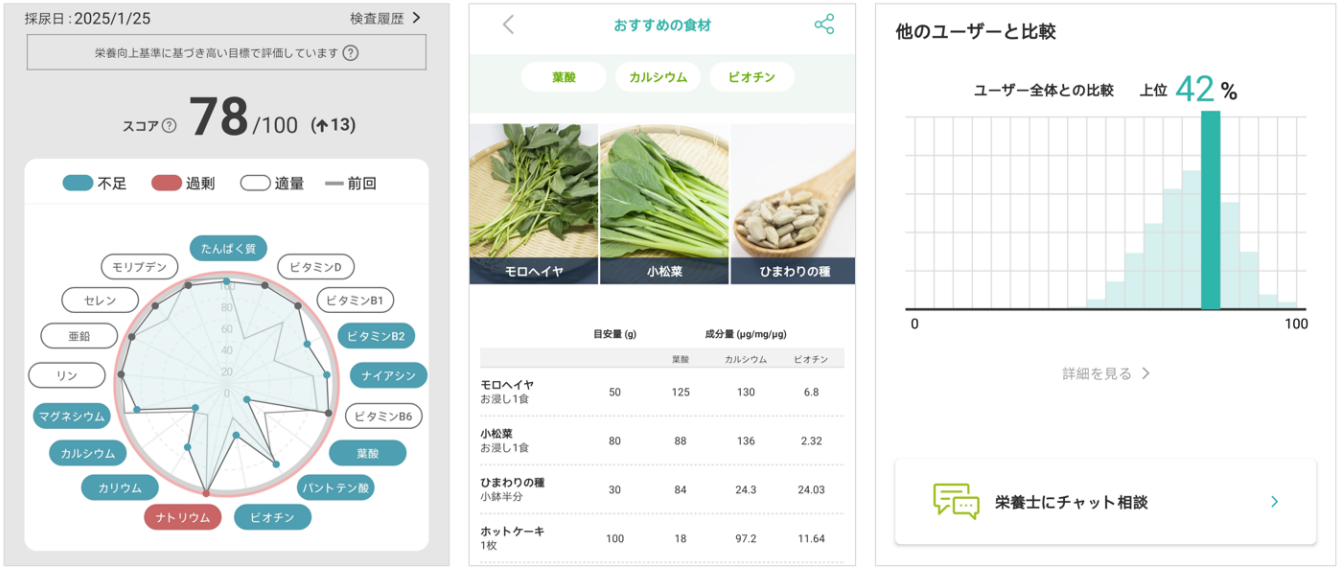

Figure 1: Nutritional test results from the VitaNote app for one participant. Left: The overall nutrition score was 78 out of 100. This participant demonstrated sufficient levels in 7 nutrients (vitamin D, vitamin B1, vitamin B6, phosphorus, zinc, selenium, and molybdenum), deficiencies were noted in 9 nutrients (protein, vitamin B2, niacin, folic acid, pantothenic acid, biotin, potassium, calcium, and magnesium), and sodium level was high. Middle: Recommended foods to address deficiencies in folic acid, calcium and biotin, including jute leaves, mustard spinach, sunflower seeds, and hot cake. Right: This participant's score is benchmarked at the 42nd percentile compared to others.

Abstract

Vitamins and minerals are essential for human health, yet deficiencies are common. Recent advances in consumer health technology have led to the rise of at-home nutritional health test services, which offer an affordable and accessible way to measure nutrient levels. This pilot study explores how young people interpret their results from a mail-in urine micronutrient test. The findings revealed that none of the 13 participants met the target levels for all micronutrients, with high sodium levels and deficiencies in vitamin B, calcium, and magnesium being particularly common. Despite consuming nutrient-rich foods or supplements, some participants still experienced deficiencies, highlighting the complexity of nutrient absorption. Although participants appreciated the food recommendations, barriers such as personal food preferences, resource constraints (i.e., limited time, space, and budget), and lack of cooking skills hindered their ability to follow through the recommendations. Based on these findings, we propose two design recommendations to enhance the utility of consumer nutritional tests.

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CCS Concepts

• **Human-centered computing** → **Empirical studies in HCI**; • **Applied computing** → **Consumer health**.

Keywords

Personal informatics, Consumer informatics, Sensemaking, Nutritional health tests, Micronutrients, Minerals, Vitamins

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1 Introduction

Micronutrients, including vitamins and minerals, play important roles in various functions of the human body, from immune support to energy production [11]. Despite their importance, micronutrient deficiencies are widespread, particularly among young people who may face dietary challenges due to factors like busy schedules, limited food options, and academic stress [1], which may potentially impact their short-term and long-term health [12].

Traditional methods for assessing micronutrient levels require complicated laboratory-based testing, which limits their accessibility for individuals [6]. However, recent developments in consumer health technology have led to the emergence of at-home nutritional health test services. These services offer a more accessible and affordable way for individuals to measure the levels of key nutrients by simply submitting a urine sample [7]. While these services seem to provide valuable information, little is known about how individuals users interpret and apply the results they receive. Understanding how users make sense of their micronutrient test results is important, as it can influence their health-related decisions and behaviors. This study aims to explore how young people interpret their mail-in urine nutrient test results. By examining their perceptions and responses, this research seeks to contribute to a foundational understanding of how consumer nutritional tests may influence personal health management in everyday life.

2 Related Work

In personal health informatics, users often struggle to make sense of large volumes of self-tracking data about their diet, activity, sleep, or medical conditions [4, 8]. The challenge of sensemaking is further exacerbated in clinical settings, where deep domain knowledge is required to understand the medical test reports [9].

A related aspect of personal health management is food journaling, which involves tracking macronutrients such as proteins, fats, and carbohydrates. While users can gain useful insights into their dietary habits by tracking these macronutrients, a noticeable gap exists in tools designed to help users understand their micronutrient intake. Unlike macronutrients, which can often be tracked using basic food journaling apps, micronutrients—such as vitamins and minerals—are more challenging to monitor and interpret. Lahtiranta [5] explores how sensemaking in personal health typically focuses on high-level factors like diet and exercise but often overlooks the more complex issues surrounding micronutrient intake and its role in long-term health. These knowledge gaps are one of the driving forces behind our study, which aims to explore how individuals interpret and make sense of their micronutrient profiles.

3 Method

To explore how young people interpret their micronutrient profiles, we recruited 13 university students (10 male, 3 female) aged 19-34 from Kyoto University of Advanced Science (KUAS), a private university in Japan. The study began with a one-on-one kickoff meeting where the research team explained the purpose and process of the study, and obtained written informed consent. Participants were provided with a VitaNote nutritional test kit, along with instructions on how to perform the test. They collected urine samples the following morning and mailed them to the VitaNote testing center. The test results were then made available to the research team via the VitaNote smartphone app. A screenshot of the VitaNote app is shown in Figure 1.

Following the receipt of test results, a second meeting was held where semi-structured interviews were conducted. During these interviews, participants were shown their test results, asked to interpret their nutrient levels, and provided with some recommendations. Participants were also asked about any actions they planned to take based on the results. All interviews were recorded, transcribed verbatim, and uploaded to DoveTail software for subsequents analysis.

We employed thematic analysis as described in [3]. The first author reviewed all transcripts to get familiar with the content and identify preliminary themes. Initial coding was done manually by marking relevant data segments that appeared to capture participants' perceptions, actions, and interpretations of their nutritional test results. After the first round of coding, the research team gathered to discuss and refine the codes, ensuring consistency and resolving discrepancies. Codes were then grouped into broader themes that reflected recurring patterns in participants' responses. These themes were iteratively reviewed and refined, with some codes being merged or split based on deeper analysis.

4 Results

4.1 Popularity of Nutrients

The test results revealed that none of the participants were free of nutrient deficiencies. Many participants sought to better understand the functions of the nutrients they were lacking, inquired about symptoms of deficiencies, and tried to identify potential causes based on their lifestyles, particularly their diets. However, the attention given to different nutrients varied.

Sodium stood out as the most discussed nutrient, with more than 50% (7 out of 13) of the participants immediately expressing concerns about their sodium intake and attempting to pinpoint reasons for their elevated levels. A common theme was the consumption of fast food, instant noodles, and lunch boxes, which were frequently cited as major contributors to their high sodium levels. As P004 noted: "*I do eat fast food, and that contains a lot of sodium, like I go to McDonald's maybe twice a week.*"

Calcium followed as the second most commonly discussed micronutrient, with 4 participants actively reflecting on their calcium intake. P007 noted that "*The calcium level seems about right because I don't really consume many calcium-rich products right now.*" P012, on the other hand, thought his calcium intake aligned with his milk consumption but was unaware of the recommended daily intake: "*I think the calcium level matches my milk consumption, but I didn't know the recommended daily intake was this high.*" (019)

Other nutrients, including folic acid, Vitamin D, Vitamin B group, potassium, and zinc, also received attention. Participants attributed their deficiencies to the lack of certain foods in their diet–such as

spinach for folic acid, bananas for potassium, and liver for zinc–or to insufficient sunlight exposure for Vitamin D. Health conditions, such as polycystic ovary syndrome (PCOS), were also mentioned as potential factors contributing to Vitamin B deficiency. In contrast, selenium and molybdenum were the least discussed nutrients, as participants were unfamiliar with these minerals.

4.2 Results Confirming Expectations

In some cases, the results of the nutritional test aligned with participants' expectations. For instance, some participants believed they were getting enough of certain nutrients, and the test results reassured them that they had no deficiencies in those areas. As one participant shared his thoughts on his calcium level: "*I used to take a lot of calcium supplements when I was a child. That may explain why my calcium level is better than others.* " (P011)

On the other hand, some participants were already aware that their diet was not ideal, so they were not surprised by the abnormal levels in their results. As P009 explained: "*I do eat snacks, you know, the nori (dried seaweeds) I eat a lot. Instant noodles or chips, I eat a lot. So I'm not surprised that my sodium level was off the chart.*"

4.3 Results Contradicting Expectations

However, more often than not, participants found that the results contradicted their expectations. In some cases, the levels of certain nutrients were much lower than anticipated, revealing deficiencies despite consuming foods that were believed to be rich in those nutrients. In other cases, participants were surprised to find that their nutrient levels were better than expected.

4.3.1 Unexpected Sufficiency. Some participants were pleasantly surprised by the results, discovering higher-than-expected levels of certain nutrients. P009 noted: "*I'm more curious about the stuff that I'm already fulfilling. It's weird that I'm doing great on minerals. Where are these from? Or maybe, you know, in the supermarkets, there's this small salad...maybe that's where I got the minerals from. I do eat the salad because it tastes really good.*" Similarly, P010 was surprised by his sufficient levels of magnesium and phosphorus, stating that "*I was not aware I had enough magnesium and phosphorus. Are those rich in natural products?*""

4.3.2 Unexpected Deficiency. On the other hand, some participants were shocked to find deficiencies in nutrients they had assumed they were consuming adequate amounts, especially considering their diet or supplement intake. For example, P011 and P012 were puzzled by their low levels of vitamin D and calcium, despite regularly taking vitamin D supplements or drinking a lot of milk. Similarly, P003 and P006 were shocked to find their calcium levels were low, despite consuming calcium-rich fish: "*I'm surprised that my calcium level was low. I was eating fish spreads a lot.*" (P006)

Some participants, like P003, were especially puzzled because they had no perceivable symptoms to back up the deficiencies they were experiencing: "*And another thing, especially for the performance of the brain, magnesium and calcium... magnesium, yeah, it's very low, but I think I'm doing well. So, still, I'm thinking that the magnesium level should be higher.*" (P003)

Surprises did not just stem from deficiencies; high nutrient levels were also a cause for shock, particularly with sodium. Some participants were surprised to learn that their sodium levels were two or three times higher than the recommended daily intake: "*I don't really consume that much salt. Only on certain meals, I would consume a little bit more sodium, but that's on the rarer side.*" (P008)

4.4 Planning for Action

Following the discussion of their test results, participants were asked about the steps they planned to do based on their findings. Their responses largely revolved around dietary adjustments and, in some cases, considering supplements.

4.4.1 Adjust Diet. All participants mentioned adjusting their diet as the first step towards improving their nutritional profile, as they preferred natural solutions and some participants expressed a reluctance towards supplements: "*I mean, first I would try changing my diet because I know it's not the greatest. And if it doesn't work, then I would consider buying supplements.*" (P007) or "*Oh, maybe not supplements. Honestly, I don't mind the price of supplements, but if possible, I'll try to eat from natural sources first.* " (P005)

Participants outlined specific dietary changes they planned to implement, including eating more whole food (1 participant), consuming more meat and organ meats like liver (5), vegatables (3), diary products (3), fruits (2), and nuts (2).

"*I think chicken liver gives you zinc and magnesium...also, I need more meat, different types of meat.*" (P011)

"*Like incorporate a lot more variety of food groups. For example, I said dairy products such as milk, yogurts... I've stopped eating them for some time. I'll pick them up again, and nuts as we mentioned. I'm already eating beef, so I'll be adding other things too, like vegetables. I will try liver, now that I know it's packed with vitamins.*" (P007)

A few also expressed a desire to cut down on sodium sources, such as bread: "*I think I should have less sodium in general. I think I should eat less bread; it has a lot of salt.*" (P010)

Diet changes also involved adjusting meal portions and schedules. P001 expressed a desire to work on meal consistency: "*Two more consistent meals, like a very good breakfast, lunch, and dinner. Currently, it's good but not great because it's in the university cafeteria. I want better quality and larger portions.*"

4.4.2 Take Supplements. Interestingly, while some participants showed reluctance toward supplements, 4 participants viewed them as a necessary complement to a healthy diet. P009 found it hard to make significant changes to his diet and stated "*it's easy to just take pills.*" P011 further explained that *"I need more supplements. Maybe because I can't get enough fruits in Japan, so supplements are easier.*"

P001 highlighted the importance of dose control when taking supplements: "*Yes, in the week I didn't eat too much, and I just take the pill. That supplements me for a while, not every day. For me, I don't feel well taking a pill every day...just twice a week.*"

4.5 Barriers to Change

Although the VitaNote app provides food recommendations for addressing micronutrient deficiencies, some participants were reluctant to try certain foods due to personal preferences. Green leafy vegetables like spinach and fermented foods such as natto were commonly disliked. One participant shared, "*I don't know if this is doable. I hate spinach so much. And natto... one time in the cafeteria*

they had natto. I took it as my side dish. I opened the pack, and I was like, oh my God..." (P009). Similarly, reducing salt intake proved difficult for some, with one participant commenting, "*If I cut down on salt or salty food, it wouldn't have much flavor.*" (P013).

Time and budget constraints were also common issues. One participant remarked, "*It's hard to find time, and I prioritize school over my health. I don't think that will change.*" (P004), while another noted the high cost of certain foods: "*Nuts are very expensive here. I'm okay with deficiency.*" (P007). The challenge of balancing meal planning with busy schedules was also mentioned, with P008 stating, "*It would depend on if I can adjust my schedule to make it more manageable to plan my meals more mindfully.*" In addition, space and practicality issues were mentioned, particularly in relation to cooking. P009 explained, "*It's really impractical to cook meat at my place. If it's just chicken breast, I guess it's fine because it's easy. But preparing more complicated meals is difficult because I don't have the space to do that.*"

Finally, some participants noted that a lack of cooking skills prevented them from preparing nutritious meals. For instance, P007 stated, "*I don't know how to cook spinach in a way that I would enjoy it.*" and P012 mentioned, "*Fish is hard to cook.*" Several participants also noted that they were unfamiliar with cooking organ meats like liver, despite recognizing their nutritional benefits.

5 Discussions

5.1 Prevalence of Micronutrient Deficiency

While the sample size was small, our results reveal a concerning trend that no participant was able to meet the target levels for all micronutrients measured in the test. Deficiencies in vitamin B, folic acid, calcium, and magnesium were more prevalent than initially expected, with many participants unaware of these deficiencies. In contrast, the majority of the participants had high sodium levels, with some reaching 2-3 times the recommended daily intake.

A key observation was that participants did not prioritize nutrients equally when interpreting their test results. The level of concern often correlated with participants' familiarity with these nutrients. Nutrients such as sodium and calcium, which are commonly highlighted in the media, received the most attention. This suggests that public awareness campaigns may shape individuals' perceptions of what constitutes a "healthy" nutrient profile.

An intriguing finding was that several participants experienced deficiencies in specific minerals despite consuming foods rich in those nutrients or taking supplements. This underscores the complexity of nutrient absorption, which cannot simply be assumed based on dietary intake. The discrepancies between food consumption and nutrient levels may be due to factors such as nutrient bioavailability, which is influenced by genetics [2], lifestyle [13], and food combinations [10]. This suggests that tracking dietary intake alone may not provide a complete picture of an individual's nutritional status. To address the gap between the two, we propose the following design recommendation:

Design Recommendation 1. Integrate food logs with nutritional test to assess whether nutrient consumption aligns with the levels derived from metabolites. Any discrepancies should be highlighted to alert users, encouraging them to consider more bioavailable food options that may better support their nutritional needs.

5.2 Utility of Consumer Nutritional Tests

Participants found the VitaNote test useful, especially as it highlighted deficiencies they were previously unaware of and prompted reflection on their lifestyles and diets. However, many struggled to fully understand their results due to limited nutritional knowledge. This points to the need for educational support in interpreting test results to bridge this knowledge gap.

Despite these challenges, the intuitive nature of the test results, coupled with food recommendations, provided participants with actionable insights. Still, this does not guarantee that users will follow through on the recommendations. Many participants expressed concerns about food preferences, and the practicality of incorporating the recommended foods into their daily routines. This highlights a design opportunity for consumer nutritional test services: the need to ensure that recommendations are not only tailored but also feasible within users' specific contexts. Based on these findings, we propose the following design recommendation:

Design Recommendation 2. Food recommendations should be personalized not only based on test results but also considering individual contexts such as food preferences and resource constraints. Offering recipes that incorporate the recommended foods, as well as reminders to purchase these items while grocery shopping, may help users more easily integrate these foods into their daily meals.

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