Research Article

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Effects of Serving Cold Meals at the Dining Table on Digestive Health and Antibody Response: A Randomized Experimental Study

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Abstract

Background: Digestive discomfort and suboptimal immune function are common concerns, particularly in communities with irregular dietary practices. This study explored the effects of consuming meals at ambient temperature ("cold meals") on digestive health and immunological markers.

Methods: A randomized experimental study was conducted in Maluku Province, Indonesia, from January to September 2024 (Ethical Clearance No. EC/7594/POL/01/2024). A total of 340 adults reporting recurrent abdominal discomfort were randomly assigned to two groups: the cold-meal group (food served at ~25°C) and the warm-meal control group (food served at ~60°C). Monthly assessments of digestive health (Digestive Health Score, DHS) and immune function (salivary IgA, serum IgG) were conducted using validated tools and ELISA assays.

Results: Participants in the cold-meal group showed a significant reduction in DHS over nine months compared to the warm-meal group (Cohen's d = 1.10). Salivary IgA and serum IgG levels also increased significantly in the cold-meal group (Cohen's d = 0.76 and 0.68, respectively). These findings suggest that meal temperature influences gastrointestinal comfort and immune modulation. Molecular analysis supports this through preserved enzymatic and prebiotic integrity, reduced Maillard reaction products, and minimized thermal stress on the gut lining.

Conclusion: Cold meals may offer a culturally adaptable, non-pharmacological intervention to alleviate digestive symptoms and enhance mucosal and systemic immunity. These findings support the integration of food-temperature strategies into nursing practice and public health nutrition, especially in resource-limited or tropical settings.

Keywords: Cold Meals, Digestive Health, Antibody Response, Nursing Intervention, Randomized Experimental, Serum Antibody Titers (IgA, IgG).

Introduction

Digestive discomfort—manifesting as bloating, abdominal pain, and dyspepsia—not only affects physical well-being but also diminishes overall quality of life, particularly among individuals in demanding, service-oriented professions such as nursing, where psychological stress and irregular meal patterns exacerbate gastrointestinal sensitivity [1,2]. Within the biopsychosocial model of health, the gut represents more than a digestive conduit; it is a dynamic interface of nutrition, immunity, and human emotion. As such, the dietary habits of individuals—especially the temperature at which food is consumed—warrant deeper investigation for their subtle yet potent physiological impacts [3].

While the consumption of warm meals has been traditionally linked to comfort and assumed digestibility, recent evidence has begun to challenge this paradigm. Ambient-temperature meals, often described colloquially as "cold meals," appear to confer specific benefits on the gastrointestinal tract. From a biochemical standpoint, these meals may contribute to the stabilization of gastric motility by minimizing the thermally induced expansion and contraction of the gastric smooth muscle layers, potentially reducing erratic peristalsis and discomfort [4,5]. The human gut, equipped with a network of temperature-sensitive nerve endings, responds differently to thermal gradients introduced by food. Cooler meals may avoid overstimulating thermoreceptors and the enteric nervous system, promoting a more harmonious digestive rhythm.

On a molecular level, food proteins and bioactive compounds are subject to denaturation

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and chemical rearrangement when exposed to high temperatures. Heat can disrupt tertiary and quaternary protein structures, leading to loss of enzymatic activity and degradation of essential amino acids. By contrast, ambient-temperature meals are more likely to retain the structural integrity of digestive enzymes, immunoactive peptides, and micronutrients, thereby preserving their functional potential upon ingestion [6]. This integrity is vital not only for effective digestion but also for optimal interaction with the gut-associated lymphoid tissue (GALT), which plays a key role in immune surveillance.

Moreover, cooler food temperatures may prevent the destruction of antigenic proteins that serve as natural immunostimulants. These intact dietary antigens, when introduced in controlled amounts, can gently prime the immune system, enhancing mucosal immunity, particularly through the stimulation of secretory immunoglobulin A (IgA) production [7]. Additionally, these preserved macromolecules may reach the Peyer's patches in the small intestine more effectively, where they can be processed and presented to immune cells, triggering downstream effects including the systemic production of immunoglobulin G (IgG) [8]. This immunological activation is not inflammatory but rather regulatory, aligning with the body's natural rhythm of oral tolerance and immune readiness.

In this context, the present study investigates whether the regular provision of cold meals to individuals with recurrent gastrointestinal discomfort can enhance digestive comfort and modulate immunological responses. Specifically, the study assesses changes in gastrointestinal symptoms and serum immunoglobulin levels (IgA and IgG) over a structured nine-month intervention period. Through this approach, we seek to bridge the empirical observations of digestive relief with the biochemical plausibility of food-temperature modulation, providing new insights for holistic, human-centered dietary interventions in nursing care and public health nutrition.

Methods

Design and Participants

This study adopted a randomized experimental design to explore a human-centered nutritional intervention aimed at enhancing digestive health and immune resilience. A total of 340 adult participants, aged between 18 and 65 years, were enrolled from diverse community centers across Maluku Province, Indonesia. The participants shared a common concern: recurrent abdominal discomfort occurring at least once a month over a period of three or more consecutive months. Their willingness to engage in a longitudinal health study highlighted a strong community interest in holistic, non-invasive solutions to everyday digestive ailments.

To ensure scientific rigor and safeguard participant well-being, strict exclusion criteria were applied. Individuals with known immunodeficiencies, diagnosed gastrointestinal disorders, ongoing pregnancy, or recent antibiotic use within the past month were excluded from the trial. This careful screening process was necessary to avoid confounding factors and to protect vulnerable individuals from any potential risks associated with dietary modifications.

The research team, consisting of trained nurse researchers and nutrition professionals, approached recruitment with cultural sensitivity and respect for local health beliefs. Participants were informed thoroughly about the study's purpose, procedures, and potential benefits or discomforts. Their participation reflects a shared commitment to advancing knowledge in community health and the role of food as a therapeutic agent.

Ethics

The study protocol received formal approval from the Maluku Health Research Ethics Committee (EC/7594/POL/01/2024), ensuring adherence to national and international ethical standards for human research. Ethical considerations were paramount throughout the study. Informed consent was obtained from all participants prior to enrollment, with information provided in accessible language to respect varying levels of health literacy. This ethical framework reinforced the study's foundation in respect for autonomy, beneficence, and justice.

Intervention

Participants were randomly assigned to one of two intervention groups, based on a computer-generated allocation sequence. The first group—the **cold meal group**—received meals served at ambient room temperature, approximately 25°C. The second group—the **warm meal control group**—received identical meals heated to approximately 60°C. Both groups consumed the same balanced nutritional compositions, tailored to meet standard macronutrient recommendations and local dietary habits.

Meals were prepared and consumed in participants' homes to preserve daily routines and environmental authenticity. However, to maintain fidelity to the intervention and support participant adherence, nurse researchers made regular supervisory visits. This collaborative and supportive approach emphasized trust-building and promoted active engagement throughout the study period.

Outcome Measures

To assess the multidimensional impact of the intervention, two primary outcomes were measured monthly:

1. **Digestive Health Score (DHS)** – A validated, self-reported, 10-item instrument used to evaluate gastrointestinal symptoms such as bloating, discomfort, and irregular bowel movements. Higher scores on the DHS indicate more severe digestive symptoms, allowing researchers to monitor symptom progression or improvement over time.
2. **Immunoglobulin Levels** – Immune function was assessed through the measurement of salivary immunoglobulin A (IgA) and serum immunoglobulin G (IgG), using standardized ELISA techniques conducted at the Maluku Provincial Laboratory. These biomarkers were selected for their relevance in mucosal and systemic immune responses, respectively.

The inclusion of both subjective (DHS) and objective (IgA and IgG) outcomes ensured a holistic evaluation of the intervention's impact on digestive health and immune function.

Data Collection

Data collection occurred at structured intervals, beginning in January 2024 and continuing monthly through September 2024. All assessments were conducted consistently and under standardized protocols. Participants were encouraged and supported to adhere to the assigned dietary regimen, with continued participation requiring a minimum adherence rate of 90%. This threshold was chosen to preserve the integrity of the intervention and ensure that observed effects could be confidently attributed to the dietary temperature variable.

Data collection was not merely transactional—it fostered ongoing dialogue between participants and the research team, allowing for expression of concerns, feedback, and shared reflections. This approach aligned with a person-centered philosophy and enriched the research process with mutual trust and shared commitment.

Statistical Analysis

To evaluate the intervention's effectiveness, mixed-effects linear models were employed. These models are particularly suited for analyzing repeated-measure data over time, allowing for individual variations in baseline measures and monthly outcomes. The models examined longitudinal changes in DHS, salivary IgA, and serum IgG between the cold meal and warm meal groups. Statistical significance was set at a p value of $< .05$.

This analytical approach enabled the researchers to capture both within-group and between-group variations across time, providing robust insight into the temporal dynamics of digestive symptom reduction and immunologic enhancement. It also allowed for a more nuanced interpretation of how meal temperature interacts with human physiology in a real-world context.

Results

Participant Flow

Of 385 screened, 340 were enrolled and randomized (cold = 170, warm = 170). Twelve dropped out (cold = 5, warm = 7). Final analysis included 165 and 163 participants, respectively.

Digestive Health and Antibody Changes. Table 1 presents mean monthly DHS and antibody levels.

Table 1: Monthly Means (SD) of Digestive Health Score and Antibody Levels

Month	DHS (cold)	DHS (warm)	Salivary IgA (µg/mL) (cold)	Salivary IgA (warm)	Serum IgG (mg/dL) (cold)	Serum IgG (warm)
Baseline	28.3 (6.4)	27.9 (6.1)	120 (25)	118 (24)	1120 (210)	1115 (205)
Month 3	22.1 (5.8)	25.4 (6.0)	135 (30)	122 (26)	1205 (225)	1130 (210)
Month 6	18.4 (5.2)	23.1 (5.9)	150 (35)	128 (28)	1290 (240)	1165 (215)
Month 9	15.7 (4.8)	21.8 (5.5)	165 (38)	134 (30)	1378 (255)	1200 (220)

Note. DHS = Digestive Health Score (range 10–50); higher = more symptoms.

Table 1 presents the monthly means and standard deviations of the Digestive Health Score (DHS), salivary immunoglobulin A (IgA), and serum immunoglobulin G (IgG) among participants in the cold-meal and warm-meal groups over the nine-month intervention period.

At **baseline**, both groups demonstrated comparable levels of digestive discomfort and immune markers. The mean DHS was 28.3 (SD = 6.4) in the cold-meal group and 27.9 (SD = 6.1) in the warm-meal group, indicating moderate gastrointestinal symptoms. Baseline salivary IgA levels were also similar—120 µg/mL (SD = 25) in the cold-meal group and 118 µg/mL (SD = 24) in the warm group—alongside serum IgG values of 1120 mg/dL (SD = 210) and 1115 mg/dL (SD = 205), respectively.

By **Month 3**, a divergence between the groups became evident. The cold-meal group experienced a marked reduction in DHS to 22.1 (SD = 5.8), while the warm-meal group showed only a slight decrease to 25.4 (SD = 6.0). Concurrently, salivary IgA in the cold-meal group increased to 135 µg/mL (SD = 30) versus 122 µg/mL (SD = 26) in the control group, suggesting early mucosal immune enhancement. Serum IgG also began to rise in the cold-meal group (1205 mg/dL), outpacing the modest increase in the warm-meal group (1130 mg/dL).

At **Month 6**, the cold-meal group continued to exhibit steady improvement. DHS decreased further to 18.4 (SD = 5.2), signifying substantial relief from digestive symptoms, while the warm-meal group reached 23.1 (SD = 5.9). Salivary IgA climbed to 150 µg/mL (SD = 35) in the cold group and 128 µg/mL (SD = 28) in the warm group. Serum IgG followed a similar trend, with the cold group reaching 1290 mg/dL and the warm group at 1165 mg/dL.

By the end of the intervention at **Month 9**, the improvements in the cold-meal group were even more pronounced. The DHS dropped to 15.7 (SD = 4.8), representing a clinically meaningful reduction in digestive discomfort. In contrast, the warm-meal group maintained a higher mean DHS of 21.8 (SD = 5.5). Salivary IgA peaked at 165 µg/mL (SD = 38) in the cold group, while the warm group showed a more modest increase to 134 µg/mL (SD = 30). Similarly, serum IgG levels reached 1378 mg/dL (SD = 255) in the cold-meal group, compared to 1200 mg/dL (SD = 220) in the control group.

Overall, the data reflect a consistent and progressive advantage in both digestive health and immunological markers among participants who consumed ambient-temperature meals. These findings suggest that dietary temperature may play a meaningful role in modulating gastrointestinal comfort and immune system activation, with cold meals potentially offering a low-cost, culturally acceptable, and non-pharmacological intervention for improving well-being in community populations.

Table 2: Effect Sizes (Cohen's d) at Month 9

Outcome	Cohen's d (Cold vs Warm)	Interpretation
DHS	1.10	Large effect
Salivary IgA	0.76	Medium to large
Serum IgG	0.68	Medium

Table 2 presents the effect sizes (Cohen's d) for the primary outcomes at the ninth month of the intervention, comparing participants who consumed cold meals to those who consumed warm meals. The values provide a standardized estimate of the magnitude of differences between the two groups, facilitating interpretation beyond statistical significance alone.

The **Digestive Health Score (DHS)** showed a **Cohen's d of 1.10,** which reflects a large effect size according to conventional benchmarks. This indicates that the cold meal intervention had a strong impact on reducing digestive symptoms relative to the warm meal control. A large effect suggests that the improvement in gastrointestinal comfort among cold meal consumers was not only statistically significant but also clinically meaningful. This finding supports the hypothesis that meal temperature plays a considerable role in symptom modulation for individuals with functional digestive discomfort.

For **salivary IgA**, the effect size was **0.76**, corresponding to a medium-to-large effect. Salivary IgA serves as a key marker of mucosal immunity, and its increase implies enhanced local immune defense, particularly within the gastrointestinal and upper respiratory tracts. The medium-to-large magnitude of change suggests that the cold meal intervention contributed to an immunologically beneficial environment, possibly through improved gut epithelial integrity and reduced inflammatory load. This finding has notable implications for nursing interventions aimed at bolstering frontline immunity in community populations.

The **serum IgG** level yielded a **Cohen's d of 0.68**, which is interpreted as a medium effect. While smaller than the effect observed for DHS, this still represents a substantial improvement in systemic immune function over the nine-month period. Serum IgG is indicative of longer-term humoral immunity, and a moderate increase reflects the potential of ambient-temperature meals to enhance broader immunological resilience. The consistency of immune-related improvements across both IgA and IgG underscores the systemic relevance of dietary temperature and reinforces the biological plausibility of the intervention.

Taken together, these effect sizes demonstrate that the intervention had varying degrees of influence across physiological domains: strong effects on symptomatic relief, and moderate to substantial effects on immune biomarkers. From a nursing and public health perspective, these findings suggest that simple, culturally adaptable dietary modifications—such as serving food at room temperature—may offer measurable benefits for digestive wellness and immune enhancement. These outcomes further validate the integration of dietary temperature considerations into holistic nursing care plans and community nutrition strategies.

Molecular and Chemical Rationale

Understanding the physiological effects of food temperature requires an interdisciplinary approach encompassing nutrition science, immunology, and molecular gastroenterology. Several biochemical and molecular mechanisms provide a plausible explanation for the observed benefits of consuming cold meals in improving digestive health and enhancing immune response. These mechanisms are discussed in the following sub-sections.

Enzymatic Integrity

Food processing and temperature exposure directly influence the structural stability of digestive enzymes and bioactive peptides. Elevated temperatures—commonly encountered in the preparation of warm meals—can cause irreversible denaturation of enzymes and proteins by disrupting their tertiary and quaternary structures. This structural disruption leads to a reduction in their biological activity, bioavailability, and therapeutic potential [9,10]. In contrast, cold meals preserve the integrity of these molecules. The maintenance of protein conformation at ambient temperatures supports the preservation of enzymatic functionality, allowing essential nutrients, peptides, and bioactive compounds to remain active as they enter the gastrointestinal tract. This preservation is particularly important for the stimulation of mucosal immunity, as intact peptides are more likely to interact with gut-associated lymphoid tissue (GALT), thereby promoting immune surveillance and local immune activation.

Maillard Reaction Products (MRPs)

Thermal processing, particularly at high temperatures, facilitates the formation of Maillard Reaction Products (MRPs), a group of complex molecules resulting from the non-enzymatic browning of sugars and amino acids. While MRPs contribute to flavor and aroma in cooked foods, their accumulation can have deleterious effects on gastrointestinal physiology. Specifically, MRPs have been shown to provoke oxidative stress, irritate the gut epithelial lining, and compromise tight junction proteins that maintain intestinal barrier function [11]. These effects can lead to increased intestinal permeability, commonly known as "leaky gut," and contribute to systemic inflammation. By minimizing exposure to high temperatures, cold meals naturally contain lower concentrations of MRPs. This reduced MRP content offers a protective effect against epithelial irritation and facilitates the maintenance of gut homeostasis.

Thermal Stress on the Gut Lining

Ingesting warm or hot meals introduces a thermal gradient to the gastric environment, elevating mucosal temperatures and potentially contributing to subclinical inflammation. This elevation in luminal temperature may disrupt the homeostatic balance of the mucosal surface, increasing epithelial permeability and promoting localized inflammatory responses [12]. Chronic or repeated thermal exposure may exacerbate mucosal damage, particularly in individuals with pre-existing gastrointestinal sensitivities. Cold meals, by contrast, exert a cooling effect on the gastric mucosa. This effect supports thermal stability and preserves the integrity of the epithelial barrier. Moreover, lower gastric temperatures may reduce the risk of endotoxin translocation from the gut lumen into systemic circulation, thereby mitigating inflammatory responses and supporting immune regulation [13]. From a therapeutic perspective, cold meals may thus act as modulators of gastric microenvironmental stress, offering both preventative and restorative benefits for gut health.

Prebiotic Retention

Prebiotics, such as oligosaccharides and resistant starch, are essential for the growth and maintenance of beneficial intestinal microbiota. These non-digestible food components serve as substrates for fermentation by commensal bacteria, leading to the production of short-chain fatty acids (SCFAs) that play a key role in gut barrier maintenance and immune function. Thermal processing can degrade or chemically modify these prebiotic compounds, diminishing their functional capacity [14]. Conversely, cold meal preparation avoids excessive heating, thereby preserving the structural integrity and functional activity of prebiotics. This preservation facilitates a more favorable gut microbiota composition and enhances mucosal immunity, including the promotion of secretory IgA production—a key immunoglobulin involved in protecting the intestinal lining from pathogenic invasion and maintaining microbial balance [15]. These findings underscore the importance of meal temperature not only in digestion but also in shaping host-microbe interactions and immune homeostasis.

The molecular and chemical rationale behind the cold meal intervention highlights a confluence of benefits rooted in the preservation of nutrient bioactivity, protection of the gut epithelium, and promotion of host immunity. These mechanisms provide a compelling scientific foundation for integrating ambient-temperature dietary strategies into evidence-based nursing and nutritional interventions for individuals experiencing gastrointestinal discomfort.

Discussion

This nine-month randomized controlled trial (RCT) conducted in Maluku Province offers compelling evidence that ambient-temperature meals—referred to here as cold meals—may serve as a safe, accessible, and non-pharmacological strategy to improve digestive health and enhance immune function. Participants who consistently consumed meals at room temperature (~25°C) experienced significant improvements in digestive comfort, as reflected by reduced Digestive Health Scores (DHS), and measurable increases in key immunological markers, namely salivary IgA and serum IgG. These outcomes point to a novel intersection between dietary temperature and human physiology, reinforcing the value of integrating environmental and nutritional variables into holistic healthcare.

The findings affirm the biochemical rationale that cold meals preserve enzymatic and prebiotic content, reduce the accumulation of harmful Maillard Reaction Products (MRPs), and help maintain the integrity of the gastrointestinal mucosa [9-15]. Such preservation is not trivial; it represents a molecular conservation of the bioactivity of food components that are otherwise vulnerable to thermal degradation. This may be particularly important in individuals with recurrent digestive discomfort, whose mucosal linings are often in a heightened state of vulnerability. By minimizing thermal stress on the gastric environment, cold meals contribute to a more stable gut barrier and support systemic immune readiness, as indicated by the improvements in both local (IgA) and systemic (IgG) immunoglobulin levels.

From a humanistic perspective, the intervention resonates with culturally grounded and economically feasible practices. In many parts of the world—including rural and semi-urban regions such as those in Maluku—meal preparation and consumption practices are often influenced by access to fuel, food preservation techniques, and longstanding cultural habits. Cold meal strategies may, therefore, align more naturally with local customs than high-technology or pharmaceutical interventions, making this approach particularly relevant for nursing professionals working in resource-limited settings. Moreover, by centering the intervention on daily eating practices, this study empowers individuals to take active roles in managing their health—an important tenet of humanistic nursing care [16-20].

The consistent improvement in immune biomarkers underscores a broader implication: dietary patterns, including food temperature, are not merely passive cultural expressions but active modulators of human biology. Nurses, nutritionists, and health educators can draw upon this insight to design evidence-informed dietary interventions that are respectful of local practices and biologically effective.

Nevertheless, several limitations should be acknowledged to contextualize the findings. First, the study was conducted in a single geographic and cultural setting. While this strengthens the internal validity and cultural relevance of the intervention, it also limits the generalizability of the results. Broader applicability across different climates, culinary traditions, and genetic backgrounds requires validation through future multicenter trials. Second, the use of self-reported symptom data, while practical and reflective of patient experience, may introduce recall or response biases. Future studies should incorporate more objective physiological assessments, such as gastric motility testing or endoscopic evaluations of mucosal integrity.

Moreover, this study did not investigate the gut microbiome, which plays a critical intermediary role between diet and immune regulation. Incorporating microbial sequencing in future trials would provide valuable insights into how ambient-temperature meals shape microbial diversity and function. Additionally, long-term outcomes beyond the nine-month period—such as recurrence of symptoms, changes in chronic inflammation markers, and quality of life assessments—remain to be studied.

This trial provides an important contribution to the growing field of food-based interventions in nursing science. The evidence supports the idea that cold meals are not only physiologically beneficial but also practical and culturally adaptable. As healthcare shifts toward more person-centered and prevention-focused paradigms, interventions like this may represent a low-cost, high-impact strategy to address the burden of functional gastrointestinal discomfort and suboptimal immunity. By translating molecular insights into daily practice, nurses are uniquely positioned to lead this integration of science, culture, and care [21-25].

Conclusion

Ambient-temperature meals may represent more than a nutritional choice—they offer a human-centered, non-pharmacological intervention that supports both digestive well-being and immune competence. In an era where functional gastrointestinal discomfort affects a significant portion of the global population, often without clear pathological findings or definitive treatments, the importance of gentle, accessible, and evidence-based solutions becomes increasingly relevant. The findings of this study suggest that by simply adjusting the temperature at which meals are consumed, individuals may experience meaningful relief from digestive symptoms and a measurable enhancement of immunological markers, such as salivary IgA and serum IgG.

From a nursing perspective, this intervention aligns closely with the profession's core values: compassion, cultural sensitivity, and the promotion of holistic health. Nurses are uniquely positioned to implement and advocate for dietary modifications that are not only grounded in scientific evidence but also attuned to the patient's lifestyle, environment, and cultural practices. Integrating cold meal strategies into dietary guidance is an opportunity to translate molecular and biochemical knowledge into tangible improvements in patient comfort and physiological resilience.

Moreover, this approach fosters a respectful partnership between healthcare providers and patients. Rather than imposing complex or costly medical interventions, nurses can empower individuals with practical, low-risk strategies that promote self-care and bodily awareness. The humanistic appeal of cold meals lies in their simplicity, accessibility, and compatibility with daily life—especially in communities where resources may be limited, but the desire for health and well-being is profound.

As healthcare systems worldwide strive for more sustainable and person-centered models of care, interventions such as ambient-temperature meals offer a compelling example of how scientific insight and human experience can be harmonized. Moving forward, nursing practice should continue to explore and validate such integrative strategies—honoring the interconnectedness of the body, environment, and cultural identity in the pursuit of health.

Limitations of the Study

While this study offers important insights into the physiological and immunological effects of cold meals, several limitations should be acknowledged to ensure balanced interpretation of the findings. First, the study was conducted in a single geographic region—Maluku Province, Indonesia—where dietary practices, climate, and cultural norms may have influenced participant responses and intervention adherence. As such, the generalizability of the results to other populations with different environmental or dietary contexts may be limited.

Second, digestive symptom outcomes were based on self-reported data using the Digestive Health Score (DHS), which, although validated, may be subject to recall bias, reporting inconsistencies, or individual variations in symptom interpretation. Future studies should consider complementing subjective assessments with objective diagnostic tools, such as gastrointestinal motility testing or endoscopic evaluations.

Third, the intervention focused solely on meal temperature, without controlling for other potentially confounding dietary variables such as meal timing, composition, or individual food preferences, all of which may influence digestive and immune responses.

Fourth, the study did not include microbiome profiling or biomarker analysis related to gut barrier function, both of which could provide deeper mechanistic understanding of how cold meals influence gastrointestinal and systemic health. Incorporating these biological markers in future research would enhance the explanatory power of the intervention.

Finally, the nine-month study period, while sufficient to observe medium-term effects, may not capture long-term outcomes or sustainability of health benefits. Longitudinal follow-up and multicenter trials are needed to evaluate the durability and broader applicability of cold-meal strategies in diverse clinical and community settings.

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Conflict of Interest Statement

The author declares no conflict of interest related to the design, implementation, analysis, or publication of this study. No financial, personal, or institutional relationships influenced the outcomes or interpretation of the findings.

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Implications for Nursing Practice

- **Dietary Guidance**: Nurses can recommend cold meals for patients with functional gastrointestinal discomfort.
- **Public Health**: Ambient temperature serving may be culturally and economically feasible in tropical regions.
- **Future Research**: Incorporate microbiome profiling, barrier integrity biomarkers, and longer follow up.

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