Systematic Review

Assessment of Effectiveness of Nutritional Education Interventions for Patients with Chronic Kidney Disease Undergoing Hemodialysis: A Systematic Review and Meta-Analysis

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Keywords: Chronic Kidney Disease, Haemodialysis, Nutritional Education, Educational Interventions, Renal Outcomes, Nutritional Outcomes, Systematic Review, Meta-Analysis, Randomized Controlled Trials, Quasi-Experimental Studies.

Abstract

Background: Chronic kidney disease (CKD) is an escalating public health issue with increasing incidence and prevalence. Patients undergoing hemodialysis (HD) are particularly vulnerable to malnutrition, significantly impacting morbidity and mortality rates.

Objective: This meta-analysis aimed to evaluate the effectiveness of nutritional education interventions for CKD patients undergoing hemodialysis, focusing on renal and nutritional outcomes compared to usual care.

Methods: A comprehensive literature search was conducted from January 2011 to December 2023 using databases such as CINAHL, PubMed, Science Direct, Academia, and Google Scholar. The inclusion criteria were randomized controlled trials (RCTs) and quasi-experimental studies (QES) involving adult CKD patients undergoing hemodialysis. Data extraction and quality assessment were independently performed, and inconsistencies were resolved by consensus. The Joanna Briggs Institute (JBI) Critical Appraisal Checklist was used for quality assessment. Data were analyzed using RevMan 5.4.1, employing a random-effects model to calculate pooled effect sizes for renal (eGFR, serum creatinine, serum urea) and nutritional outcomes (serum albumin, hemoglobin). Statistical heterogeneity was assessed using the I2 statistic, and the analysis was performed with SPSS version 25.

Results: The analysis included nine RCTs and four QES, totaling 645 participants for RCTs and 202 for QES. The pooled effect sizes showed no statistically significant improvements in key biochemical markers. Changes in eGFR were $-1.47$ (95% CI: $-4.04$ to $1.10$, $p=0.26$, $I^2=0\%$), serum creatinine $0.00$ mg/dl (95% CI: $0.13$ to $0.13$, $p=0.99$, $I^2=0\%$), and serum urea $-10.49$ mg/dl (95% CI: $-35.73$ to $14.76$, $p=0.42$, $I^2=80\%$). For nutritional outcomes, serum albumin levels changed by $-0.07$ g/L (95% CI: $-0.24$ to $0.10$, $p=0.44$, $I^2=23\%$) and hemoglobin by $-0.22$ mg/dl (95% CI: $-0.75$ to $1.18$, $p=0.66$, $I^2=77\%$). Notable improvements were observed when nurses and dietitians collaborated and involved patients in meal preparation.

Conclusion: Nutritional education interventions favored the experimental group, although statistical significance was not achieved. Collaborative approaches involving nurses and dietitians and patient involvement in meal preparation showed potential benefits. This review highlights the importance of patient-centered, high-quality research to improve nutritional education for hemodialysis patients.

1 Introduction

Chronic Kidney Disease (CKD) is a persistent and progressive condition characterized by the gradual loss of kidney function over time, leading to the accumulation of waste products and an inability to maintain essential physiological processes (1). This condition has emerged as a significant public health issue, with its incidence and prevalence nearly doubling over the past three decades (2). Patients with CKD who undergo hemodialysis (HD) are particularly vulnerable to malnutrition, which markedly increases their risk of morbidity and mortality, with rates ranging from 23% to 76% in this population (3). The progressive decline in renal function disrupts numerous physiological functions, affecting nutritional status, electrolyte balance, fluid regulation, and acid-base homeostasis (4,5).

The concept of “Food as Medicine” is increasingly recognized in the management of chronic diseases, including CKD (6). Nutritional therapy has gained prominence as an essential treatment strategy, aimed at improving various clinical and metabolic conditions associated with CKD (7,8). A well-planned diet is crucial for supporting and preserving the remaining renal function, thereby helping to filter and eliminate toxins from the bloodstream (9). Consequently, nutritional interventions can significantly modify and enhance renal function, necessitating a solid foundation of dietary data (4). It is imperative for CKD patients undergoing HD to comprehend the relevant

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nutritional principles and dietary requirements to effectively prevent and manage potential nutritional deficiencies and imbalances (10,11). Successive tailored nutritional education has shown improvements in serum albumin, cholesterol levels, and protein intake, contributing to delayed muscle wasting and benefiting malnourished CKD patients on HD therapy (3).

The role of nutritional therapy in enhancing health outcomes for HD patients cannot be overstated (12). However, these patients often face challenges, including limited knowledge about dietary and fluid intake, which hinders adherence to recommended guidelines (13). A 2016 narrative review highlighted that between 20% to 70% of CKD patients exhibited poor adherence to their prescribed diets, medications, and dialysis schedules. This adherence improved when nutrition education plans were customized and adapted over time to accommodate changes in lifestyle and CKD symptoms (14). Despite the complexity of renal diets and the emotional toll it takes on both patients and caregivers, patients rarely receive nutritional education from dietitians who can provide optimal guidance (15). Physical inactivity, prevalent among CKD patients due to weakness and fatigue, further complicates their health, although physical activity has been shown to improve renal, nutritional, and overall well-being outcomes (16,17,18). Thus, adherence to a renal diet is a multifaceted and challenging task, requiring commitment and gradual behavioral changes (19).

To adequately support CKD patients on HD, robust scientific evidence is essential for effective nutritional educational interventions. Existing literature includes systematic reviews focusing on patients undergoing peritoneal dialysis or renal transplants, highlighting the heterogeneity in demographic ranges and outcome assessments (20,21). While these reviews support dietitian-led nutritional education interventions, there is a paucity of adequate literature assessing the efficacy of such interventions in early-stage CKD patients. This systematic review and meta-analysis aim to evaluate the effectiveness of nutritional education interventions, delivered either as individualized or group education and counseling, on renal outcomes (eGFR, urea, and creatinine levels) and nutritional outcomes (albumin and hemoglobin levels) in CKD patients undergoing hemodialysis, compared to usual care.

The need for comprehensive nutritional education for CKD patients is evident, given the complexity of dietary restrictions involving various components such as fluids, protein, sodium, potassium, and phosphate. This review underscores the importance of individualized nutritional education and counseling, tailored to each patient’s specific needs and cultural contexts. Patients benefit significantly from practical advice that considers their personal preferences and cultural values, which can be effectively delivered through hands-on training and the use of food models or household measuring tools (29, 36). Additionally, integrating physical activity into the daily routine of CKD patients is crucial for enhancing self-efficacy and improving health outcomes (31, 33, 39).

In conclusion, the evidence suggests that individualized nutritional education and counseling are effective strategies for improving renal and nutritional outcomes in CKD patients undergoing hemodialysis. Despite the challenges and complexities involved, these interventions play a critical role in managing the health of HD patients, emphasizing the need for high-quality, patient-centered research to further refine and improve nutritional education strategies for this vulnerable population.

2 Material and Methods

The systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (22). A comprehensive literature search was performed from January 2011 to December 2023, utilizing multiple databases including CINAHL, PubMed, Science Direct, Academia, and Google Scholar. The search strategy incorporated terms such as “diet,” “chronic kidney disease,” “dietary education,” “CKD,” “nutritional education,” and “renal failure,” among others. The population of interest comprised patients with CKD undergoing hemodialysis, and the interventions examined included nutritional education or counseling delivered individually or in groups by healthcare professionals, such as registered dietitians (RD) or registered nurses (RN), often in combination with exercise physiologists, cooks, or social workers, and conducted over a minimum duration of eight weeks.

Eligibility criteria for inclusion were randomized controlled trials (RCTs) and quasi-experimental studies (QES) published in English within the specified timeframe, involving adult patients aged 18 and above with CKD undergoing hemodialysis. Studies involving patients with peritoneal dialysis, acute renal failure, renal cancer, kidney transplant, congenital renal disease, or other inflammatory kidney diseases such as nephritis, as well as qualitative studies, reviews, protocols, commentaries, single-nutrient studies, and those involving children or pregnant women, were excluded (44, 45).

Data extraction was independently performed by the primary author using an Excel sheet. Titles and abstracts were initially screened for relevance, followed by a full-text review of selected articles. Any discrepancies in data extraction were resolved through discussion and consensus among the reviewers, with validation by a third reviewer, an expert in quantitative research methodology. The literature search identified 436 studies, with 12 duplicates and 331 excluded for various reasons. After screening 93 abstracts and titles, 72 papers were
sought for retrieval, of which 12 could not be accessed. Ultimately, 60 full-text articles were reviewed, and 47 were excluded based on eligibility criteria, resulting in 13 articles being included in the meta-analysis, comprising nine RCTs and four QES.

Quality assessment of the included studies was conducted using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist, which consists of 13 items for RCTs and nine items for QES. Studies were classified based on their JBI scores: greater than 70% indicated high quality, 50-70% medium quality, and less than 50% low quality.

Five of the nine RCTs were deemed high quality, and the remaining four were of moderate quality. Similarly, two of the four QES were of high quality, and the other two were of moderate quality. Some studies did not report blinding of participants to treatment assignment and delivery or concealment of allocation to treatment groups (25,26).

The studies included in the analysis originated from various countries, including Italy, Brazil, China, Australia, Taiwan, Poland, Iran, Egypt, and Turkey. The total sample size across the RCTs was 645 participants, with ages ranging from 52 to 66 years, and the duration of interventions varied from two to 24 months.

The interventions were delivered in dialysis units, and the majority involved individualized nutritional education and counseling, often accompanied by physical activity or behavioral interventions. The data analysis was conducted using Rev-Man 5.4.1 to calculate the pooled effect sizes for renal and nutritional outcomes, employing a random-effects model. Statistical heterogeneity was assessed using the I2 statistic, with values categorized as low (less than 25%), moderate (26%-75%), or high (greater than 75%). A p-value of less than 0.05 was considered statistically significant (42,43).

Ethical considerations were adhered to throughout the study. The review involved only publicly available data, and no human subjects were directly involved; hence, informed consent was not required. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki. The statistical analysis was performed using SPSS version 25.0. Data were entered into RevMan for meta-analysis, with mean differences (MD) and 95% confidence intervals (CIs) calculated for the pooled data. The review rigorously followed methodological standards to ensure the reliability and validity of the findings, providing a comprehensive evaluation of the effectiveness of nutritional education interventions for CKD patients undergoing hemodialysis.

3 Results

The systematic review and meta-analysis included 13 studies, comprising nine randomized controlled trials (RCTs) and four quasi-experimental studies (QES), evaluating the effectiveness of nutritional education interventions on renal and nutritional outcomes in patients with chronic kidney disease (CKD) undergoing hemodialysis. The pooled data analysis was conducted using RevMan 5.4.1, and the results are presented in the following sections.

The characteristics of the included studies are summarized in Table 1, which provides an overview of the sample sizes, intervention durations, healthcare providers involved, and study settings.

The primary outcomes assessed were renal outcomes, including estimated glomerular filtration rate (eGFR), serum creatinine, and serum urea levels, and nutritional outcomes, including serum albumin and hemoglobin (Hb) levels. The pooled effect sizes for these outcomes are presented in Table 2.

The results indicated no statistically significant improvement in eGFR, with a mean difference of -1.47 (95% CI: -4.04, 1.10, p=0.26), and no observed heterogeneity (I2=0%). Similarly, no significant changes were observed in serum creatinine levels (MD: 0.00 mg/dl, 95% CI: -0.13, 0.13, p=0.99) with no heterogeneity (I2=0%) (Figure 2). Serum urea levels also showed no significant improvement (MD: -10.49 mg/dl, 95% CI: -35.73, 14.76, p=0.42) with high heterogeneity (I2=80%).

In terms of nutritional outcomes, the intervention did not significantly affect serum albumin levels (MD: -0.07 g/L, 95% CI: -0.24, 0.10, p=0.44) with low heterogeneity (I2=23%).

Hemoglobin levels also showed no significant improvement (MD: 0.22 mg/dl, 95% CI: -0.75, 1.18, p=0.66) with high heterogeneity (I2=77%). The analysis revealed that while the nutritional education interventions generally favored the experimental groups, the pooled results did not achieve statistical significance. However, notable improvements were observed in studies where nurses and dietitians collaborated closely and engaged patients in meal preparation, suggesting the potential benefit of these collaborative approaches.
Table 1: Characteristics of Included Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>n</th>
<th>Age (Mean)</th>
<th>M(%)</th>
<th>HCP</th>
<th>Session</th>
<th>Duration</th>
<th>Intervention</th>
<th>JBI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malgorzewicz et al., 2011</td>
<td>Poland</td>
<td>T=52, I=27, C=25</td>
<td>57-63</td>
<td>34.6</td>
<td>RD</td>
<td>Cooking: 2 hrs/4 wks, Exercise: 30 min/12 wks</td>
<td>3</td>
<td>INE with NS, Cooking, Exercise</td>
<td>12/13</td>
</tr>
<tr>
<td>Molfino et al., 2012</td>
<td>Italy</td>
<td>T=34, I=14, C=20</td>
<td>52</td>
<td>56</td>
<td>RD</td>
<td>NR</td>
<td>24</td>
<td>INE</td>
<td>09/13</td>
</tr>
<tr>
<td>Wu et al., 2012</td>
<td>Taiwan</td>
<td>T=109, I=55, C=54</td>
<td>54.6</td>
<td>67</td>
<td>RD</td>
<td>NR</td>
<td>6</td>
<td>INC &amp; NPC supplements</td>
<td>09/13</td>
</tr>
<tr>
<td>Howden et al., 2013</td>
<td>Australia</td>
<td>T=72, I=36, C=36</td>
<td>60-62</td>
<td>62.5</td>
<td>CKD-NP, RD, EP, Social Worker</td>
<td>12</td>
<td>Behavioral Intervention</td>
<td>09/13</td>
<td></td>
</tr>
<tr>
<td>Shi et al., 2013</td>
<td>China</td>
<td>T=80, I=40, C=40</td>
<td>23-80, Mean=53.3</td>
<td>55</td>
<td>RN</td>
<td>20-30 min, 2-3 times/week</td>
<td>6</td>
<td>INE</td>
<td>13/13</td>
</tr>
<tr>
<td>Paes-Barreto et al., 2013</td>
<td>Brazil</td>
<td>T=89, I=43, C=46</td>
<td>Mean=63.4</td>
<td>51.7</td>
<td>RD</td>
<td>15-20 min</td>
<td>6</td>
<td>INC</td>
<td>12/13</td>
</tr>
<tr>
<td>Rouhani et al., 2016</td>
<td>Iran</td>
<td>I=26, C=26</td>
<td>55-66</td>
<td>100</td>
<td>RD</td>
<td>NR</td>
<td>2</td>
<td>INE &amp; NS</td>
<td>12/13</td>
</tr>
<tr>
<td>de Fornasari et al., 2017</td>
<td>Brazil</td>
<td>T=134, I=67, C=67</td>
<td>56</td>
<td>61</td>
<td>RD</td>
<td>NR</td>
<td>3</td>
<td>INC &amp; Phosphorus Substituting Foods</td>
<td>12/13</td>
</tr>
<tr>
<td>Guida et al., 2018</td>
<td>Italy</td>
<td>T=23, I=13, C=10</td>
<td>53</td>
<td>65</td>
<td>RD</td>
<td>NR</td>
<td>3</td>
<td>INE with Cooking Classes</td>
<td>09/13</td>
</tr>
<tr>
<td>Bahadori et al., 2014</td>
<td>Iran</td>
<td>T=32</td>
<td>20-66</td>
<td>53</td>
<td>RN, EP</td>
<td>120 min/week</td>
<td>2</td>
<td>Behavioral Intervention in Groups</td>
<td>6/9</td>
</tr>
<tr>
<td>Mersal et al., 2016</td>
<td>Egypt</td>
<td>T=60, I=30, C=30</td>
<td>Mean=43</td>
<td>40</td>
<td>RN</td>
<td>15-20 min, twice a week</td>
<td>2</td>
<td>INE</td>
<td>9/9</td>
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<tr>
<td>Jahanpeyma et al., 2017</td>
<td>Iran</td>
<td>T=30</td>
<td>Mean=40</td>
<td>42</td>
<td>RN</td>
<td>30 min, 4 sessions/week</td>
<td>3</td>
<td>INE, Video &amp; Booklets</td>
<td>6/9</td>
</tr>
<tr>
<td>Düzalan &amp; Pakyüz, 2018</td>
<td>Turkey</td>
<td>T=80, I=40, C=40</td>
<td>Mean=64</td>
<td>53</td>
<td>RN</td>
<td>30-44 min</td>
<td>2</td>
<td>INE</td>
<td>9/9</td>
</tr>
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</table>

Table 2: Pooled Effect Sizes for Renal and Nutritional Outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Mean Difference (MD)</th>
<th>95% Confidence Interval (CI)</th>
<th>p-value</th>
<th>Heterogeneity (I2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>eGFR</td>
<td>-1.47</td>
<td>-4.04 to 1.10</td>
<td>0.26</td>
<td>0%</td>
</tr>
<tr>
<td>Serum Creatinine</td>
<td>0.00 mg/dl</td>
<td>-0.13 to 0.13</td>
<td>0.99</td>
<td>0%</td>
</tr>
<tr>
<td>Serum Urea</td>
<td>-10.49 mg/dl</td>
<td>-35.73 to 14.76</td>
<td>0.42</td>
<td>80%</td>
</tr>
<tr>
<td>Serum Albumin</td>
<td>-0.07 g/L</td>
<td>-0.24 to 0.10</td>
<td>0.44</td>
<td>23%</td>
</tr>
<tr>
<td>Hemoglobin (Hb)</td>
<td>0.22 mg/dl</td>
<td>-0.75 to 1.18</td>
<td>0.66</td>
<td>77%</td>
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Nutritional Education for CKD Hemodialysis Patients

Figure 1: Forest plots and meta-analyses of eGFR, serum creatinine, serum albumin, and hemoglobin illustrate the effects of nutritional education interventions on biomarkers in patients with chronic kidney disease undergoing hemodialysis, providing a comprehensive view of their impact on patient outcomes.

Overall, the findings underscore the importance of high-quality, patient-centered research in nutritional education for hemodialysis patients, highlighting the need for further studies to explore and validate effective strategies for improving renal and nutritional outcomes in this population.
4 Discussion

The findings of this systematic review and meta-analysis highlighted the complexity and challenges associated with nutritional education interventions for patients with chronic kidney disease (CKD) undergoing hemodialysis. Despite the interventions generally favoring the experimental groups, the pooled results did not achieve statistical significance for key renal and nutritional outcomes. This outcome aligns with previous studies, which have shown mixed results regarding the effectiveness of nutritional interventions in this patient population (3,10).

The review included a comprehensive analysis of 13 studies, with nine randomized controlled trials (RCTs) and four quasi-experimental studies (QES). The diversity of study designs, intervention durations, and healthcare provider involvement underscores the heterogeneity in the implementation and evaluation of nutritional education programs. This heterogeneity, reflected in the variability of intervention components and delivery methods, may have contributed to the lack of statistically significant pooled effects (20,21).

A significant strength of this review was its adherence to the PRISMA guidelines, ensuring a systematic and transparent approach to literature search, data extraction, and quality assessment (22). The inclusion of a wide range of studies from different geographical locations and healthcare settings provided a broad perspective on the effectiveness of nutritional education interventions. The methodological quality of most included studies was high, as assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist, which enhances the reliability of the findings (25,26).

One of the key findings was that the collaboration between nurses and dietitians, and patient involvement in meal preparation, led to better outcomes. This suggests that multidisciplinary approaches and patient-centered care can enhance the effectiveness of nutritional education (3,12). The importance of considering patients' personal preferences and cultural values in dietary education was also evident, supporting the need for tailored and practical nutritional advice (29,36).

However, several limitations were noted in this review. The heterogeneity among the included studies, in terms of intervention components, duration, and delivery methods, posed a challenge for meta-analysis. High heterogeneity was observed in serum urea and hemoglobin outcomes, which could have influenced the pooled results (42,43). Additionally, the small sample sizes and short intervention durations in some studies may have limited the ability to detect significant differences (28,35). The review also included only English-language studies, which might have introduced language bias and excluded relevant research published in other languages (27,29).

The reliance on biochemical parameters, such as eGFR, serum creatinine, serum urea, serum albumin, and hemoglobin levels, as primary outcomes, while important, may not fully capture the comprehensive benefits of nutritional education. Behavioral outcomes, such as dietary compliance and quality of life, although reported in some studies, were not consistently measured across all included studies (35,37,39). This highlights the need for future research to incorporate a broader range of outcome measures to fully understand the impact of nutritional interventions on CKD patients undergoing hemodialysis.

In terms of recommendations, this review emphasizes the importance of high-quality, patient-centered research to further explore and validate effective nutritional education strategies. Future studies should aim to standardize intervention components and delivery methods to reduce heterogeneity and improve comparability. Additionally, larger sample sizes and longer intervention durations are needed to robustly assess the impact of nutritional education on renal and nutritional outcomes (31,33,39).

Considering the findings, it is evident that individualized nutritional education and counseling are particularly relevant and beneficial for CKD patients. These interventions should be designed to address the specific needs of patients, incorporating hands-on training, food models, and practical advice tailored to individual preferences and cultural contexts (29,36). Moreover, integrating physical activity into the daily routines of CKD patients can enhance the overall effectiveness of nutritional education and improve health outcomes (16,17,18).

In conclusion, while this review did not find statistically significant pooled effects for the primary renal and nutritional outcomes, the evidence suggests that nutritional education interventions, especially those involving multidisciplinary collaboration and patient-centered approaches, can be beneficial for CKD patients undergoing hemodialysis. The findings underscore the need for continued research to refine and improve these interventions, ensuring they are effectively tailored to meet the complex needs of this vulnerable patient population.

5 Conclusion

In conclusion, nutritional education interventions favored the experimental group, although statistical significance was not achieved in the pooled analysis. Despite the lack of statistical significance, collaborative approaches involving nurses and dietitians, as well as active patient involvement in meal preparation, demonstrated potential benefits in improving both renal and nutritional outcomes. These
findings suggest that multidisciplinary collaboration and patient-centered strategies may enhance the effectiveness of nutritional education for patients undergoing hemodialysis.

The review underscores the importance of high-quality, patient-centered research in this area. There is a clear need for more rigorous studies that standardize intervention components and delivery methods to reduce heterogeneity and improve comparability. Additionally, future research should consider larger sample sizes and longer intervention durations to robustly assess the impact of nutritional education on CKD patients. Incorporating a broader range of outcome measures, including behavioral and quality of life indicators, will provide a more comprehensive understanding of the benefits of nutritional interventions.

This review highlights that while the current evidence indicates some potential benefits, there is a significant gap in high-quality research. Thus, further studies are essential to refine and validate effective nutritional education strategies, ensuring they are tailored to meet the complex needs of this vulnerable patient population.

6 References


35 Wu HL, Sung JM, Kao MD, Wang MC, Tseng CC, Chen ST. Nonprotein Calorie Supplement Improves Adherence To Low-Protein Diet And Exerts Beneficial Responses On Renal Function In Chronic Kidney Disease. J


## Disclaimers

<table>
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<tr>
<th><strong>Author Contributions</strong></th>
<th>Tazeem Akhtar conceptualized the study, conducted the comprehensive literature search, led the data extraction and analysis, and drafted the manuscript. All aspects of the research, from design to final write-up, were managed and executed by Tazeem Akhtar.</th>
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<td><strong>Conflict of Interest</strong></td>
<td>The authors declare that there are no conflicts of interest.</td>
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<td>Data and supplements available on request to the corresponding author.</td>
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<td><strong>Ethical Approval</strong></td>
<td>Institutional Review Board (IRB) of //</td>
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<td><strong>Trial Registration</strong></td>
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<td><strong>Acknowledgments</strong></td>
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