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Original Paper

Study on Prevention of Pregnancy Complications and Health Management Based on Prenatal Dietary Nutrition Intervention from Public Health Perspective

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Abstract

Pregnancy complications (such as pregnancy diabetes, pregnancy hypertension, anemia, etc.) seriously threaten the health of mothers and infants. The traditional passive management model, which focuses on clinical treatment after the occurrence of complications, has problems such as delayed intervention, high cost, and limited effect. From the perspective of public health, promoting the transformation of pregnancy health management from "passive treatment" to "active nutritional intervention" is an inevitable choice to reduce the incidence of pregnancy complications and improve the health level of mother and baby. This article refers to the standardized academic paper architecture, systematically elaborates on the core differences between passive clinical management and active dietary nutrition intervention, constructs an active health management framework with maternal full cycle nutrition data as the core, multi-source monitoring as the support, risk prediction and stratified intervention as the engine, studies the key implementation paths of data collection, nutrition assessment, risk warning, personalized intervention, and effect evaluation, proposes a technology system and guarantee measures for transformation and implementation, aiming to provide theoretical and practical support for the prevention and control of pregnancy complications.

Keywords

public health, Dietary nutrition during pregnancy, Pregnancy complications, Proactive health management, Data driven, risk stratification

1. Introduction

1.1 Research Background and Significance

Pregnancy complications are one of the main causes of maternal mortality, abnormal fetal development,

and adverse pregnancy outcomes. There are about 15 million pregnant women in China every year. The incidence rate of diabetes in pregnancy has reached 15%~20%, the incidence rate of hypertension in pregnancy is about 5%~12%, and the prevalence of iron deficiency anemia in pregnancy is more than 30%. Traditional pregnancy management focuses on clinical intervention after discovering abnormalities during prenatal examinations, presenting a passive mode of "complication occurrence diagnosis treatment". The timing of intervention is delayed, medical resources are consumed, and it is difficult to prevent the pathological progression of complications. The public health perspective emphasizes "prevention first, moving the checkpoint forward", and through systematic, group, and continuous dietary and nutritional interventions, risk control can be started in early pregnancy or even before pregnancy, which is the fundamental path to reduce the burden of complications and achieve full life cycle health management. Conducting this study will contribute to the construction of an active prenatal nutrition and health management system, which is of great practical significance for implementing the "Healthy China 2030" strategy and optimizing the allocation of maternal and child health resources.

1.2 Review of Domestic and Foreign Research

Developed countries generally incorporate nutrition intervention during pregnancy into the public health service system. The United Kingdom, the United States and other countries have established a layered nutrition guidance program based on pre pregnancy BMI, dietary intake, metabolic markers, and achieved dynamic monitoring and feedback through electronic health records. The incidence of diabetes and macrosomia during pregnancy has significantly decreased. In recent years, there has been a gradual promotion of prenatal nutrition clinics and personalized dietary guidance in China, but there are still some shortcomings in implementation: nutritional interventions rely heavily on empirical education and lack quantitative data support; The collection of dietary information for pregnant and postpartum women is fragmented and not effectively integrated with clinical testing data; The accuracy of risk prediction models is insufficient, making it difficult to achieve precise stratification; Poor compliance with intervention measures and lack of closed-loop effect evaluation. Most regions are still in a passive situation of "heavy inspection and light intervention". Existing research mostly focuses on single nutrients or single diseases, lacking systematic research on building an active nutrition intervention system from a public health perspective. This article takes this as a starting point and proposes a data-driven active health management model.

2. Current Situation and Transformation Demands of Nutritional Management During Pregnancy

2.1 Characteristics and Practical Shortcomings of Passive Management Mode

The passive management mode is based on the core process of "discovering problems during prenatal examination clinical diagnosis symptomatic treatment", mainly relying on nodal events such as mid-term OGTT screening, blood pressure measurement, and blood routine examination. Its typical characteristics are: late intervention initiation, and most complications are already in the clinical stage when first diagnosed after 24 weeks of pregnancy; Nutritional guidance is fragmented, mostly consisting of one-

time education or generic recipes, lacking dynamic adjustments; Lack of information exchange, separation of dietary self description, body composition, biochemical indicators, and lifestyle data; Low compliance and lack of continuous monitoring and feedback mechanisms. This model led to a large number of preventable complications that delayed the intervention window. For example, the impact of early hyperglycemia in pregnancy with diabetes on the development of fetal organs could not be reversed, and drugs or even insulin treatment was required after diagnosis, significantly increasing medical costs and maternal psychological burden.

2.2 The Connotation and Core Advantages of Active Dietary Nutrition Intervention

Active dietary nutrition intervention is based on the continuous management of the entire cycle from pre pregnancy to early pregnancy to mid to late pregnancy, emphasizing early identification of risk factors, dynamic assessment of nutritional status, pre adjustment of personalized dietary plans, and intelligent tracking of compliance. Its core connotation includes: from "waiting for the onset of diseases" to "preventing the onset of diseases", from "general guidance" to "precise nutrition", from "single examination" to "continuous monitoring", from "experience decision-making" to "data decision-making". The core advantages are as follows: significantly reduce the incidence of complications such as diabetes, hypertension and anemia during pregnancy; Reduce hospitalization and medication use, and save medical resources; Improve delivery outcomes (reduce cesarean section rate, macrosomia rate, premature birth rate); Enhancing the self-management ability and health literacy of pregnant and postpartum women, achieving dual benefits of short-term complication prevention and long-term chronic disease prevention.

2.3 Key Bottlenecks in Transitioning to Proactive Intervention

The transformation faces three core bottlenecks: firstly, incomplete data collection, most pregnant women lack continuous dietary records, and dynamic data such as body composition and blood glucose fluctuations are missing; Secondly, there is insufficient stratification ability, and existing risk assessment tools lack early pregnancy prediction models based on the Chinese population; The third is to intervene in closed-loop breakage, where there is no execution feedback or dynamic optimization mechanism after the nutrition prescription is issued. Breaking through bottlenecks requires building an active nutrition intervention system from a public health perspective, with data as the main line, hierarchical models as the support, and digital management tools as the carrier.

3. Overall Architecture of Proactive Nutrition Intervention Health Management System

3.1 Data Driven Proactive Health Management Logic

Taking the full cycle nutrition and health data of pregnant and postpartum women as the core asset, following the closed-loop logic of "data collection nutrition assessment risk stratification precise intervention dynamic monitoring effectiveness evaluation". Through the integration of multiple data sources such as wearable devices, dietary recording apps, and clinical testing systems, an individualized nutrition digital portrait is established. Machine learning algorithms are used to predict the probability of complications, output graded intervention strategies (universal health education, enhanced nutrition

counseling, medical nutrition treatment), and continuously track indicators such as blood glucose, blood pressure, weight gain, hemoglobin, etc. The plan is dynamically adjusted to achieve a closed-loop management.

3.2 Proactive Intervention Data System and Standards

The data system covers four categories: basic data (age, parity, BMI, genetic history, history of previous pregnancy complications); Monitoring data (fasting and postprandial blood glucose, blood pressure, hemoglobin, urinary ketones, body composition, dietary intake logs); Behavioral data (exercise intensity, sleep, medication adherence); External data (season, regional dietary culture, food supply). Establish a unified data collection frequency (such as daily recording of dietary logs and 2-4 weekly monitoring of blood glucose), format, and interface standards, and establish data quality control and privacy protection mechanisms.

3.3 Four Layer Integrated Overall Architecture Design

Based on the closed-loop logic of full cycle data, build a four layer architecture consisting of perception collection layer, data resource layer, intelligent analysis layer, and landing application layer. At the bottom level, through intelligent devices APP、 Medical institutions collect various maternal and child health data; Middle level unified organization and storage of all standardized data; The analysis layer relies on algorithms to complete nutritional assessment and risk grading warning; Top level personalized interventions are implemented for pregnant women, medical staff, and public health managers, with feedback data flowing back to the front-end to form a circular management.

Table 1. Brief Explanation of Four Layer Architecture

Level	Main Content
Perception & Collection Layer	Intelligent devices, mobile APPs, offline prenatal examination data entry
Data Resource Layer	Data sorting, filing and privacy-preserving storage
Intelligent Analysis Layer	Risk assessment and formulation of intervention plans
Application Implementation Layer	Personalized guidance and administrative statistics

4. Key Technical Methods for Active Nutritional Intervention

4.1 Multimodal Assessment Technology for Maternal Nutrition Status

Integrating multimodal information such as 24-hour dietary review method, food frequency questionnaire, image recognition dietary records (using AI to identify the type and amount of food on the plate), body composition analyzer (muscle mass, fat percentage, visceral fat grade), biomarkers (prealbumin, ferritin, vitamin D), etc., to achieve accurate baseline assessment of nutritional status. By cross validation of multidimensional data, the problem of large deviation in self-report of a single diet can be solved, providing a reliable basis for stratified intervention.

4.2 Risk Prediction and Early Warning Model for Pregnancy Complications

Using early pregnancy (≤ 13 weeks) data as input, a mixed prediction model was constructed: traditional logistic regression selected strong correlation factors such as age, pre pregnancy BMI, family history, and previous GDM history; Machine learning (XGBoost, random forest) incorporates nonlinear features such as dietary structure, body composition, and exercise intensity to output individualized risk probabilities and ranking of major risk factors. Set dynamic warning threshold: If the risk probability is higher than 80% and the abdominal blood glucose is>5.3mmol/L for 3 consecutive days, a red warning will be triggered, and nutritionist intervention and daily blood glucose monitoring will be initiated.

4.3 Layered and Graded Precise Dietary Intervention Strategy

Implement differentiated interventions based on risk levels:

Low risk: Universal health education, promotion of dietary guidelines during pregnancy, weekly weight self testing.

Medium risk: Individualized nutrition plan (sugar control, iron supplementation, salt restriction, etc.), at least one dietary review and blood glucose/blood pressure feedback per week, intelligent reminders of meal order, portion size, and additional meals.

High risk: Medical nutrition therapy combined with outpatient follow-up, continuous dynamic blood glucose monitoring, customized menus and recipes, regular follow-up to adjust plans.

The intervention plan adopts a multi-objective optimization model (meeting nutritional needs, controlling blood sugar/blood pressure, conforming to personal dietary preferences, and minimizing costs) to improve compliance.

4.4 Dynamic Evaluation and Closed-loop Optimization of Intervention Effects

Establish short-term, medium-term, and long-term three-level evaluation indicators: short-term refers to the weekly compliance rate (blood glucose, blood pressure, dietary compliance); Mid term incidence of complications (GDM, preeclampsia, anemia); Long term delivery outcomes (macrosomia, low birth weight, premature birth, cesarean section) and postpartum recovery. Using reinforcement learning algorithms, personalized intervention strategies are adjusted based on each evaluation feedback to achieve continuous optimization of "evaluation adjustment re evaluation".

5. Implementation Path and Guarantee Measures

5.1 Phased Implementation Path

Phase 1 (Infrastructure Construction Period): Build a maternal nutrition and health data platform, develop data collection standards, pilot deploy a dietary AI recognition and real-time blood glucose upload system in maternal and child health hospitals, and complete personnel training.

Phase 2 (Capability Enhancement Period): Launch a risk prediction model and a layered intervention engine, select 3-5 communities to conduct active intervention control studies, verify the effectiveness of the model and the feasibility of the intervention process.

Phase Three (Comprehensive Promotion Period): Incorporate proactive nutrition intervention into the

basic public health service pregnancy health management package, connect with regional health information platforms, and achieve full coverage and normalized operation.

5.2 Technical Equipment and Platform Support

Develop or integrate low-cost intelligent hardware (Bluetooth blood glucose meter, blood pressure monitor, smart weight scale); Develop a maternal health management app (supporting meal photo recognition, task reminders, online consultation, and report generation); Build a cloud based decision support system to achieve automatic data analysis and warning, and collaborate with nutritionist workstations. The platform must comply with information security level protection and privacy regulations.

5.3 Management Mechanism and Talent Team Guarantee

Adjust the assessment mechanism to include the coverage rate of nutritional interventions during pregnancy, the control rate of complications, and the compliance rate in the performance evaluation of maternal and child health care. Establish a multidisciplinary team consisting of nutritionists, obstetricians, and health managers to conduct evidence-based training based on real-world data; Implement a health credit incentive mechanism for pregnant and postpartum women to enhance their willingness to actively participate.

6. Discussion

This article starts from the perspective of public health and systematically studies the data-driven methods for the transformation of dietary nutrition intervention during pregnancy from "passive clinical treatment" to "active health management". It clarifies the shortcomings of passive mode and the advantages of active intervention, constructs an active nutrition intervention system that includes perception, data, analysis, and application, proposes key technical paths for multimodal nutrition assessment, complication risk warning, layered precision intervention, and closed-loop optimization, and plans a dual guarantee measure of phased implementation path and technical management. Research has shown that proactive dietary nutrition interventions centered on data can effectively improve the prevention and control of pregnancy complications, reduce medical burden, improve maternal and infant outcomes, and provide practical engineering solutions and policy references for building a full cycle health management system covering pre pregnancy, pregnancy, and postpartum.

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