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RESEARCH

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Development of an algorithm impacting COPD care through personalized nutrition and IoT-based monitoring

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Abstract

Background Chronic obstructive pulmonary disease (COPD) is a chronic respiratory condition characterized by high morbidity and mortality rates. This study aims to assess the clinical outcomes of COPD patients after implementing an algorithm within the MyTatva app.

Methods The study involved a sample of 10 COPD patients, evaluating key parameters such as Forced Expiratory Volume in 1 s (FEV1), Forced Vital Capacity, Weight, Body Mass Index (BMI), Fat-Free Mass Index, and Distance Covered during the 6-Minute Walk Test (6MWT) before and after the algorithm's implementation in the MyTatva app. Patient satisfaction was assessed through a CSAT survey.

Results Following the implementation of the MyTatva care plan, significant improvements were observed in several key clinical outcomes for COPD patients. FEV1 increased from a median of 3.24–2.0 L ($p=0.0379$), while weight and BMI decreased significantly, with a reduction in weight from a median of 86–70 kg ($p=0.0007$) and a corresponding decrease in BMI from 28.43 to 24 kg/m^2 ($p=0.0031$). The distance covered during the 6MWT also improved from 420 to 568 m ($p=0.0019$). The participation of 10 COPD patients in surveys yielded an overall CSAT score of 85%, indicating a high level of satisfaction with the MyTatva app.

Conclusion The comprehensive features and functionalities of the MyTatva app, combined with the personalized care plan and real-time feedback mechanisms, have led to substantial clinical improvements in COPD management. These findings highlight the promise of this innovative digital therapeutic approach in addressing chronic respiratory conditions.

Keywords COPD, Diet, Nutrition, Digital therapeutics, Algorithm, MyTatva

Introduction

Chronic obstructive pulmonary disease (COPD) is a chronic inflammatory lung disease that obstructs airflow from the lungs. It is characterized by symptoms such as dyspnea, cough, expectoration, and exacerbations. In 2019, COPD ranked as the third leading cause of global mortality, resulting in 3.23 million deaths, with a majority occurring in low- and middle-income countries. The prevalence of COPD among individuals aged 30–79 years was estimated at 10.3% in 2019 [1]. The Global Initiative for Chronic Obstructive Lung Disease (GOLD) provides evidence-based recommendations for COPD management, including smoking cessation, pulmonary rehabilitation, and pharmacological therapy. Inhaled bronchodilators, corticosteroids, noninvasive ventilation, and oxygen therapy are also recommended based on disease severity [2]. COPD is not only a respiratory

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condition but also has systemic effects, often accompanied by comorbidities such as cardiovascular disease, diabetes, depression, sleep disorders, malnutrition, and sarcopenia. Malnutrition in COPD can occur due to increased energy expenditure, reduced appetite, and difficulties in eating and absorbing nutrients, leading to sarcopenia and impaired respiratory function. Nutritional assessment, screening, and intervention are crucial in COPD management. The European Respiratory Society (ERS) guideline 2023 emphasizes the importance of nutritional screening, with specific tools such as the Mini Nutritional Assessment short form (MNA-SF) and the Malnutrition Universal Screening Tool (MUST) showing notable levels of specificity [3].

COPD patients often experience nutritional deficiencies that manifest as various metabolic phenotypes, including obesity, wherein adipose tissue inflammation can lead to insulin resistance, morbid obesity, sarcopenic obesity, sarcopenia, cachexia, and precachexia. Malnutrition and sarcopenia are prevalent in this population, with malnutrition-sarcopenia syndrome being particularly common in those with severe COPD. Research shows that nutrition plays a crucial role in managing these conditions with potentially improving muscle strength and physical performance in patients [4].

Personalized diet and nutritional plans play a vital role in improving the nutritional status, muscle strength, and respiratory function of COPD patients. Challenges such as poor adherence, lack of education, limited access to care, and societal factors hinder effective management. Advanced technologies such as telemedicine and digital therapeutics have shown promise in enhancing outcomes for COPD patients. Personalized diet plans, delivered through digital health platforms, can optimize nutritional support by tailoring interventions to individual patient characteristics and needs. Remote patient monitoring (RPM) interventions, integrated with digital health and digital therapeutics, enable continuous data acquisition and personalized interventions, improving disease management precision and efficacy [5]. Digital health platforms provide interactive features, educational resources, and reminders to engage and motivate COPD patients in adhering to their personalized nutritional plans. These platforms also offer continuous support, educational resources, recipe ideas, and tips for managing specific dietary challenges associated with COPD [6].

MyTatva, a groundbreaking digital health therapeutic app, leads the way in personalized nutrition for COPD patients. It combines evidence-based interventions with algorithms to provide personalized nutritional plans, real-time monitoring, automated data analysis, and continuous guidance. By leveraging digital platforms and personalized nutrition, COPD patients can actively participate in their care, maintain long-term dietary changes, and optimize their overall health. By providing tailored and evidence-based nutritional plans, MyTatva offers COPD patients a comprehensive solution to address malnutrition, sarcopenia, and overall nutritional needs. It fills the gap in personalized diet plans for COPD management, empowering patients to take control of their health and improve their well-being (Fig. 1).

Methodology

Study design and participants

The research conducted a comparative analysis to assess the clinical outcomes of individuals diagnosed with COPD before and after onboarding patients on the MyTatva app embedded with the algorithm. The

Fig. 1 Role of MyTatva in COPD patients

study involved a sample of 10 COPD patients, evaluating key parameters such as Forced Expiratory Volume in 1 s (FEV1), Forced Vital Capacity (FVC), Weight, Body Mass Index (BMI), Fat free mass index (FFMI) and Distance Covered during the 6-Minute Walk Test (6MWT). Data collection occurred at two distinct time points: pre and post onboarding of the patients in the MyTatva app. Statistical analysis was performed to determine the significance of the differences in these parameters. The primary aim of this comparative analysis was to assess the algorithm's efficacy in improving COPD management and enhancing the clinical outcomes of the participants within the MyTatva app environment.

The eligibility criteria for the study included adults aged between 40 and 75 years with diagnosed cases of COPD confirmed by spirometry results (FEV1/FVC ratio < 0.7 post-bronchodilator). Participants were required to be capable of understanding and consistently using the MyTatva app and willing to adhere to the dietary, lifestyle, and monitoring interventions outlined in the study protocol. The study excluded individuals with unstable comorbidities, such as heart failure or acute infections, pregnant or lactating women, patients with cognitive impairments that could hinder adherence to the study requirements, and those already engaged in other conflicting clinical trials.

Research objective

The study aims to develop and implement an algorithm within the MyTatva app to enhance clinical outcomes for patients with COPD. The research objective focuses on evaluating the impact of the algorithm on COPD patients by assessing key parameters such as lung function, weight, body composition, and exercise capacity before and after the algorithm's implementation in the MyTatva app. The algorithm, centered around nutrition and diet intervention, aims to improve various aspects of COPD management within the app. The key components of the algorithm include strategies for weight normalization, improvement in Body Mass Index (BMI) and wight management, monitoring the 6-Minute Walk Test (6MWT) through smart wearables, facilitating diet adherence via an in-app food diary, and monitoring Forced Expiratory Volume in 1 s (FEV1) rates using a Bluetooth-enabled spirometer. While these components may seem overlapping in their focus on health and COPD management, they collectively contribute to a comprehensive approach to addressing COPD symptoms and improving patients' quality of life. The 6-Minute Walk Test (6MWT) was used to assess physical performance as it is a widely validated, simple, and non-invasive measure of functional exercise capacity, reflecting the overall endurance and physical capabilities of COPD patients in real-world settings. Fat-Free Mass Index (FFMI) was used to assess body composition as it provides a reliable indication of muscle mass, which is crucial for evaluating nutritional status and sarcopenia, both of which significantly impact respiratory function and overall health in COPD patients.

Search strategy

A rigorous literature search was conducted, focusing on articles published in scholarly databases such as PubMed, Google Scholar, ScienceDirect, and Web of Science. The search string employed was as follows: "(Digital therapeutics OR DTx, FDA OR SaMD OR MDD OR MDR, Digital health OR Healthcare, Smartphone OR Application, diet, dietary factor, food, nutrition, nutrient, antioxidant, calorie intake, dietary pattern, food pattern, eating habit, lung function, CAT score, MUST score, weight management, 6MWT, FEV1, chronic obstructive pulmonary disease, and COPD)". It is important to note that the search was limited to articles that could be identified using this specific search string. Articles from other sources, such as research protocols, conference abstracts, theses, preprints, news articles, and workshop proceedings, were excluded. This was done to ensure that the selected articles were published in reputable sources and met high standards of scientific research.

Algorithm development

The process of algorithm development involved thorough research in nutrition-based outcome studies conducted in COPD patients. These studies yielded invaluable insights and served as a fundamental basis for establishing pre-existing timelines that were further substantiated by literature evidence. This approach ensured that the selected outcomes were solely related to the impact of nutrition on COPD management. To establish the timelines for assessing these outcomes, the expected timeframes within which nutrition-based interventions typically show measurable effects were considered. This involved examining the duration of dietary interventions in the literature and determining when significant changes in the selected outcomes were observed. These timelines were then incorporated into the algorithm to guide healthcare professionals in monitoring and evaluating the effectiveness of nutrition interventions for COPD patients.

Patient onboarding on the Mytatva app

Once a COPD patient is onboarded on the My Tatva app, they undergo a comprehensive health assessment to understand various aspects of their well-being. This includes measuring BMI, muscle mass, and fat free mass index, conducting spirometry to measure FEV1 score, observing CAT and MUST scores, recording

comorbidities, and performing a nutritional assessment covering dietary preferences, food allergies, and lifestyle habits.

Based on this assessment, a personalized dietary plan was developed by a clinical nutritionist. The plan includes specific instructions tailored to the patient's requirements, such as macronutrient distribution, portion sizes, and food choices. It also incorporates practical elements such as recipes and recommendations for nutrient-rich snacks.

Patients have the opportunity to engage with the nutritionist through voice or video communication, allowing for further discussion and setting health objectives. Bimonthly chat sessions are conducted to track progress, address concerns, and answer any questions.

Throughout the process, patients are encouraged to log their food intake, water consumption, sleep patterns, physical activity, respiration metrics, and ambulatory strides using the My Tatva app. The app provides timely reminders for appointments and meal schedules to improve adherence.

Regular assessments are conducted to evaluate progress, including changes in weight, improvements in symptoms, adherence to the dietary plan, Fat-Free Mass Index, 6-Minute Walk Test, and Forced Expiratory Volume in 1 s rate. This ongoing support and monitoring aim to effectively manage COPD and enhance the patient's overall health and well-being.

The My Tatva app provides a comprehensive approach to personalized nutrition therapy, ensuring that COPD patients receive tailored care and support throughout their journey (Fig. 2).

Patients' safety

The MyTatva app incorporates an incident reporting feature that empowers patients to promptly report any adverse events they may experience during the course of the intervention.

Patient feedback surveys

To evaluate customer satisfaction at various stages of the MyTatva care plan, a structured CSAT survey was conducted after key interactions. The survey consisted of targeted questions to assess satisfaction levels and user experiences through a CSAT survey form (refer to annexure 1).

Implementation of algorithm in Mytatva app

The management of COPD has traditionally focused on pharmacological treatment. However, there is growing recognition of the importance of incorporating diet and nutrition-based interventions to improve patient outcomes. As highlighted in the introduction, research has shown that nutritional counseling, dietary supplementation, and antioxidant-rich diets can address malnutrition, improve symptom management, and enhance Body Mass Index (BMI) among COPD patients. These interventions also have the potential to positively influence the quality of life of COPD patients and reduce healthcare costs associated with the disease.

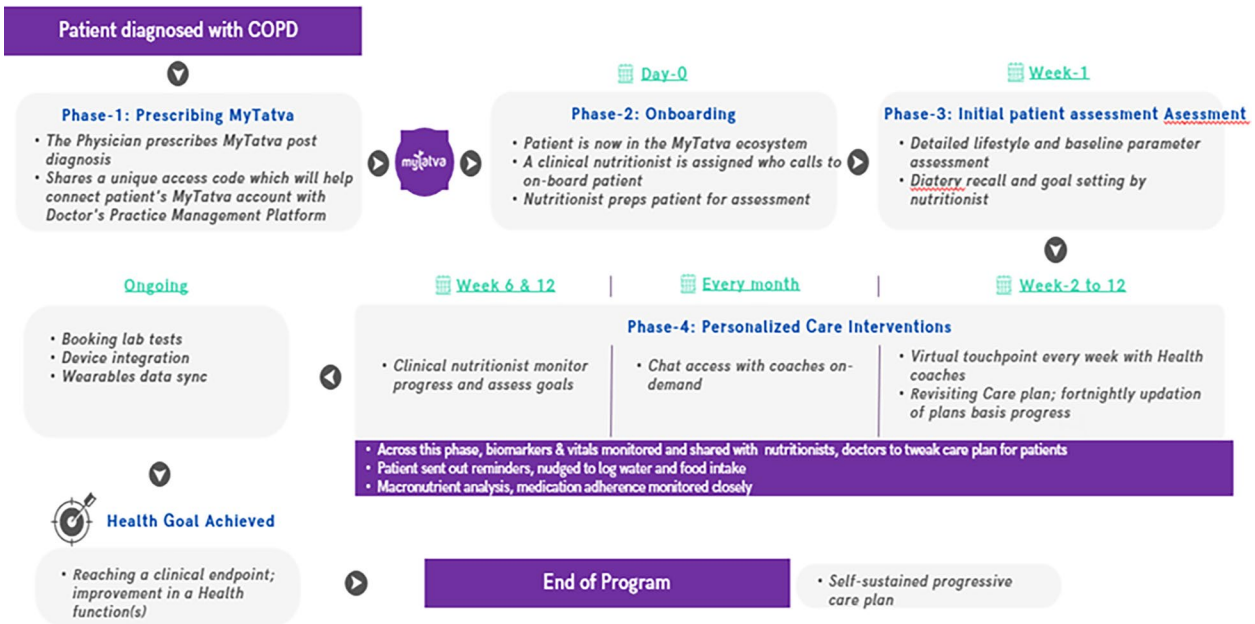

Fig. 2 Patient journey's on the MyTatva app

To optimize patient outcomes, a comprehensive nutritional intervention algorithm has been developed and integrated into the MyTatva application, as described in the methodology section. This algorithm facilitates clinical nutritionists in creating a personalized patient profile by conducting a thorough assessment of clinical, lifestyle, and nutritional factors. Following the patient registration on the MyTatva platform, a detailed assessment is performed of their clinical history, lifestyle factors, and nutritional status.

The algorithm employs a comprehensive evaluation of five essential factors to create patient profiles. This includes analyzing the patient's BMI and weight management using a BCA machine, as well as capturing Forced Expiratory Volume in 1 s (FEV1) readings with a Bluetooth-enabled spirometer to assess COPD severity. By considering these factors, clinical nutritionists can develop personalized nutritional recommendations that improve patient outcomes and reduce healthcare costs.

The MyTatva application utilizes electronic patient-reported outcomes (ePROs) to calculate COPD Assessment Test (CAT) and Malnutrition Universal Screening Tool (MUST) scores. These scores help identify potential malnutrition risks and the severity of COPD, as outlined in the introduction. The 24-h dietary recall captures information on the patient's diet, food frequency, regional cuisine, and food allergies. The patient's BMI is categorized to determine appropriate caloric intake and nutritional requirements. The CAT score categorizes the impact of COPD on the patient's life, while the MUST score stratifies the risk of malnutrition. Comorbidities such as hypertension, diabetes, dyslipidemia, and cardiovascular disease are also considered for specific nutritional modifications.

The algorithm also takes into account the patient's lifestyle data, including smoking, alcohol, sleep, and stress habits. This information is gathered through a lifestyle challenge questionnaire on the MyTatva app. It helps create a comprehensive patient profile for initiating nutrition therapy, as described in the methodology section.

A customized diet plan, referred to as Diet Plan 1, is developed to meet the patient's specific nutritional requirements while aligning with their preferences. The algorithm respects cultural and regional food habits, incorporating specific area-dominated diets to promote patient satisfaction and adherence.

Monitoring patient progress is an integral part of the algorithmic approach. Regular assessments, including lifestyle, nutritional, and clinical evaluations, are conducted from day 1 to track patient progress, as mentioned in the methodology. These assessments provide valuable feedback on the effectiveness of the diet plan and allow for necessary adjustments.

The initial diet plan, Diet Plan 1, spans a 15-day program. If the patient adheres to the plan with at least 80% compliance, improvements in symptoms, weight, and weight management are assessed. If positive improvements are observed, the patient progresses to Diet Plan 2, which lasts for one month. Diet Plan 2 builds upon the initial plan by incorporating more specific goals and adjustments based on the patient's progress and feedback. Throughout Diet Plan 2, the patient continues to follow the personalized diet plan while receiving ongoing support and guidance from the clinical nutritionist. Regular assessments are conducted to monitor adherence to the plan and track progress in terms of symptoms, weight, and weight management.

The MyTatva application plays a crucial role in facilitating communication and monitoring between the patient and the clinical nutritionist, as described in the methodology. Patients can record their food diary on the app, providing valuable information for assessing adherence to the diet plan. The app also allows patients to track their progress, including symptoms, weight, and weight management, and communicate any concerns or feedback to the clinical nutritionist.

The algorithmic approach employed in this study ensures a systematic and structured process for managing COPD through diet- and nutrition-based interventions. By considering various factors, such as clinical data, lifestyle habits, dietary preferences, and regional considerations, the algorithm helps create personalized diet plans tailored to the individual needs of each patient, as outlined in the methodology (Fig. 3).

Statistical analysis

Statistical analysis was performed using SPSS version 25. Continuous variables, such as FEV1, BMI, and 6MWT distance, were analyzed using the Wilcoxon signed-rank test to compare pre- and post-intervention values, as the sample size was small and data distribution non-normal. Results were summarized as medians with interquartile ranges, and a p-value < 0.05 was considered statistically significant. Descriptive statistics were used for baseline characteristics, and categorical data were presented as frequencies and percentages.

Result

The MyTatva Chronic Care Management App offers personalized care for conditions such as COPD, Asthma, and Fatty Liver. Through data-driven coaching, exercise plans, diet recommendations, medication reminders, and access to specialist doctors, the app aims to enhance health outcomes and elevate the quality of life. By providing gamified nudges, insights, reminders, and comprehensive data tracking, it enables patients and healthcare

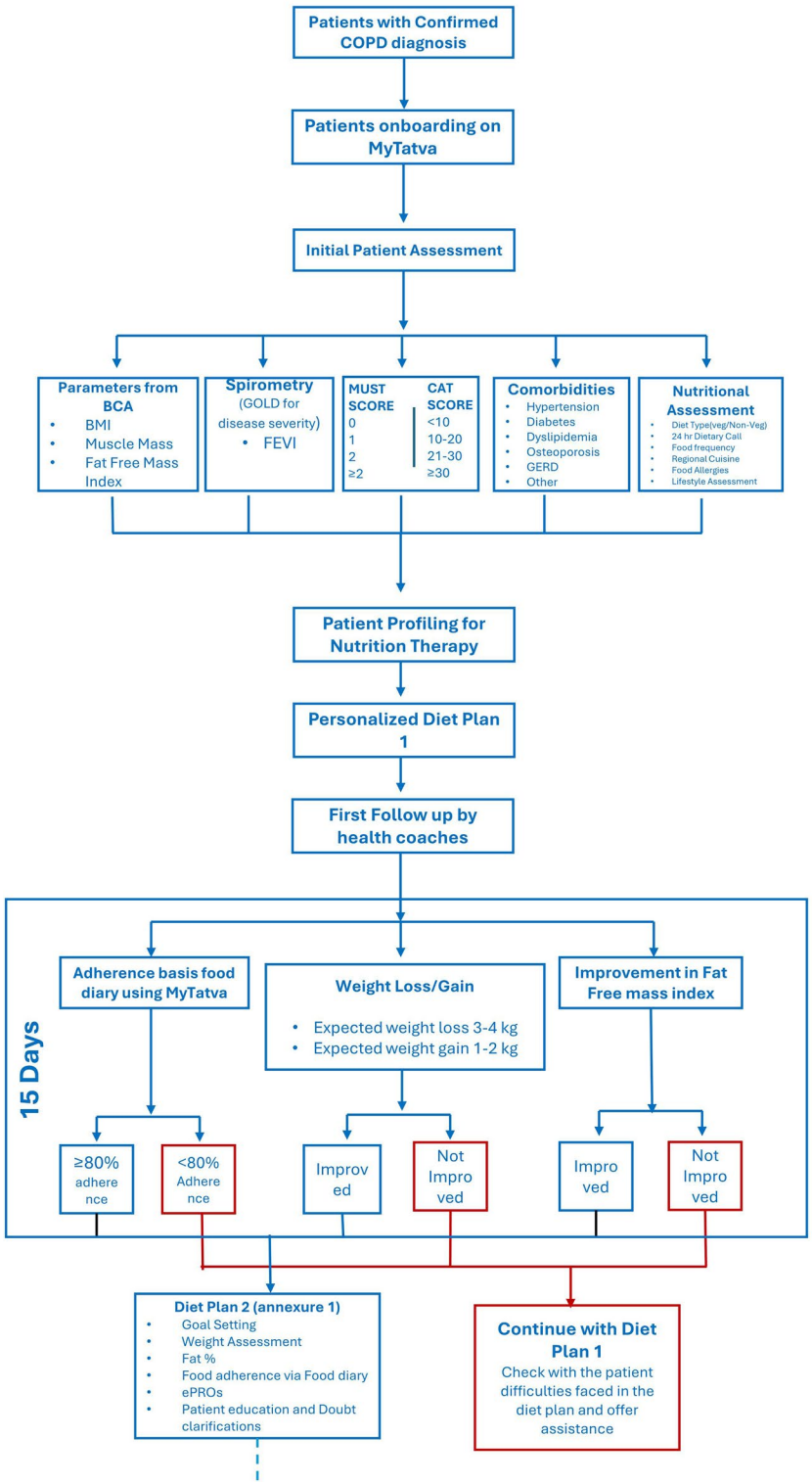

Fig. 3 COPD patient approach algorithm on the MyTatva App

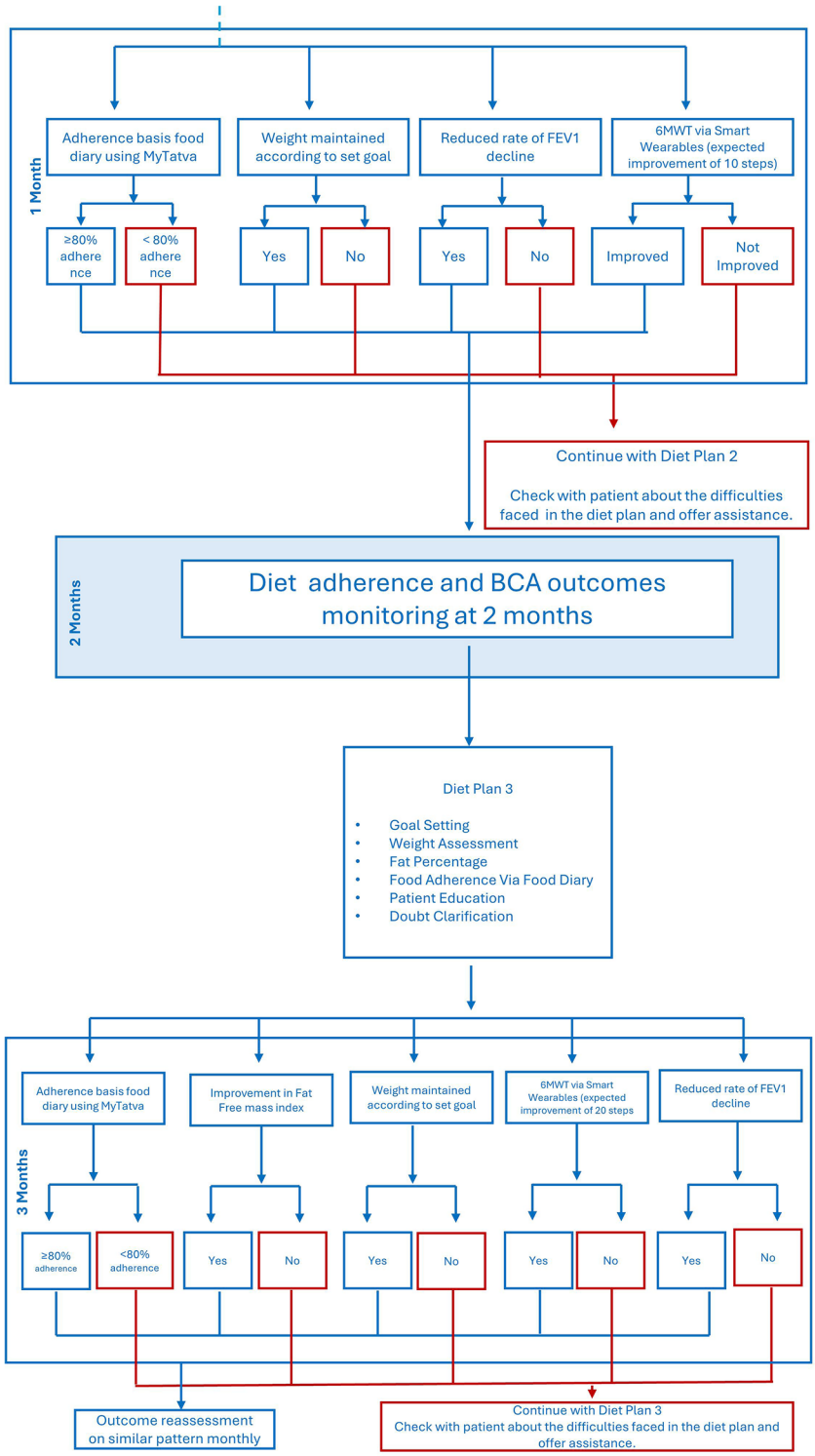

Fig. 3 continued

providers to monitor progress, prevent complications, and engage with health experts for individualized guidance.

Following the implementation of the MyTatva care plan, significant improvements were observed in several key clinical outcomes for COPD patients. Forced Expiratory

Volume in 1 s (FEV1), a measure of lung function, notably increased from a median of 3.24–2.0 L ($p=0.0379$), while weight and BMI decreased significantly, with study participants experiencing a significant reduction in weight from a median of 86–70 kg ($p=0.0007$), accompanied by a corresponding decrease in Body Mass Index (BMI) from 28.43 to 24 kg/m^2 ($p=0.0031$). Furthermore, the distance covered during the 6-Minute Walk Test, a measure of exercise capacity, significantly improved from 420 to 568 m ($p=0.0019$). These results highlight the potential benefits of this digital therapeutic approach in managing COPD, demonstrating substantial improvements in lung function, weight, body composition, and physical endurance among COPD patients.

The algorithmic approach ensures a structured process for managing COPD by creating personalized diet plans based on clinical data, lifestyle habits, dietary preferences, and regional considerations. The MyTatva application plays a pivotal role in facilitating communication and monitoring between patients and clinical nutritionists, allowing patients to conveniently record their food intake, track progress, and share concerns or feedback.

To further optimize the feedback collection process, it is recommended to incorporate end-user feedback to gain valuable insights and enhance the MyTatva care plan based on user experiences and satisfaction levels. The participation of 10 COPD patients in surveys yielded an overall CSAT score of 85%, indicating a high level of satisfaction.

These findings demonstrate the significant potential of the MyTatva digital therapeutic approach in effectively managing COPD and improving the overall health and well-being of patients. The comprehensive features and functionalities of the app, combined with the personalized care plan and real-time feedback mechanisms, have led to substantial clinical improvements, highlighting the promise of this innovative solution in the management of chronic respiratory conditions.

Discussion

Nutrition plays a crucial role in managing COPD. Brug's 2004 study underscores the potential benefits of implementing dietary changes and nutrition education in COPD patients, suggesting that educating and supporting patients regarding dietary modifications can prevent weight loss and enhance outcomes [7]. Similarly, the 2016 study by Russian Pulmonology emphasizes integrating nutritional support with physical rehabilitation for COPD individuals, resulting in improved outcomes and quality of life [8].

Aligned with these findings, Beijers (2023) stresses the importance of consuming a healthy diet for COPD patients. The study highlights the necessity for tailored nutritional screening instruments to accurately assess and address the specific dietary requirements of COPD individuals. By customizing nutritional approaches, healthcare professionals can effectively support overall health and enhance quality of life [9].

Personalized nutrition is integral to COPD management. Schols et al. highlight digital therapeutics' effectiveness in providing personalized nutritional solutions to mitigate COPD symptom exacerbation due to malnutrition [10]. Digital interventions, as demonstrated by Jacobs' 2016 study, also aid in smoking cessation, medication adherence, and symptom tracking, enhancing self-management and engagement [11].

Digital health technologies, including telehealth and wearable devices, hold promise in early COPD diagnosis and management [12]. Nyberg underscores how these technologies improve patient monitoring and self-management through remote monitoring and real-time data collection, offering opportunities for personalized COPD care. However, it's crucial to consider healthcare professionals' perspectives in assessing digital health intervention impact [13].

Slevin demonstrates healthcare providers' recognition of capturing patient data between appointments, aligning with digital therapeutics like MyTatva, facilitating continuous monitoring and data collection for informed decision-making and personalized care. Although digital health interventions hold promise, addressing challenges is imperative [14].

Watson discusses digital healthcare interventions' advantages and pitfalls, emphasizing the need for further research and refinement. Efforts are underway to integrate AI and ML components and mitigate healthcare access disparities, particularly among the elderly. Clear communication, support for individuals with limitations, adaptation of health applications for older patients, and government support are crucial in promoting digital health in underserved areas [6].

As the digital health revolution continues, MyTatva stands out in COPD management. This innovative app integrates personalized dietary plans, remote monitoring, and health coach expertise to achieve significant outcomes, empowering patients to manage COPD actively. However, challenges such as AI integration and healthcare access disparities need addressing. Bridging these gaps encourages technology adoption among older patients and promotes digital health in underserved areas. MyTatva, a leading digital therapeutics app, embodies digital health's potential to provide effective, patient-centered healthcare, marking a significant step forward in COPD management.

The participation of 10 COPD patients in surveys yielded a high level of satisfaction with the MyTatva

care plan, reflecting the app's effectiveness in addressing COPD patient needs and improving overall health and well-being. The integration of incident reporting within the MyTatva app empowers patients to promptly report adverse events, ensuring efficient communication with healthcare professionals and upholding safety and efficacy in interventions. This real-time feedback mechanism promotes transparency and continuous enhancement in patient care practices, further contributing to positive user experiences.

Regular assessments and adjustments throughout the program enable a dynamic and responsive approach to COPD management, ensuring continuous optimization of the diet plan for maximal patient outcomes, including improvements in FEV1, 6-Minute Walk Test (6MWT), BMI, weight management, and diet adherence.

The incorporation of diet- and nutrition-based interventions, supported by the MyTatva application and the algorithmic approach, shows promise in improving COPD patient outcomes by addressing malnutrition, enhancing symptom management, and optimizing BMI. These interventions have the potential to enhance the quality of life for COPD patients and reduce associated healthcare costs. However, the study's primary limitation is its small sample size, which could limit the generalizability of the findings. Future research should focus on including a larger and more diverse patient population to strengthen the study's validity and relevance across a broader demographic of patients. The limitation of the study is its small sample size of 10 participants, which may limit generalizability. Additionally, reliance on self-reported data via the MyTatva app and the absence of a control group may influence the accuracy of the findings. These factors highlight the need for larger, randomized trials to validate the results.

Conclusion

MyTatva Chronic Care Management App demonstrates significant potential in effectively managing COPD and improving patients' overall health and well-being. Through personalized care plans, including tailored dietary recommendations, exercise plans, and medication reminders, the app aims to enhance health outcomes and elevate the quality of life for individuals with COPD. Following the implementation of the MyTatva care plan, significant improvements were observed in key clinical outcomes, including increased Forced Expiratory Volume in 1 s (FEV1), reduced weight and Body Mass Index (BMI), and improved exercise capacity. The integration of an algorithmic approach ensures a structured process for managing COPD, creating personalized diet plans based on individual clinical data, lifestyle habits, and dietary preferences. Moreover, incorporating end-user feedback further enhances the app's effectiveness and user satisfaction. With its comprehensive features and real-time feedback mechanisms, MyTatva represents a promising digital therapeutic approach in COPD management, offering improved patient outcomes and empowering individuals to actively manage their condition.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s41043-024-00727-9.

Additional file 1.

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Author contributions
Substantial contributions to the conception OR design of the work: MG, DA, and Dr Prachi Sharma OR have drafted the work or substantively revised it: DA,MG, VT, BS, PS, DJ, DL,VA, IS, KJ AND to have approved the submitted version (and any substantially modified version that involves the author's contribution to the study): MG, DA, Dr Prachi Sharma AND to have agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature: MG, DA, Dr Prachi Sharma.

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Availability of data and materials
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
All authors agreed to submit the manuscript to the Journal of Health, Population and Nutrition.

Competing interests
The authors declare no competing interests.

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