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SYSTEMIC POPULATION RESPONSIBILITY AND TERRITORIAL DIGITAL TWIN: APPLICATION TO COPD

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ABSTRACT

This ongoing study aims to develop a territorial digital twin for Chronic Obstructive Pulmonary Disease (COPD) to enhance health strategies focusing on patient care and resource optimization. Initially, we used process mining to model the COPD clinical pathway, revealing common care patterns and disease stages. The model shows strong indicators of fitness and precision, with accuracy metrics over 60%. Currently, we are validating the model by comparing simulated costs with real-world data, and using Monte Carlo simulations and Markov chains to assess various health strategies and measure their impact in the clinical pathway. Preliminary results suggest that the model could be effective for simulations and testing new health measures. Future work will focus on integrating real-time data to optimize resource allocation and healthcare strategies and, ideally, to automate the process for application to other diseases, while adhering to Population Responsibility principles.

1 INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) affects millions globally and imposes significant burdens on healthcare systems (Sandelowsky 2021), (Anzueto 2010), (Koczulla et al. 2018). This study aims to develop a digital twin model of the COPD clinical pathway to explore how different health strategies can enhance patient care and outcomes. The model is based on the concept of Population Responsibility (Trottier 2013), which aims to improve health, optimize care, and reduce costs by considering the needs of the entire population rather than individual patients. This approach has shown success in managing diseases like diabetes and heart failure, leading to reduced hospital admissions and improved patient outcomes (Malone 2023).

We used process mining to understand and map the COPD clinical pathway model. Currently, we are validating this model by comparing simulated costs with real-world data and employing Monte Carlo simulations with Markov chains to evaluate the impact of various health interventions. Preliminary results suggest that the model is effective for simulating different scenarios and that targeted health measures could potentially improve patient quality of life.

2 METHODOLOGY

The study aims to integrate data analysis, machine learning, process mining (Van der Aalst 2011) and simulation (Augusto et al. 2016). Process mining techniques are employed to reveal common care pathways and validate COPD stages based on criteria such as fitness, precision, generalization, and simplicity (Tula et al. 2024). Using the clinical pathway models as simulation models, a digital twin of the population will be created to test various scenarios and evaluate the impact of new interventions on disease progression, focusing on cost-benefit analysis. Patient profiles will be examined through unsupervised learning methods like clustering to identify predictive factors and assess how intrinsic and extrinsic elements influence care pathways. Ultimately, we aim to automate the entire process to streamline COPD management and improve health outcomes efficiently.

3 RESULTS

The initial development of the COPD process mining model has been successful in mapping disease progression across various stages. The model has demonstrated strong indicators of fitness and precision, with accuracy metrics exceeding 60%. However, the validation of the model and the simulation of health interventions are still ongoing. Preliminary analyses suggest that the model is well-aligned with real-world data, but definitive results on its effectiveness and the impact of health measures are yet to be finalized.

4 CONCLUSION AND FUTURE WORKS

In conclusion, the process mining model for COPD has shown promising initial results with substantial indicators of fitness and precision. However, further validation and simulation are required to fully assess its impact. Future work will involve completing the validation process and analyzing the outcomes of health interventions through simulations. Additionally, future research will focus on examining patient profiles to identify factors influencing disease progression and response to treatment, using advanced machine learning techniques to refine and enhance the model's predictive capabilities and optimize healthcare strategies.

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