Transforming Chronic Disease Therapy with Telemedicine: A Single Case Study of Integrated Clinical Pathways for COPD Management Employing Telemedicine Technologies and BPM Methods

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Abstract

This paper delves into the transformative potential of integrating telemedicine and business process management (BPM) methods in chronic disease therapy, advocating for a shift beyond traditional models. Through a single case study focusing on Chronic Obstructive Pulmonary Disease (COPD), the research underscores the crucial need for collaborative efforts among healthcare professionals, patients, and caregivers. It emphasises the potential of telemedicine for personalised care and reduced healthcare costs. Additionally, it identifies key challenges that stand in the way of the widespread adoption of the proposed approach, such as the lack of regional digital healthcare systems and transparent legal and financial frameworks. However, these challenges are not insurmountable. This research contributes significantly to the evolving landscape of chronic disease management, advocating for a more patient-centric and technologically driven approach that empowers individuals and facilitates collaborative care.

Keywords

Clinical pathways (CPs), diagnostic and therapeutic processes, telemedicine, business process management (BPM), chronic disease therapy, illustrative case study

1. Introduction

The healthcare sector grapples with the challenge of delivering high-quality, individualised care amidst resource constraints. This necessitates a fresh approach to diagnostic and therapeutic processes that promotes a holistic patient-centric approach. Business Process Management (BPM) and telemedicine technologies emerge as potential game-changers, having already succeeded in optimising workflows across diverse sectors [1]. Within healthcare, BPM holds promise for streamlining clinical processes and enabling automated, continuous tracking of key health parameters without constant medical

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intervention. However, broader clinical acceptance and robust research are crucial to unlocking its full potential. The possible benefits of this approach are vast, including the potential for improved patient outcomes, reduced healthcare costs, and a more sustainable healthcare system.

Chronic conditions pose a significant and growing burden, impacting a substantial portion of the European population [2]. Managing these long-term, often expensive therapies demands coordinated interdisciplinary efforts. The evolving healthcare landscape emphasises engaging patients and caregivers, aligning with rising telemedicine adoption for remote, real-time health monitoring. However, effectively utilising telemedicine requires a departure from traditional models, where doctors dictate treatment and patients passively receive it. This shift is especially crucial for chronic diseases, where long-term collaboration between patients, caregivers and doctors is essential. Healthcare professionals must empower patients with knowledge, clearly define their roles, and continuously adapt treatments based on real-time data and evolving medical knowledge. This necessitates dynamically adjusting individual care pathways (ICPs) through ongoing analysis of vital signs. The ICP approach fosters collaboration among interdisciplinary teams with shared goals, roles, and communication channels, adhering to evidence-based standards [3].

The evolving healthcare landscape necessitates collaborative efforts between healthcare professionals, patients, and caregivers to address chronic disease challenges effectively. This research explores the transformative potential of integrating telemedicine and Business Process Management (BPM) methods in chronic disease therapy. Through a single illustrative case study focusing on Chronic Obstructive Pulmonary Disease (COPD), the authors investigate how an integrated ICP can enhance patient engagement, optimise therapeutic processes, and improve health outcomes.

This paper addresses a critical research gap by investigating the reconfiguration of diagnostic and therapeutic procedures for chronic disease management, exemplified by Chronic Obstructive Pulmonary Disease (COPD), by integrating novel telemedicine techniques. Additionally, the authors advocate for a patient-centric approach in telemedicine, ultimately paving the way for a more effective and collaborative healthcare landscape.

The paper begins by thoroughly reviewing relevant literature in the field. The authors then outline the methodology employed in the study. Subsequently, the case study results are presented. The final section encapsulates conclusions and practical recommendations derived from the research.

2. Related Work

2.1. Application of Business Process Management in Healthcare

Business Process Management (BPM) is today's highly effective management concept [4]. Its application demands a focus on recipient needs, accountability of all participants, transparency, and continuous improvement [5]. Traditional BPM falls short in healthcare due to process unpredictability and outcome reliance on contextual knowledge application. Thus, the dynamic BPM, empowering process executors, is essential for describing and implementing diagnostic and therapeutic processes [6].

Diagnostic and therapeutic processes, known as clinical pathways (CPs) or care chains, are detailed at three levels:

- Level I: National/international guidelines developed by specialist teams.
- Level II: Clinical pathways at the healthcare unit level based on guidelines, unit resources, and staff competencies.
- Level III. Individual Care Plans (ICPs) based on second-level pathways, considering patient specifics [7].

Implementing BPM in healthcare necessitates ongoing consideration that the patient, not the disease, is the focus of treatment; the patient and their caregivers should be engaged in the treatment process; various CPs and supportive processes must form a cohesive system; knowledge available in the form of CPs should be accessible and reflected in available data on the everyday use of information technology and telemedicine systems by all participants in the diagnostic and therapeutic process. Executing ICP requires empowering process executors to make diagnostic and therapeutic decisions based on their knowledge and the requirements of the clinical process context [8]. Decisions significantly impact the course and value delivered by these processes. More excellent expertise and engagement of the patient and the therapeutic team reduce risks during process execution and increase the likelihood of achieving the intended goals.

Diagnostic and therapeutic processes are typical knowledge-intensive business processes (kiBPs) because their outcomes depend closely on the efficient use of the knowledge and engagement of all process participants [9]. Due to their unpredictability, it is essential to acknowledge that full, detailed knowledge about how they are executed is unavailable during their modelling and design. Therefore, regardless of the form of the ICP description, it is necessary to consider the possibility of dynamically directing the process flow and making decisions that were not foreseeable during ICP's design.

In modelling such cases, utilising the capabilities provided by BPMN, such as the "ad hoc subprocess" object, becomes natural. It allows for the incorporation of situations where the process executor (including the patient) decides on the tasks to be performed, their sequence, the potential number of repetitions, and the transition to the execution of the next task or task group. If, for example, the Patient Diagnosis process is modelled in this way, it concludes when the diagnostician deems that they have sufficient information to make a diagnosis based on their knowledge. Each process execution may have a different course (a different sequence of performed tasks) depending on the patient's condition, the doctor's knowledge, initially available medical documentation, diagnostic tests, consultation possibilities, or unforeseen events such as immediate patient assistance.

Analysing executed ICPs verifies the correctness of conducted therapy and assesses the usefulness and effectiveness of the knowledge used. It also facilitates the creation of new knowledge based on the analysis of individual cases and the identification and analysis of deviations from the standard CP [10]. From this perspective, ICP serves as a knowledge repository, verifying existing knowledge and identifying new knowledge obtained directly from the data of conducted therapy [5].

2.2. Characteristics of Chronic Disease Management

In diseases characterised by prolonged disturbances leading to disability or dysfunction, specialised supervision, care, and rehabilitation are essential, requiring a well-designed and adapted treatment plan [11]. These diseases significantly impair functioning and often progress over time. Enhancing therapeutic effects involves comprehensive information flow between medical personnel, patients, and caregivers [11]. Involving patients as active participants transforms their role from passive recipients to co-creators of therapy, aiding in information gathering and treatment modification [12].

The treatment plan should include Level III clinical pathways (ICPs) tailored to each patient, with clear goals and evaluation parameters. It should describe planned medical care and patient participation, ensuring awareness of conditions, activities, and therapeutic actions during consultations. Parameters for patient measurement, presentation, reporting, and recommended levels should be outlined [12].

Following integrated care and personalised medicine principles, the treatment plan serves as an agreement between the therapeutic team and the patient, fostering mutual responsibilities and health education [11]. Understanding ongoing therapy and involving patients is crucial for chronic diseases, which present long-term challenges to daily life. COPD, the most prevalent chronic respiratory ailment in adults, is a leading cause of mortality globally, with cases often undiagnosed or detected late [13]. With ageing populations and environmental threats, COPD cases are expected to rise continuously.

2.3. Telemedicine

The American Telemedicine Association defines telemedicine as a revolutionary force in healthcare, enabling remote delivery of services through information and communication technology (ICT) [14]. It encompasses diverse clinical services utilising various ICT mediums like the Internet, wireless satellite, telephone, and sensors to enhance healthcare accessibility. Telemedicine has evolved over the past century from the telegraphic transmission of clinical data to NASA monitoring astronauts' health [15]. Despite substantial technological advancements, such as improved platforms, health devices, and innovations in AI, telemedicine integration into daily practice was historically limited [16]. Factors like reimbursement challenges, legislation, state restrictions, stakeholder awareness, and privacy concerns contributed to this. In primary care, telemedicine has surged, especially during the COVID-19 pandemic, from rarity to standard practice [17]. Despite pre-pandemic barriers like digital literacy, its expansion in 2020 saw significant increases in virtual visits globally, benefiting patient empowerment and engagement [18]. In long-term care (LTC), telemedicine's significance has grown due to technological advancements and value-based care trends. The pandemic accelerated its adoption, addressing exposure risks and ensuring care for older people, with bureaucratic challenges temporarily relaxed [19]. Telemedicine's evolving role facilitates collaborative decision-making, presenting new opportunities and challenges in healthcare delivery. Its transformative potential reshapes healthcare decisions, paving the way for improved outcomes and holistic care.

3. Methodology

This article aims to demonstrate and evaluate the reconfiguration of diagnostic and therapeutic procedures, emphasising a patient-centric approach by incorporating innovative telemedicine techniques. Specifically, the authors illustrate how BPM methods can be utilised to develop comprehensive ICPs for treating COPD, one of the most prevalent chronic diseases.

In pursuit of our objectives, we employed an illustrative case study method, utilising a descriptive, in-depth, context-rich approach to offer visually detailed insights crucial for supporting the research process and understanding its outcomes [20]. This approach is a guideline for interdisciplinary teams comprising health professionals, patients, and caregivers, leveraging the latest telemedicine technology to optimise treatment effectiveness and enhance healthcare system efficiency.

The complexity and deviation from routine CPs make this case particularly intriguing for exploration [21]. The study not only illustrates the development of an ICP as a process but also identifies the benefits arising from the application of telemedicine technologies, enabling the ongoing monitoring of various patient characteristics and parameters.

4. Results

In treating chronic diseases, significant importance is attributed to increasing the patient's role in the ongoing, daily control of essential parameters defined in IPC and taking independent therapeutic actions based on them without needing direct consultation with a doctor each time. A crucial aspect is the conscious, active prevention of exacerbations by the patient and their caregivers by identifying the threat of their occurrence and taking preventive actions appropriately early. Therefore, IPC must be prepared in collaboration with and agreed upon with the patient and, in case of doubts, should be the subject of specific negotiations between the patient and the therapy provider [13].

For effective and systematic collaboration between the patient, caregivers, and members of the therapeutic team, it is essential to use a tool understandable to both parties for assessing significant parameters of the patient's actual health status and comparing them with the levels recommended, cautionary, or alarm specified in IPC. These conditions are met by ICPs describing in a clear, graphical manner the assumed course of the implemented therapy, tasks of individual participants, and significant health parameters requiring monitoring that may impact even sudden changes in how the treatment is conducted.

Telemedicine devices radically change the clinical pathway - "The therapeutic care process" (Figure 1). Its central point is no longer the doctor’s consultations but the task "Ongoing IPC execution and monitoring of health parameters." The patient and their caregivers are responsible for this task. Support by telemedicine devices allows for immediate signalling of exceeding essential parameters of the patient's health or sudden accidents (e.g. patient falling). However, this requires, especially in the case of chronic diseases, that patients always have a telemedicine device with them. Therefore, they must meet two primary conditions: the patients must be able (and willing) to use them, and the patients must have such a device or be able to obtain it quickly.

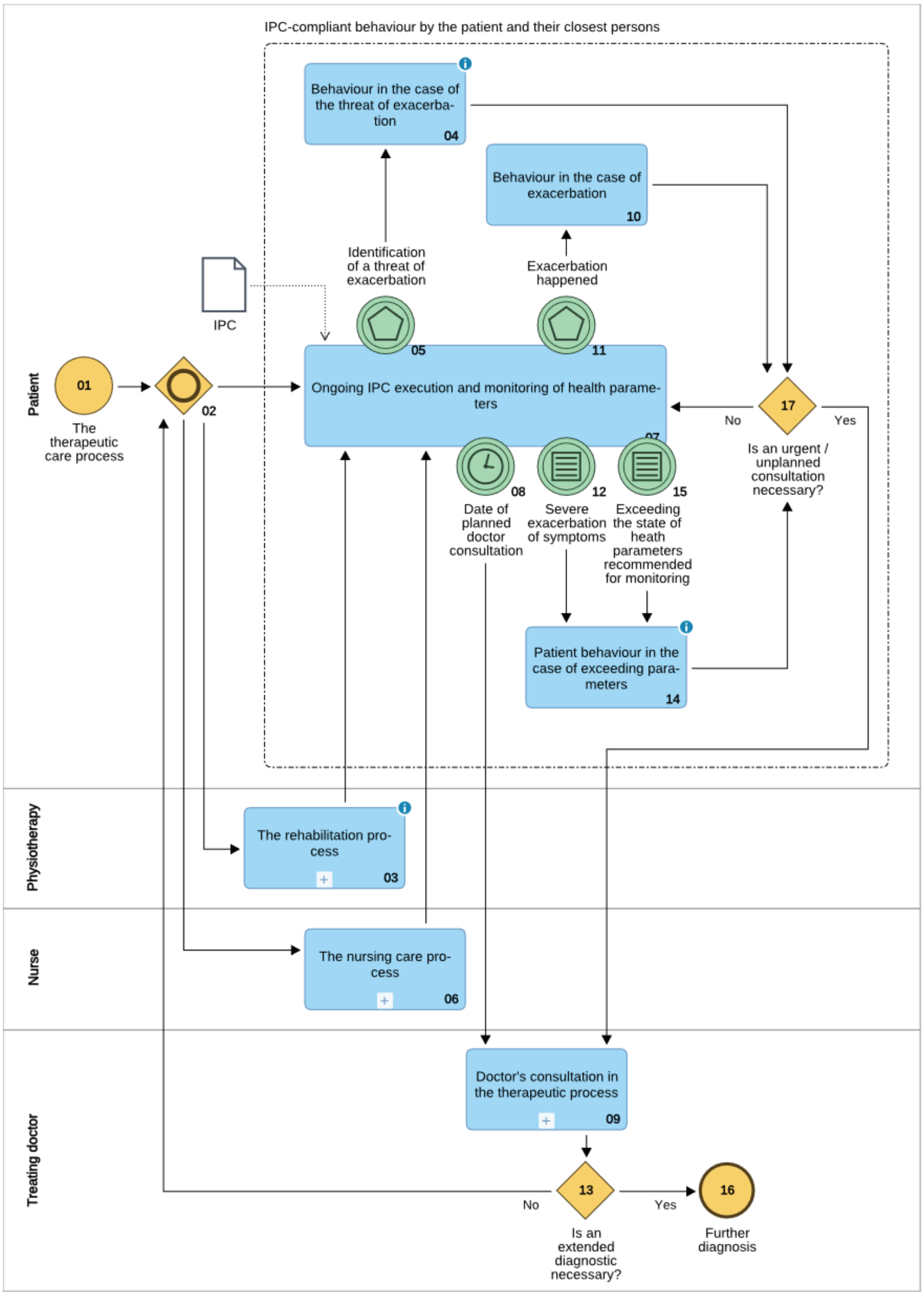

Figure 1: The therapeutic care process (a patient's process in which the doctor and others participate).

The data collected in telemedicine devices or online and sent to healthcare systems allow therapists to reconstruct changes in vital parameters of the patient's health post factum based on process mining techniques. In the case of AI, the current analysis of the available data may enable the prediction of impending exacerbations of the patient's condition (e.g. in the case of COPD). This allows for taking actions in advance to eliminate or mitigate threats. The ability to track essential parameters of the patient's health continuously and prevent acute conditions significantly increases patient safety during therapy.

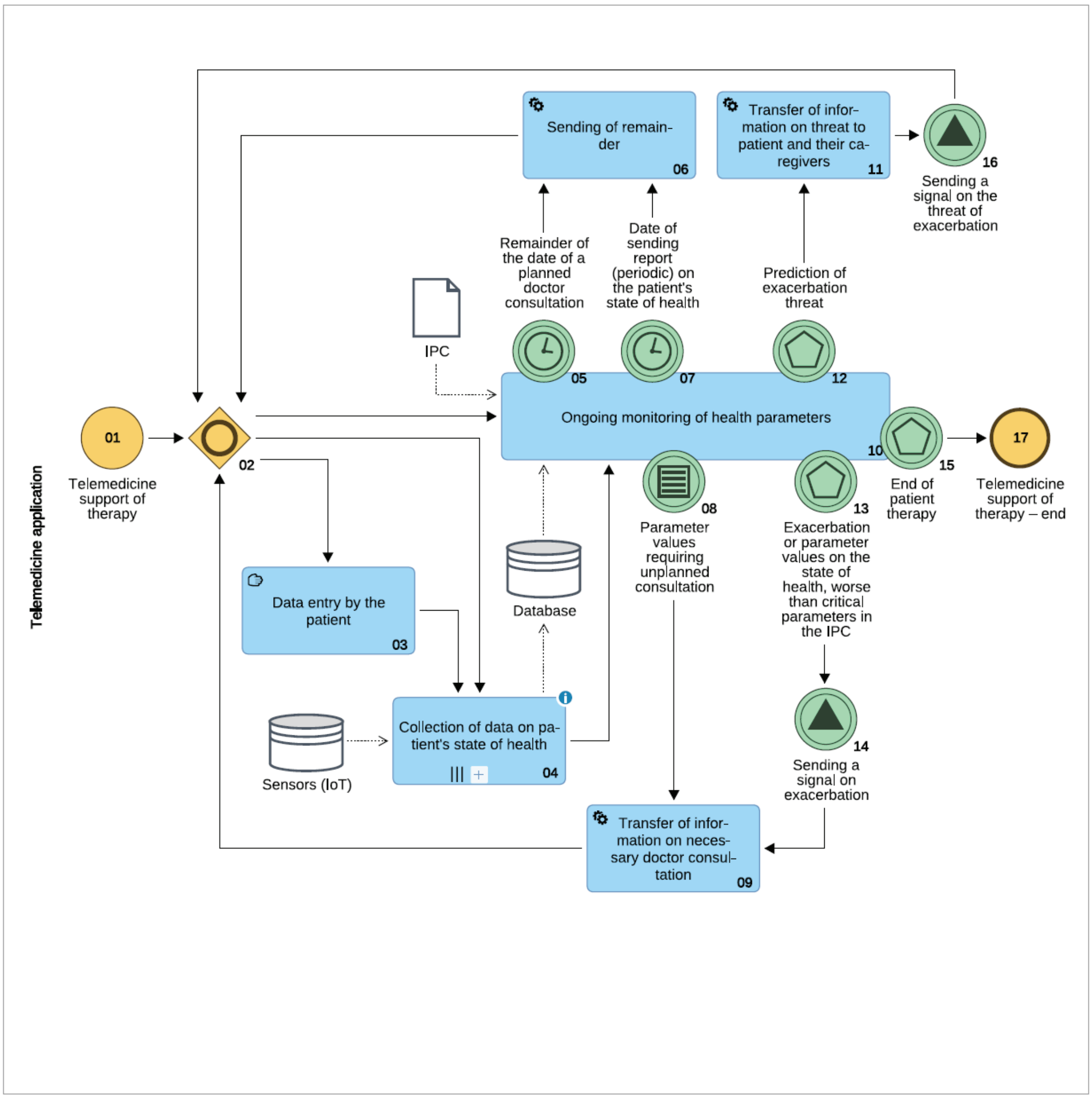

Figure 2: Telemedicine-supported therapy (the implementation of treatment for a patient with a chronic disease).

As shown in the diagram of the "Telemedicine-supported therapy" process (Figure 2), based on the IPC prepared by specialist doctors, including current data from telemedicine devices, AI can autonomously, without the doctor's participation, analyse the data on an ongoing basis and communicate the recommended treatment to the patient. With this ability to use AI, the patient's doctor can schedule follow-up consultations at longer intervals without compromising the quality or safety of the therapy. Data analysed:

- can be obtained from telemedicine devices equipped with various built-in sensors or communicating with the device on which the application is installed via Bluetooth or the Internet,

- if required by the IPC recommendations, and there are no autonomously operating sensors available, they can also be entered manually by the patient or their caregivers (this applies, for example, to the monitoring of medication intake),
- if required by IPC recommendations, environmental data, such as atmospheric pressure or other weather data, can be obtained from indicated reliable external sources, e.g. via the Internet.

5. Conclusions

This paper aimed to showcase and assess the reconfiguration of diagnostic and therapeutic procedures, facilitating a patient-centric therapy organisation through incorporating novel telemedicine techniques. The authors demonstrate the impact of the implementation of BPM and telemedicine in the following areas:

1. Patients' empowerment:

- Telemedicine devices and CPs enable patients to actively participate in monitoring their health and taking actions based on defined parameters.
- Telemedicine devices facilitate early detection of potential exacerbations through continuous monitoring, allowing for prompt preventive measures to be taken.
- Continuous monitoring and timely interventions contribute to improved patient safety and potentially reduce the need for hospitalisation.

2. Healthcare delivery transformation:

- Telemedicine devices make personalised preventative measures accessible to a broader audience, potentially reducing the burden on healthcare systems.
- Real-time data from telemedicine devices enables healthcare professionals to monitor and analyse remotely, allowing for more informed decision-making.
- AI can analyse data and recommend adjustments to CPs (or even ICPs), potentially reducing the need for frequent specialist consultations.
- Telemedicine can streamline workflows and improve communication between patients and healthcare providers, potentially reducing costs.

However, authors point to specific challenges, such as:

- Ensuring all patients access necessary telemedicine devices is crucial for equitable implementation.
- Patients and caregivers need adequate training to use telemedicine tools and understand their data effectively.
- Robust data protection measures are essential to ensure patient privacy and trust in telemedicine systems.
- Seamless integration of telemedicine data into existing healthcare infrastructure is vital for effective utilisation.

The primary conditions for the widespread use of telemedicine already exist. Telecommunications infrastructure, widespread availability and literacy of smartphones and telemedicine devices, and even AI algorithms that enable real-time determination of expected warning and alarm values and monitoring of current patient health parameters already exist. To fully exploit their potential, the following are missing:

- regional or national digital healthcare systems for data collection and analysis,
- legal basis for the use of telemedicine, e.g. regarding anonymisation and data sharing,
- rules for financing the use of telemedicine by healthcare providers, for whom, for example, the cost of a multi-day hospital stay in a patient with acute COPD is readily accepted. Still, financing telemedicine to avoid exacerbation is not accepted.

A significant limitation of this work is its conceptual nature. Despite the availability of telemedicine technologies and the current relevance of COPD treatment during the COVID-19 pandemic according to GOLD guidelines, further studies are essential to investigate the effectiveness of the proposed CP and its impact on accelerating the development of medical knowledge. An especially critical area for future research, with substantial implications for COPD treatment effectiveness, involves data-driven analysis of exacerbation causes or signals. The authors and pulmonologists in the study anticipate that analyses of extensive Big Data from conducted treatments will lead to the proposal of new CP variants, aiming to mitigate the risk of exacerbations. Simultaneously, conducting economic analyses to highlight the potential reduction in direct costs of COPD treatment (e.g., hospital visits for exacerbations) and long-term costs (e.g., social costs associated with patients leaving the labour market or expenses related to long-term care) will prompt swift changes in healthcare rules and regulations, facilitating their widespread implementation.

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