A quintuple-helix framework for digital transformation in community pharmacy: Evidence from Portugal

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Abstract

Community pharmacies (CP) are increasingly adopting digital technologies that reshape operations, stakeholder coordination, and patient-facing services. Yet, research on digital transformation (DT) in community pharmacy remains fragmented and often lacks a management-oriented integrative framework. This study proposes and empirically explores an adapted Quintuple Helix model for DT in community pharmacy, translating the canonical helixes into five managerial dimensions: leadership and culture, technology, strategic management (including regulation), customer experience, and sustainability. We conducted eight semi-structured interviews with (i) pharmacy owners/technical directors and (ii) professionals from technology firms serving the community-pharmacy channel in Portugal. Data were analysed through theory-driven thematic coding using MAXQDA. Findings support ten operational propositions linking Enterprise Resource Planning (ERP) maturity, interoperability, cybersecurity and in compliance with the General Data Protection Regulation (GDPR), digital channels, analytics dashboards, financing strategies, and paperless/energy efficiency initiatives to service quality, operational efficiency, customer outcomes, and Environmental, Social and Governance (ESG) perception. The framework clarifies the multi-actor nature of DT in community pharmacy and offers actionable KPIs for monitoring progress. Implications are discussed for pharmacy managers, technology providers, and policymakers, alongside limitations and directions for comparative and longitudinal research.

Keywords: Community Pharmacy; Digital Transformation; Healthcare Management; Interoperability; Quintuple Helix.

1. Introduction

This article addresses a reality marked by reconfigurations and challenges that require a redefinition of the operational and organizational paradigms of contemporary society. The continuous development of advanced integrated circuit (chip) electronic systems opens up a portal of discoveries in areas such as Quantum Computing, driving gains in energy efficiency and structural performance.

Digital Transformation has revolutionized the modus operandi of interaction in society at an accelerated pace.

The world of work is constantly changing in a competitive and complex environment that demands ever greater adaptability and tenacity. New digital tools are not just transforming processes: they are creating entirely new realities. Progressing in this environment requires more than just occasional innovation—it requires strategic vision and the ability to turn threats into competitive advantages.

This scenario became more apparent when the COVID-19 pandemic prompted organizations to invest more in digital transformation (Hanelt et al., 2021).

In Portugal, digital transformation has been led by organizations in the technology, finance, and healthcare sectors, which are adopting advanced digital technologies to take their products/services to the next level. This progress is supported by government initiatives such as the National Strategy for Economic Digitization and the Industry 4.0 initiative. Nevertheless, asymmetries and structural challenges remain (Ribeiro, 2023).

This article fits into this context, focusing on the impact of digital transformation on the overall management of community pharmacies in Portugal. It is a sector that has been incorporating new digital technologies that are reshaping not only its operational processes—prescriptions, stock management, clinical support—but also the very role of the pharmacist in the healthcare chain.

Over time, we have witnessed a gradual transformation driven by technological innovations, some of which are already commonplace in the sector, such as proprietary software for the individualized preparation and dispensing of drugs, the use of diagnostic and therapeutic aids, robotization, and chatbots that contribute to greater operational capacity – personalized patient care, scientific assistance to pharmacists, real-time logistical and financial tracking, energy efficiency, home delivery service, and commercial aspects (promotional campaigns, inventory and current account management) – optimizing strategic decision-making, thereby minimizing potential errors and reducing costs, as well as providing better service to patient care. As a result, there is an increase in terms of loyalty and reputation, leading to a more professional and modern environment.

Advances in new technological tools, such as Artificial Intelligence (AI), Blockchain, Internet of Things (IoT), and online analytical platforms are restructuring pharmaceutical services and health education (Almeman, 2024). With the emergence of the Industrial Revolution 4.0 and the appearance of the concept of Health 4.0, the idea of exploring a new service (pharmacy 5.0) has developed, which includes mobile systems, with the aim of expanding business and providing a new service to the community, such as mobile digital pharmaceutical counselling and programs focused on health and fitness (Barata et al., 2022).

In fact, with the increase in global data traffic, economies are integrating advanced information systems—5G technology—fifth-generation wireless communication technology—enabling the viability, expansion, and connectivity of digital information technologies that are transforming traditional paradigms. This advanced information system has made it possible for robotic surgeries to exist today, for patients to be monitored through electronic devices (wearables) that have the ability to continuously provide data on key indicators, such as blood pressure, heart rate, and glycemia data. (Devi et al., 2023).

In this sense, the future of organizations increasingly depends on this new technological revolution that drives sustainable business practices, aiming to achieve better performance and competitive advantage (Jovane et al., 2008). Thus, in the pharmacy channel, continuous digital transformation generates potential benefits and value creation, since there are new consumption dynamics and nowadays the pharmacy is more than just a place where medicines are dispensed; it is also considered a hub for healthcare, beauty, and well-being.

The ability to monitor and explore niche markets and anticipate future trends, transforming simple observations into innovative business strategies, is a differentiating factor (Leite et al., 2024).

Digital transformation is a complex, multifaceted, and dynamic process in which an organization incorporates changes resulting from digital technology and innovation in all areas.

It is a change that transcends the simple integration of new tools and involves a profound evolution in the culture, leadership, processes, and strategies of an organization and in entrepreneurship, aiming to improve efficiency, the value delivered to the customer, and constant adaptation to new opportunities in an increasingly connected and digital global market (Bonnet & Westerman, 2021).

In academic literature, there are several definitions of DT, including a wide variety of concepts and dimensions. Authors such as Bharadwaj et al. (2013), Sebastian et al. (2017), Li (2020), and Kraus et al. (2021) have a strongly technological view of DT on organizational structures. In contrast, authors such as Pousttchi et al. (2019), Vial (2019), Verhoef et al. (2021), and Schilirò (2022) integrate a holistic and multidimensional perspective beyond the technological component.

A critical point for most of the authors referenced is the fact that there is no in-depth approach to the three pillars of sustainability.

According to Nadkarni and Prügl (2021), DT lacks both technology and people, which are intrinsically and symbiotically linked.

Value creation should be the main objective of a business organization, as this is the only way to achieve sustainable competitive advantage. According to Schwartz (2001), over time it has become clear that digital technology is the future of all movements in society, and it is important for organizations to consider digital transformation in their businesses, since it is predicted that companies that fail to adapt to the digital world will be victims of "Digital Darwinism" – structures that resist digital transformation may disappear in the face of companies that are more adapted and oriented towards this new technological reality, which will solidify them in a competitive environment.

The Organization for Economic Cooperation and Development (OECD, 2018) has launched a new global project – "Going Digital: Making the Transformation Work for Growth and Well-being" – which aims to help policymakers better understand the digital transformation that is taking place and create a policy environment that allows their economies and societies to thrive in an increasingly digital world.

Over time, companies have invested and allocated resources to technology in order to innovate products and services that they offer to an increasingly demanding society.

Today, we are witnessing a convergence and synergy of disruptive technologies known by the acronym DARQ: Distributed Ledger Technology (DLT), AI, Extended Reality, and Quantum Computing. These technologies are already defining the future of society individually, but together they provide a synergy model, known as the DARQ Synergy Model, which incorporates quantum optimization algorithms, resulting in the resolution of complex combinatorial problems in a universe of data, facilitating the presentation of optimal integration strategies for a given sector (Hamiid et al., 2025).

The challenges that arise include the lack of a change management strategy in organizations, talent acquisition and retention, monitoring the continuous evolution of customer needs, internal resistance to change, lack of cybersecurity, and budget constraints (PECB, 2022).

The existing literature on DT in community pharmacies is limited, with many studies focusing on hospitals. Another point to note is the lack of comparative studies between community pharmacies with different degrees of digital maturity and their impact on internal dynamics and returns for both the pharmacy and for patients.

Pharmacies are healthcare facilities whose mission is to promote health, prevent disease, and care for the well-being of users, with underlying values of professional ethics, transparency, and encouraging literacy about the use of medication. Some pharmacies are not just dispensaries for medication and the assessment of certain biological parameters, but have built a modular, layered architecture where they carry out other activities such as screening, support for other organizations, such as nursing homes, and provide public health guidance and primary care for the community. In a restricted, regulated, and highly competitive market, we are now seeing an expansion of services, such as nutrition and dietetics and sports nutrition services.

Community pharmacies in Portugal have made significant advances in digital technology over time, continuing to evolve alongside new technologies and digital practices. An example of this process of digital transformation is the first steps taken toward robotization.

For Baines et al. (2020), the pharmaceutical sector intrinsic to community pharmacies cannot remain stuck in traditional, linear thinking, assuming that the future will be an extension of the past. If it takes this position, the Industrial Revolution 4.0 could be more of a threat than an opportunity: "If the new game is understood, pharmacists may become the playmaster of tomorrow" (p. 1281).

In this sense, the main objective of this article is to analyse the impact of digital transformation on general management in community pharmacies, assessing how digital technologies influence processes in customer service, improvement of internal processes, and continuous adaptation to digital evolution, based on the

perceptions of technical directors and/or pharmacy owners and a group of professionals with different academic backgrounds who work in different technology companies that collaborate with the community pharmacy channel.

The conceptual model applied was the Quintuple Helix, which, according to Carayannis & Campbell (2010), is an analytical framework in which knowledge and innovation are related to five distinct interconnected dimensions that drive innovation and development in a society.

It is an interdisciplinary analysis model that addresses the resolution of transdisciplinary issues in the context of the socio-ecological transition of common interests. Thus, the Quintuple Helix supports knowledge and innovation, creating synergies between the various dimensions, promoting integrated collaboration in a context of sustainability, with the aim of ensuring that structural transformations are guided by the common interest.

In this article, the five dimensions that impact digital transformation in general management in community pharmacies are:

1) Leadership and Organizational Culture;
2) Technology;
3) Strategic Management;
4) Customer Experience;
5) Sustainability.

Figure 1: Quintuple Helix Framework for Digital Transformation (DT) in Community Pharmacy (CP).

Thus, the model applied allows for an analysis of the interactive and multidimensional dynamics that occur in a specific and well-known environment such as the community pharmacy.

Although the Quintuple Helix (Carayannis & Campbell, 2010) serves as a theoretical basis for understanding collaborative innovation, this study proposes an applied evolution of the model, adapted to digital transformation in community pharmacies. The integration of advanced technologies (e.g., AI, IoT, and Big Data Analytics) and the growing centrality of customer experience and sustainability justify a contextualized reinterpretation, reflecting the specific dynamics of the sector in Portugal.

The following table presents the translation of the canonical Five Forces model into the management dimensions used in this study, with examples of codes and indicators.

Table 1: Mapping of the Quintuple Helix to the adapted model.

Canonical Helix	Dimension (adapted in the dissertation)	Exemplary codes	KPIs/Indicators	Key Actors
Academia (Education/Research)	Leadership and Organizational Culture	Training and Evaluation; Role of the Pharmacist; Technical Barriers	Training hours per person; Digital adoption rate (%); Certifications	Portuguese Pharmaceutical Society/Universities; IT Suppliers; Technical Management
Industry (Companies/Supply)	Technology	Technical Support; Financial Incentives; Interinstitutional Collaboration; Innovation; Cybersecurity; Logistics	Stockouts (%); Dispensing errors (ppm); Inventory time; Profit margin; Lead time	Wholesalers; ERP (Enterprise Resource Planning)/Hardware Suppliers; Pharmacy Management
Government (Regulation/Policies)	Strategic Management	Competition; Regulatory Compliance; GDPR; Total Technology cost (CAPEX+OPEX); Service Quality; Internal Pharmacy Data; ERP (Enterprise Resource Planning)	Privacy incidents (n); Recurrence rates; Compliance audits (%); Total cost of ownership TCO; Response time to GDPR requests	DPO (*Data Protection Officer*); Regulatory Authority; Superintendent Pharmacist
Civil Society (Customers/Community)	Customer Experience	Results for the customer; Difficulties with Digital Technology; Communication; Trust in Technology; Loyalty	NPS (*Net Promoter Score*); Waiting time; Therapeutic adherence (%); Retention/Visits; Use of digital channels	Customers; Pharmacy staff; Community partners
Environment Sustainability/ESG	Sustainability	Resource optimization; Paper Reduction; *Triple Bottom Line*	kWh/m²; € energy/revenue; Printed paper; ESG Reputation; Estimated emissions (tCO2e)	Facilities manager; Energy supplier; Community

1.1. Study Propositions (Derived From the model)

Based on the literature review, the adapted Five-Pillar model, and subsequent data analysis in MAXQDA, it is possible to identify empirical evidence that is or is not supported by the propositions formulated. Thus, the following guiding propositions for qualitative analysis are proposed:

- P1. Integrated ERP (Enterprise Resource Planning) and cycle counting reduce stockouts and dispensing errors, improving service quality.
- P2. Interoperability with wholesalers using EDI (Electronic Data Interchange) and demand forecasting increases efficiency and reduces tied-up capital.
- P3. Interinstitutional interoperability and customer data sharing improve service quality.
- P4. GDPR and basic cybersecurity controls (MFA – Multi-Factor Authentication, backups, EDR – Endpoint Detection and Response) strengthen digital trust and the adoption of online services.
- P5. Continuous training and leadership positively moderate the effect of technologies on operational efficiency.
- P6. Technological obsolescence contributes to decreased operational efficiency and negatively impacts service quality.
- P7. Digital channels contribute to service expansion and increased customer loyalty and lifetime value (LTV).
- P8. Operational dashboards coupled with AI and Big Data Analytics technology contribute to faster decisions and lower operating costs.
- P9. Financing strategy contributes to accelerating the digital roadmap and reduces TCO (Total Cost of Ownership).
- P10. Paperless and energy efficiency contribute to reducing OPEX and increase ESG (Environmental, Social, and Governance) perception.

2. Methodology

Methodology is a vital component, as it defines how the research problem is addressed and how data were collected and analysed for subsequent interpretation of the results. To contribute to a solution, research needs to combine theory with applied methodology, transforming itself into a research design tailored to a specific problem (Jonker & Pennink, 2010).

The choice of a qualitative methodology was based on the possibility of obtaining different perspectives from the interviewees, greater flexibility and openness in the study of the data, in order to discover patterns and trends within a specific study framework (Miles & Huberman, 1994).

According Jonker & Pennink (2010), "*A single perception of reality does not exist. There is no explicit condition or situation that everyone interprets as universal reality*" (p.3).

According to Miles & Huberman (1994), qualitative data is characterized by relevant informational density and a holistic view, demonstrating strong potential for producing theoretical and practical insights that guide the understanding of a complex phenomenon.

This article takes an exploratory approach, given the emerging nature of digital transformation in community pharmacy.

As mentioned above, the methodology applied is qualitative, using individual semi-structured interviews based on a previously prepared script.

The sample will be non-probabilistic for convenience, targeting two independent groups: technical directors and/or pharmaceutical owners whose designated name is Farma, and another group named Techfarma, composed of professionals with different academic backgrounds, but who have in common the fact that they work in different technology companies that contribute to the community pharmacy channel.

Semi-structured interviews are designed to ensure relevant insights into digital transformation, specifically in community pharmacies.

2.1. Qualitative Sample

With regard to the composition of the sample, an equitable distribution was considered, with each group consisting of four members. The choice of participants was based on their level of knowledge and experience on the subject under study.

Why were two different groups formed?

The reason for forming two independent groups was to obtain a comprehensive and multidimensional view, with different understandings of the topic under study.

The Farma group has theoretical and practical knowledge of a professional reality, as they have daily contact with the community pharmacy context and have mastered its structural dynamics.

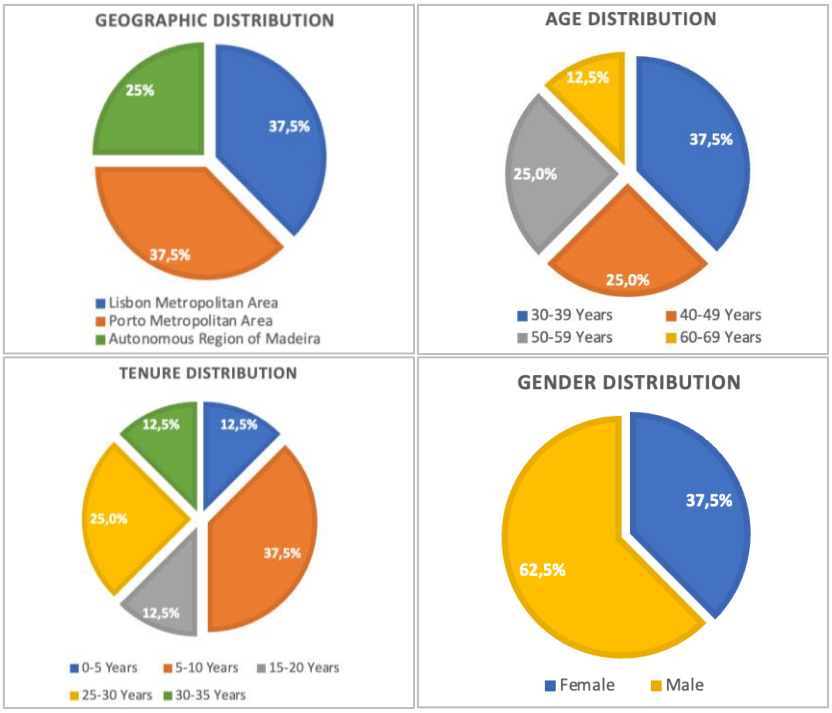
The Techfarma group has a vision that extends beyond community pharmacies, yet it serves as a bridge for building a new reality for community pharmacies, assisting in technological aspects with strategic contributions and know-how that play an indispensable role in understanding the changes arising from an ever-changing world.

2.2. Illustrative Characterization of the Sample

Table 2: Sample Characterization.

	Interview	Profession	Position	Date	Mode of Communication
Farma Group	A	Pharmacist	Owner and TD	19/03/2025	Online
	B	Pharmacist	Owner	20/03/2025	Online
	C	Pharmacist	TD	27/05/2025	In person
	D	Pharmacist	TD	09/07/2025	Online
Techfarma Group	E	Marketing Executive	Retail & Consumer Health Business Unit Director	28/05/2025	By phone
	F	Engineer	IT Consultant	28/05/2025	Online
	G	Manager	Sales Coordinator	06/06/2025	Online
	H	Pharmacist	Sales Coordinator	09/07/2025	Online

Figure 2: Sample Geographic, Demographic and Tenure Distribution.



2.3. Data Collection and Analysis

The interviews were recorded with the consent of the participants using a specific app for this purpose.

Most of the interviews were conducted via the Microsoft Teams platform and transcribed manually, clean verbatim, into a Microsoft Word document, ensuring the consistency and clarity of the data provided by the interviewees.

The interviews were analysed using MAXQDA 2024 software with a thematic analysis coding process. According to Braun & Clarke (2013), it is essential for researchers who use a theory-driven thematic approach to construct a coding system based on a theoretical framework in the literature.

The analysis reached a point of saturation, as no further themes were developed and the coding system reached a point of stabilization.

3. Results

In this regard, the respective codes and subcodes were determined for each dimension, in line with the respondents' answers to the research questions. Thus, the following coding was developed with the relative distribution of the segments coded by the respective code, revealing the percentage of mentions by each participant for the total number of times each theme was described, as shown in the following table:

Table 3: Participants' Percentage Coding Matrix.

List of Codes	A	B	C	D	E	F	G	H
Technological Dimension								
Technical Support	26,7%	60,0%			13,3%			
Inertia in Hardware and Software Systems		30,8%	23,1%			23,1%	7,7%	15,4%
Financial Incentive	85,7%				14,3%			
Interinstitutional Collaboration	37,9%	20,7%	13,8%	13,8%	3,4%		6,9%	3,4%
Innovation	13,6%	21,1%	12,9%	18,4%	6,1%	7,5%	6,8%	13,6%
Cybersecurity	61,5%		15,4%					23,1%
Supply chain logistics	25,0%	18,8%	18,8%	12,5%	12,5%	6,3%		6,3%
Leadership and Organizational Culture Dimension								
Pharmacist's Role	35,1%	19,3%	7,0%	21,1%		1,8%	12,3%	3,5%
Concerns, Resistance, and Technical Barriers	7,5%	7,5%	27,5%	10,0%	7,5%	5,0%	15,0%	20,0%
Training and Assessment	25,0%	33,3%	5,6%		2,8%	11,1%	8,3%	13,9%
Strategy	16,0%	21,8%	14,3%	12,6%	10,1%	7,6%	1,7%	16,0%
Strategic Management Dimension								
Digital Ecosystem	40,0%	40,0%			20,0%			
Wholesaler Interaction			33,3%	33,3%	33,3%			
Customer Interaction	23,1%	30,8%	19,2%	15,4%	3,8%	1,9%		5,8%
Competition	8,7%	4,3%	8,7%	30,4%	30,4%	17,4%		
Business Strategy	10,9%	8,7%	8,7%	30,4%	15,2%	10,9%	6,5%	8,7%
Regulatory Compliance	22,2%	16,7%		22,2%	11,1%		27,8%	
Customer Data – GDPR	30,8%	33,3%	7,7%	5,1%	10,3%	2,6%		10,3%
Total Technology Cost (CAPEX+OPEX)	6,7%	20,0%	20,0%	20,0%				33,3%
Service Quality	38,1%	28,6%	7,6%	5,7%	2,9%	5,7%	7,6%	3,8%
Internal Pharmacy Data	22,2%		11,1%		11,1%	11,1%	11,1%	33,3%
Operational Efficiency	10,9%	17,4%	14,1%	17,4%	9,8%	9,8%	14,1%	6,5%
Financial Management	11,8%	17,6%	23,5%		5,9%	11,8%	17,6%	11,8%
Human Resources Management	3,6%	21,4%		3,6%	35,7%	3,6%	7,1%	25,0%
Inventory Management	12,0%	28,0%	8,0%	6,0%	2,0%	8,0%	30,0%	6,0%
Customer Management	21,1%	31,6%	10,5%	10,5%			5,3%	21,1%
ERP		57,9%	5,3%		26,3%	10,5%		
Customer Experience Dimension								
Patient Outcomes	42,9%	24,3%	14,3%	2,9%	4,3%	4,3%	1,4%	5,7%
Difficulties with Digital Technologies	71,4%			28,6%				
Communication	10,7%	14,3%	17,9%	21,4%	7,1%	10,7%	3,6%	14,3%
Trust in Technology		18,2%	27,3%	9,1%	9,1%	9,1%	9,1%	18,2%
Loyalty	8,8%	29,4%	20,6%	20,6%	8,8%	2,9%	5,9%	2,9%
Sustainability Dimension								
Resource Optimization	13,0%	39,1%	21,7%		4,3%	8,7%	4,3%	8,7%
Stock Management	12,5%	31,3%	18,8%		6,3%		25,0%	6,3%
Paperless	9,1%	36,4%	9,1%		18,2%			27,3%
Triple Bottom Line	6,7%	6,7%	26,7%	13,3%	20,0%	13,3%		13,3%

3.1. Proposition P1 — Integrated ERP and Cyclical Counting Reduce Stockouts and Dispensing Errors, Improving Service Quality

Inventory management is a priority in balancing sufficient stock levels with meeting user needs.

The more mature the ERP and inventory management automation, the lower the rate of stockouts and dispensing errors, resulting in greater management efficiency.

- Dimensions: Technology and Strategic Management.
- Coding terms: Technical Support, Innovation, Operational Efficiency in Stock Management, Operational Efficiency in ERP, and Service Quality.
- Empirical Evidence in the Pharma Group: "(…) ERP suppliers must challenge themselves to go much further and provide much more support to community pharmacies."; "They are largely responsible for the technological transformation of pharmacies, from a management and service perspective"; "Today we see our ERP systems stagnating. We are seeing some progress, some insights, some improvements, but we have to take the leap, and now is the time."; (participant B, lines 86, 87, 95).
- Empirical evidence in the Techfarma group: "(…) it is expected that software houses will continue to work to try to bring more innovation, because it is the only way they have to grow their business." (participant E, line 196).
- Summary of the pattern: The comments made by interviewee B reveal a need for innovation in ERP software, which is an essential tool for the operational management of pharmacies. Interviewee E's position is dominated by the idea of building a path of cooperation and technological evolution.
- Assessment: Sustained.
- Discussion: The integrated ERP software system is a tool that promotes efficiency and quality. It is considered a structural element of the business model and allows valuable insights into the internal dynamics of the CP, serving as a starting point for strategic decisions.

Thus, it follows a guideline of technology as a driver of DT, which is in line with the author Kraus et al. (2021), since one of the authors' positions is to place technology at the core of achieving competitive advantage.

- Practical implications: The results of this study demonstrate the importance of updating and improving the ERP management component. We suggest implementing a forecasting system associated with machine learning algorithms, IoT sensors for real-time stock monitoring, and decision dashboards.

Another point is the rules in cyclical inventory, where accounting can be performed periodically (monthly) instead of conducting an annual inventory.

- KPIs: Percentage of stockouts; check the quantity in terms of differences between the actual inventory and the ERP record (stock deviation) normalized to ppm; assess customer satisfaction and the recommendation metric for the pharmacy using NPS (Net Promoter Score).
- Notes: Conditions, data quality, integration with purchasing.

3.2. Proposition P2 — Interoperability with Wholesalers Using EDI and Demand Forecasts Increases Efficiency and Reduces Tied-Up Capital

Interoperability with wholesalers is vital to the functioning of any business structure.

With regard to CP, technologies such as EDI, which enable digital data transmission between these two entities, are essential for internal dynamics. The pharmacy's goal is to maintain a demand forecast that reduces capital in stock and increases the level of efficiency throughout the service, especially with clean ERP data.

- Dimension: Technology and Strategic Management.
- Coding: Logistics, Digital Ecosystem in Wholesale Interaction, Commercial Strategy, and Operational Efficiency Stock Management.
- Empirical evidence in the Pharma group: "With regard to the internal functioning of the pharmacy, there is greater connection and communication (...) with distributors, who, in the context of medicine availability management, aim to ensure that the necessary medicines are accessible to everyone in the community" (participant D, line 46).
- Empirical evidence in the Techfarma group: "Wholesalers already have integrated stocks, stock management is fully done" (participant E, line 68).

- Summary of the pattern: We can see from interviewee D that today, in the technological field, the interaction between CP and wholesalers is well established and assured in the sense that it always provides an efficient response to the community in guaranteeing regular and continuous access to medicines.

Regarding interviewee E, the high technological level with which suppliers operate in the logistics chain is evident, where there is structured and complex automation.

- Assessment: Sustained.
- Discussion: There is a complex dynamic in relation to this proposition, since in CP there is, on the one hand, the issue of CRM and, on the other hand, the issue of inventory. Therefore, cooperation between these two entities is important to meet customer needs. In this sense, we follow the line of literature by Matt et al. (2015), noting that DT is intrinsically connected in strategic terms with digital, with the supply chain, with processes, and with organizational structure.
- Practical implications: The results of this study demonstrate the importance of continuous and efficient connectivity with wholesalers, with the aim of optimizing stock parameters and continuously responding to customer needs.
- KPIs: Direct indicator that assesses supply chain efficiency – Fill rate (%); Average values of days of merchandise stock; monitor capital in stock as an indicator of the financial component.
- Notes: Dependence on wholesalers, seasonality.

3.3. Proposition P3 — Interinstitutional Interoperability and Customer Data Sharing Improve Service Quality

Interinstitutional interoperability is imperative today for a healthcare entity such as CP. Through EDI technologies following international HL7 (Health Level 7) standards for the transfer of clinical data and with the implementation of FHIR (Fast Healthcare Interoperability Resources), it is possible to establish an efficient, secure interoperability model that meets DT in healthcare.

In fact, the customer must be the focus of the system at all stages, and by placing the customer at the centre, CP must have access to the customer's clinical data, which is important for the pharmacist's performance.

- Dimensions: Technology, Leadership and Organizational Culture, Strategic Management, and Customer Experience.
- Coding terms: Interinstitutional Collaboration, Cybersecurity, Role of the Pharmacist, Regulatory Compliance, GDPR Data, Service Quality, and Results for the User.
- Empirical Evidence in the Pharma group: "(…) in the future, it is crucial that there be interoperability between the pharmacy system and what happens in health centres and local health units (ULS);" "(…) increasing integration of community pharmacists and pharmacies into the ecosystem and health systems" (participant A, line 115; 287).
- Empirical evidence in the Techfarma group: "(…) respond to the call from the national health service to complement more services and connect with health centres and hospitals, assisting these large-scale and complex structures" (participant G, line 169).
- Summary of the pattern: Through the discourse of interviewee A, the need for this cooperation for the benefit of the user is very clear. Similarly, participant G states that it will be a structural step towards a synergistic strategy for promoting user health.
- Assessment: Sustained.
- Discussion: Interoperability between the CP and the various national health structures would have to be based on the GDPR and would involve continuous monitoring of users through a health data platform. This would ensure a holistic view of the patient, improving the quality of the service.
- Practical implications: The results of this study reveal the importance of interoperability between healthcare systems and the CP. In fact, there is the issue of health data, which is one of the most

powerful resources, and there must be clear legislation to protect user privacy, always in accordance with GDPR compliance.

The data is at the service of the pharmacy for the user, and the entire internal structure must understand and establish a commitment to accountability in the treatment of such data based on criteria of seriousness and honesty.

- KPIs: Accounting for incidents (n) of failures in shared services (SPMS - Shared Services of the Ministry of Health) and GDPR response time.
- Notes: Dependence on systems.

3.4. Proposition P4 — GDPR and Basic Cybersecurity Controls (MFA, Backups, EDR) Strengthen Digital Trust and the Adoption of Online Services

Healthcare data must comply with the GDPR, given that data is seen as a strategic asset and, as such, it is well known that a huge amount of data is produced on a daily basis in pharmacies, whether in terms of CRM data or management data relating to the pharmacy itself as an organization. In this regard, basic cybersecurity is vital, as health data must be protected against unauthorized access or negligent use. There is a need to use MFA (Multi-Factor Authentication) security controls, backup systems, and technologies focused on protecting all network endpoints (EDR – Endpoint Detection and Response), increasing confidence in technologies and the use of a reinforced CRM.

- Dimensions: Technology, Leadership and Organizational Culture, Strategic Management, and Customer Experience.
- Coding terms: Cybersecurity, Role of the Pharmacist, Regulatory Compliance, GDPR Customer Data, Service Quality, and Trust in Technology.
- Empirical evidence in the Pharma group: "(…) data protection is a sensitive issue and obviously there has to be a guarantee of data protection and obviously there has to be a guarantee that the current and future mechanisms will provide security for all stakeholders" (participant C, line 158).
- Empirical Evidence in the Techfarma group: "(…) data security, whether we like it or not, the results that a pharmacy generates are enormous and are sensitive data, they are health data. I think that there is still not enough attention being paid to the data we are using and the potential for using this data" (participant H, line 80).
- Summary of the pattern: With regard to participant C, there is a concern about data and compliance with the GDPR, specifically data security. Regarding participant H, the critical issue of cybersecurity and the enormous amount of data that pharmacies generate as entities is noteworthy, as it is a strategic resource and seen as economic value.
- Assessment: Sustained.
- Discussion: At this point, it can be said that data is now a dominant resource available to CP. Within this issue, there is the legislative question, which must be transparent and guarantee privacy and personal data protection, leaving no doubt about future situations regarding who really owns the data: The customer? The CP? The State? Compliance with GDPR standards must be mandatory, and today pharmacies have a detailed and very robust database that can be classified as one of the fundamental resources for digital transformation in community pharmacies.

Regarding the role of the pharmacist, a multidisciplinary professional, they often have to find solutions to more complex problems, where access to data contributes to better performance of their work.

In relation to the literature, we can follow the guideline of the author Verhoef et al. (2021), when he states that digital technology and customer behaviour are external drivers of digital transformation and, in this specific case, the customer has great power, the power of data, and if they do not want to make it available, no one can use it.

- Practical implications: There should be a consent policy and phishing training practices for CP employees to recognize cyberattacks, always following procedures based on backup plans and information management tests.
- KPIs: Number of incidents (n), GDPR response time, recurrence rates, and percentage of signed data consents.
- Notes: Risk perception vs. cost.

3.5. Proposition P5 — Continuous Training and Leadership Positively Moderate the Effect of Technologies on Operational Efficiency

One of the key factors for a team's success is training and empowering them to work with and integrate technologies into their daily routine. There needs to be a spirit that promotes this learning and encourages digital follow-up.

- Dimensions: Leadership and Organizational Culture and Strategic Management.
- Coding terms: Role of the Pharmacist, Training and Evaluation, Strategy, and Operational Efficiency.
- Empirical Evidence in the Pharma group: "Training is crucial, it is the basis of everything, involvement, bringing people to another level, and this is one of the points I emphasize the most, the need to change the leader's mindset" (participant B, line 226).
- Empirical evidence in the Techfarma group: "(...) often having the opportunity to experiment and not just talk about it allows people to test it, to feel how this new technology can change the paradigm in the workplace" (participant F, line 81).
- Summary of the pattern: With regard to continuing education, interviewee B has a comprehensive view, in that pharmacists should have a continuous and broad line of instruction that strengthens a continuing education health team.

Regarding interviewee F, there is a need for people to get involved in the subjects and even more, so when it comes to technology practice. In fact, the opportunity to do, to touch, to relate to technology can change and add new skills to CP.

These statements are in line with interdisciplinary evidence that emotional well-being and cognitive openness enhance the generation of ideas and the adoption of digital practices in services, reinforcing the role of leadership in creating enabling environments (W.O.M.B. model) (de Almeida Leite, Audretsch & Leite, 2025).

- Assessment: Sustained.
- Discussion: Both groups agree that training and leadership that promotes innovation and the acquisition of new knowledge are better prepared to face new challenges. In an environment such as CP, having new tools means greater freedom to work towards personalizing care, and a significant technological base allows more time to spend with the customer.

Learning and using technological resources frees pharmacists from operational tasks with less added value, allowing them to perform other services focused on the user. Consequently, it is necessary to identify skills gaps and invest in structural reskilling and upskilling plans, resulting in greater efficiency while ensuring the success of DT.

This line of thinking is in line with Martínez-Morá et al. (2021), who state that companies must invest in knowledge to bridge the digital transformation gap.

- Practical implications: the results demonstrate the need to invest in training and preparing teams in CP.
- KPIs: Number of training hours for each employee, digital adoption (%), service time, and costs/revenue.
- Notes: Team turnover as a negative moderator.

3.6. Proposition P6 — Technological Obsolescence Contributes to Decreased Operational Efficiency and Negatively Impacts Service Quality

In any corporate environment, the speed and correct operational functioning of the entire technological system is essential, in this case for the internal dynamics of CP. The fact that there are constant failures, insufficient performance, and slow response times on the part of the technological infrastructure has a negative impact on service quality.

- Dimensions: Technology and Strategic Management.
- Coding terms: Hardware and Software Inertia and Service Quality.
- Empirical Evidence in the Pharma group: "(...) our computer system has recurring updates, but over time the software becomes increasingly heavy, slowing down the machines" (participant C, line 139).
- Empirical evidence in the Techfarma group: "(...) many community pharmacies use older hardware and software systems and have many difficulties integrating with the latest technologies" (participant F, line 64).
- Summary of the pattern: Regarding interviewee C, there is a clear concern that the technology used in pharmacies is not up to date and does not meet the minimum requirements necessary to absorb rapid technological development. Regarding interviewee F, he points out that many pharmacies have difficulty keeping up with this progression, leading to barriers when it comes to moving on to the next step.
- Assessment: Sustained.
- Discussion: Sometimes, the pharmacy's technological infrastructure is not updated, either for financial reasons or from a leadership perspective. There is no need to make a state-of-the-art investment, but keeping up with technological developments is imperative for innovation and growth in a constantly evolving market. This proposition is in line with Kraus et al. (2021), who argue that technology can be considered one of the key drivers for achieving DT.
- Practical implications: It is essential to carry out regular updates, making all internal processes more automated and increasing employee performance, which is essential for the success of any digital transformation.
- KPIs: Average age of technology park, process failure rate, and productivity.
- Notes: Circular Economy.

3.7. Proposition P7 — Digital Channels Contribute to the Expansion of Services and to Increased Customer Loyalty and Lifetime Value (LTV)

Digital channels are a vehicle for symbiotic interaction with customers, using flexibility that allows us to respond to each customer's needs at any time.

- Dimensions: Technology, Strategic Management, and Customer Experience.
- Coding terms: Innovation, Digital Ecosystem, Customer Interaction, Competition, Commercial Strategy, User Outcomes, Communication, and Loyalty.
- Empirical Evidence in the Pharma group: "In the case of online shopping and online appointments, these are services that also build loyalty. For example, at the pharmacy, we have an online calendar for scheduling appointments (...)" (participant C, line 220); "I don't think digital channels build customer loyalty. Social media channels and digital channels build loyalty to price. If I have a well-oiled machine for pricing, the digital channel will build loyalty very well" (participant D, line 213).
- Empirical evidence from the Techfarma group: "(…) nowadays, consumers are more easily influenced by price-driven or other factors, resulting in lower loyalty to the pharmacy channel." (participant E, line 177); "Another area is telemedicine services, online consultations, where it is possible to monitor the population more closely and even include those who, for some reason, are unable to travel to the pharmacy."; "With the new channels, it is possible to segment, reach new customers in a personalized way, facilitating loyalty." (participant H, line 21; 149).
- Summary of the pattern: Regarding the association between service expansion and loyalty, interviewees C and H mention that the introduction of services through online channels has a loyalty-building character, while interviewees D and E agree that digital channels are positive for customers, but there

is a lower loyalty profile to the digital pharmacy channel, largely due to price-driven phenomena. In line with the principle of data value chains, the combination of internal (ERP/POS) and external (wholesalers, booking platforms, public systems) data increases the usefulness for decision-making and the performance of digital channels, underlining the importance of interoperability and data governance (Sepúlveda, 2023).

- Assessment: Partially supported.
- Discussion: Nowadays, it is important for community pharmacies to provide an efficient and personalized experience for their customers and to fulfill their needs, both in terms of service provision and health literacy. Currently, there are pharmacies that offer a range of consultations and in the future may introduce digital pharmaceutical consultations. In this way, community pharmacies use a resource to strengthen their care role, providing more differentiated, efficient, personalized, and accessible services. There is digital therapy management with remote health monitoring. As in the literature, authors Verhoef et al. (2021) state that DT involves digital resources and will ultimately lead to continuous digital growth that is integral to corporate culture.

The point of contention is that digital channels amplify competition, modifying the variables that eventually lead to loyalty. According to the literature, it appears that, for the most part, digital channels with a price-driven strategy lead to a low LTV in the long term (Dara et al., 2025).

- Practical implications: Customer experience is paramount to loyalty, and digital presence is a tool that helps reach an increasingly connected and informed community. However, special attention must be paid to price-driven competition, which can lead to market distortions and whose trend can lead to unsustainable situations in the long term.
- KPIs: Frequency of use of digital channels, online conversion rate, NPS, number and volume of online channel sales, average response time on the digital channel, percentage of users of online services, and service completion rate.
- Notes: Baby Boomer generation.

3.8. Proposition P8 — Operational Dashboards Coupled with AI and Big Data Analytics Technology Contribute to Faster Decisions and Lower Operating Costs

Data is essential for decision-making. And in the context of CP, it is important to have real-time monitoring tracking the performance of the pharmacy as a business. Within this reality, visible and regularly reviewed KPIs can be applied to guide waste reduction and accelerate the response to complex problems.

- Dimensions: Technology, Strategic Management, Sustainability.
- Coding terms: Innovation, Commercial Strategy, Service Quality, Internal Pharmacy Data, Operational Efficiency, and Resource Optimization.
- Empirical Evidence in the Farma group: "(…) artificial intelligence, machine learning allowing predictive analysis and optimization of stocks and processes (…) tremendous added value from the point of view of waste control"; "From a financial management point of view, also with predictive analysis (…) sources of information that allow us to predict market developments, develop business plans, understand how the economy is evolving, but if we have all this information integrated and can be analysed using technology, it will certainly make us pharmacists better managers, at least we will be able to better predict the evolution of our company." (participant B, line 125; 180).
- Empirical evidence in the Techfarma group: "Support from highly sophisticated digital systems opens the door to an almost unlimited source of information"; "(...) with the support of software systems and digital system licenses, we are able to search for the information we need at any given moment" (participant F, lines 92; 96).
- Summary of the pattern: Interviewee B emphasizes that these new technological tools are beneficial for the management of the pharmacy itself, which brings advantages for all parties involved. Interviewee F praises these technological tools as a strong aid in decision-making by managers, since they concentrate

and analyse all the necessary information in real time. These qualitative findings are in line with national quantitative evidence: high-quality information systems improve the quality of information (financial and non-financial), increasing its usefulness for decision-making and, thereby, operational/customer performance. (See, for example, SEM models in studies with Portuguese companies). (Monteiro et al., 2022; Monteiro et al., 2024).

- Assessment: Sustained.
- Discussion: Technology is one of the drivers of DT in CP, and when automation processes are introduced, decision-making processes are streamlined, leading to a reduction in operating costs.

According to Pousttchi et al. (2019), technological optimization generates added value, leading to cost reductions and improved service delivery.

- Practical implications: Promoting innovation in CP provides a competitive advantage in the market, even if only temporary. These tools lead to the optimization of the entire organizational structure.
- KPIs: Cost/Revenue, Decision Lead Time, Productivity.
- Notes: Data quality; RACI (Responsible, Accountable, Consulted, Informed) matrix model.

3.9. Proposition P9 — Financing Strategy Contributes to Accelerating the Digital Roadmap and Reduces TCO (Total Cost of Ownership)

A financing strategy aims to modernize the entire pharmacy sector, creating a benchmark that contributes to better service quality and a much more efficient operating system, reducing CAPEX/OPEX barriers and accelerating the adoption of more modern ERP, EDI, and internal automation systems. In this regard, it is crucial to use strategic tools such as a roadmap to align objectives and follow a plan that attracts investment in order to raise CP in Portugal to a higher level.

- Dimensions: Technology and Strategic Management.
- Coding terms: Financial Incentives, Innovation, Total Technology Cost (CAPEX+OPEX), and Service Quality.
- Empirical Evidence in the Pharma group: "(...) if there are incentives and financial support for the digitization of companies and technological modernization, it will be much easier for all pharmacies in the country to adopt it." (participant A, line 172).
- Empirical evidence in the Techfarma group: "(…) ongoing process with incentives from the government and Portuguese National Association of Pharmacies (ANF)" (participant E, line 192).
- Summary of the pattern: With regard to interviewee A, there is a position of technological uniformity for all pharmacies and pharmacists in terms of investing in DT, but for this to be possible, financial incentives are needed to enable pharmacies to move in this direction. Interviewee E emphasizes two entities that can help in this DT process, reaffirming the importance of financial support in this process.
- Assessment: Sustained.
- Discussion: Financing is a catalyst for the growth of a culture of innovation. It is essential to promote accessible financial incentives to support technological transition, for example, in the fiscal field for the acquisition of technology.
- Practical implications: In a funding framework with lines of support for innovation, it is necessary to study partnerships that are eligible for this purpose. Always assessing the implications of these changes in the CP paradigm, with dossiers ready, budgets, and benefits that these changes may bring to this area.
- KPIs: euros (€) raised; Speed of implementation; TCO.
- Notes: Risk of dependence on incentives.

3.10. Proposition P10 — Paperless and Energy Efficiency Contribute to Reducing OPEX and Increase ESG (Environmental, Social, and Governance) Perception

Paper reduction and energy optimization have short paybacks and reinforce sustainability by creating long-term value for stakeholders.

- Dimensions: Sustainability.
- Coding terms: Resource Optimization, Paper Reduction, and Triple Bottom Line.
- Empirical Evidence in the Pharma group: "With regard to the optimization of material energy resources through digitization and paper reduction, we believe that we are already moving in that direction." (participant B, line 458).
- Empirical Evidence in the Techfarma group: "It promotes stock resolution, which is already one of the main sustainability practices, avoiding excessively high stocks and reducing the overall impact on their cycle." (participant G, line 183).
- Summary of the pattern: Regarding interviewee B, it can be concluded that we are on the right track, although there is room for improvement, since we have not yet achieved full sustainability. Interviewee G's position encompasses stock management in the dimension of sustainability, since greater efficiency in this field leads to greater optimization of resources at all levels.
- Assessment: Sustained.
- Discussion: In the context of sustainability, it can be said that the integration of technologies that support the viability of DT contributes significantly to circular economy practices. One example is inventory management, where there are no longer pharmacies with excess stock and others with stock shortages, i.e., there is a more equitable distribution in line with users' needs. In energy-intensive services, the literature shows that good efficiency and monitoring practices reduce consumption and operating costs, reinforcing the ESG perception — which justifies kWh/m² and € energy/revenue as environmental KPIs also in community pharmacies, by sector analogy (Mota, Leite & Ghasemi, 2024). In addition, transparency in "green" practices and staff training are emerging as vectors for tangible energy savings and reputation improvement, parallels that apply to community pharmacies (Mota, Leite & Ghasemi, 2024).

In terms of paper reduction, this is imperative both in logistics and in the implementation of the EMP system (electronic medical prescription).

However, the use of technological resources such as AI also poses challenges, particularly in terms of energy consumption.

The way forward will be to ensure greater sustainability and a reconfiguration towards user-centricity.

- Practical implications: The importance of no longer working with paper prescriptions and the fact that the entire process is now electronic.
- KPIs: Energy consumption per unit produced (kWh/m²), euros (€) energy/prescription, (n) pages printed, and ESG rating.
- Notes: Minimal investments and team habits.

4. Discussion

The literature on the concept of DT is vast, as it transcends a simple definition. In fact, DT is multidimensional and brings a new paradigm to CP, whose dynamics are complex and challenging with pharmaceutical and non-pharmaceutical players.

This qualitative study, based on semi-structured interviews with pharmaceutical and technology professionals (two groups), was analysed by thematic coding, generating operational propositions aligned with the five mapped dimensions.

In this sense, DT provides a redefinition of an entire business model, translating into efficiency, increased quality, and placing the user in a central position. It is a concept that involves several dimensions, including leadership and organizational culture, management, and technology, which, when strategically integrated, enhances

pharmaceutical services, values the customer experience, and, in a business context, confers responsibility for sustainable development.

In the field of challenges in DT itself, whenever an organization undergoes structural changes, it is expected that there will be:

a) Absence of a management strategy for organizational change, which must be initiated with the human component and not through technology;
b) Lack of specialized skills;
c) Continuous evolution of customer needs, with a view to meeting their expectations and requirements;
d) Internal resistance to change on the part of teams;
e) Concerns about digital security;
f) Potentially high investments, which may lead to budget constraints.

Regarding the empirical findings summarized. (i) ERP maturity and cyclical counting generate fewer disruptions and less administrative time; (ii) GDPR and cybersecurity provide greater digital confidence and enable online services; (iii) dashboards/KPIs make decisions faster and improve resource allocation; (iv) paperless and energy efficiency lead to reduced OPEX and enhanced ESG perception; (v) financing/support accelerates the digital roadmap (with risks of dependency); (vi) leadership/culture are critical conditions for sustained adoption.

DT introduces challenging new work configurations; however, we must never forget that we are gregarious beings and this study shows that, in general, new technologies are here to support us and not to replace us. DT involves strategic decisions, models focused on agile processes and personalized experiences, resulting in structural efficiencies.

These results indicate clear causal chains: dashboards reduce information asymmetries (intervention), shorten decision time (mechanism), and improve operational indicators (result); paperless/energy efficiency means fewer consumables and lower kWh/m²; GDPR/cybersecurity reinforce user confidence and the adoption of digital services.

In this context, there are several obstacles mentioned above, ranging from fears, resistance, and technical barriers to issues of regulatory compliance and cybersecurity. In fact, regulatory and ethical issues are important and decisive milestones in the protection of personal data in Europe; we look at other geographical areas of the planet where this issue is not so sensitive. We can conclude that we are on the right track, but we must be ready for a certain degree of flexibility so as not to block progress.

The solution lies in technically robust information security policies and government guidelines (Mott et al., 2023; Schilirò, 2024). Operationally, it is recommended to monitor five (5) core KPIs: % of breakdowns, average waiting time, pages printed/month, kWh/m², and € energy/revenue; define baselines and quarterly targets and integrate these indicators into management dashboards.

CP has the potential to become a broader ecosystem of services, starting with pharmacies and eventually reaching users' homes/workplaces, although for this to happen, it must be based on the following premises:

1. Excellence of teams, particularly in the role of the pharmacist;
2. Incorporating DT to speed up processes;
3. Considering data as a resource for optimizing patient care;
4. Financial and technical investment.

The main forces shaping the future of community pharmacy in Portugal will be technology, economics, regulation, and social values—thinking about preventing disease upstream.

With regard to the view of DT in CP, this study has some limitations that must be considered:

a) The rapid changeability of technological and regulatory realities;

b) In the Customer Experience dimension, there may be a bias in the perception of a sample with digital literacy, which does not represent the current general population of patients;
c) Absence of comparative studies on technology in the pharmacy sector in Portugal;
d) Intentional and non-probabilistic sample; inclusion criteria and evidence of saturation should be explained in the final version.

Future avenues should include converting propositions into testable hypotheses and evaluating them with before-and-after designs and time series in multiple pharmacies (e.g., impact of dashboards on % of stockouts/waiting time and paperless on OPEX/ESG).

Finally, study the role of the pharmacist, in terms of technological evolution, from a probabilistic perspective, perhaps not too far off, of living in a reality of pharmaceutical algorithms, where they do not have to be perfect, only better than human pharmacists.

5. References

Almeman, A. (2024). The digital transformation in pharmacy: Embracing online platforms and the cosmeceutical paradigm shift. *Journal of Health, Population and Nutrition, 43*(1), Article 60. https://doi.org/10.1186/s41043-024-00550-2

Baines, D., Nørgaard, L. S., Babar, Z.-U.-D., & Rossing, C. (2020). The Fourth Industrial Revolution: Will it change pharmacy practice? *Research in Social and Administrative Pharmacy, 16*(9), 1279–1281. https://doi.org/10.1016/j.sapharm.2019.04.003

Barata, J., Maia, F., & Mascarenhas, A. (2022). Digital transformation of the mobile connected pharmacy: A first step toward community pharmacy 5.0. *Informatics for Health and Social Care, 47*(4), 347–360. https://doi.org/10.1080/17538157.2021.2005603

Bonnet, D., & Westerman, G. (2021). The new elements of digital transformation. *MIT Sloan Management Review, 62*(2), 83–89.

Braun, V., & Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners*. Sage Publications.

Carayannis, E. G., & Campbell, D. F. J. (2010). Triple Helix, Quadruple Helix and Quintuple Helix and how do knowledge, innovation and the environment relate to each other? *International Journal of Social Ecology and Sustainable Development, 1*(1), 41–69. https://doi.org/10.4018/jsesd.2010010105

Dara, S., Duvvu, R., Subrahmanyam, T. S. R., Bochela, S., & Sai, M. V. (2025). Customer churn retention using machine learning. In *Proceedings of the 2025 6th International Conference on Recent Advances in Information Technology (RAIT)* (pp. 1–6). IEEE. https://doi.org/10.1109/RAIT65068.2025.11088963

De Almeida Leite, E. M., Audretsch, D., & Leite, A. (2025). Integrating philosophy and psychology to enhance creativity and innovation in entrepreneurship: The W.O.M.B. model. *The Journal of Technology Transfer, 50*, 1396–1415. https://doi.org/10.1007/s10961-024-10142-1

Devi, D. H., Duraisamy, K., Armghan, A., Alsharari, M., Aliqab, K., Sorathiya, V., Das, S., & Rashid, N. (2023). 5G technology in healthcare and wearable devices: A review. *Sensors, 23*(5), Article 2519. https://doi.org/10.3390/s23052519

Hamiid, M. V., N., V., Umamageswaran, J., & M., P. (2025). The synergy of DARQ technologies: Integration and future prospects. In *Proceedings of the 2025 International Conference on Computational Robotics, Testing and Engineering Evaluation (ICCRTEE)* (pp. 1–7). IEEE. https://doi.org/10.1109/ICCRTEE64519.2025.11052901

Hanelt, A., Bohnsack, R., Marz, D., & Antunes Marante, C. (2021). A systematic review of the literature on digital transformation: Insights and implications for strategy and organizational change. *Journal of Management Studies, 58*(5), 1159–1197. https://doi.org/10.1111/joms.12639

Jonker, J., & Pennink, B. W. (2010). *The essence of research methodology: A concise guide for master's and PhD students in management science*. Springer. https://doi.org/10.1007/978-3-540-71659-4

Jovane, F., Yoshikawa, H., Alting, L., Boër, C. R., Westkämper, E., Williams, D., Tseng, M., Seliger, G., & Paci, A. M. (2008). The incoming global technological and industrial revolution towards competitive sustainable manufacturing. *CIRP Annals, 57*(2), 641–659. https://doi.org/10.1016/j.cirp.2008.09.010

Kraus, S., Jones, P., Kailer, N., Weinmann, A., Chaparro-Banegas, N., & Roig-Tierno, N. (2021). Digital transformation: An overview of the current state of the art of research. *SAGE Open, 11*(3). https://doi.org/10.1177/21582440211047576

Leite, E. M. de A., Audretsch, D., & Leite, A. (2024). Redefining entrepreneurship: Philosophical insights in a post-individualist era. *The Journal of Entrepreneurship, 33*(2), 239–267. https://doi.org/10.1177/09713557241255399

Martínez-Morán, P. C., Urgoiti, J. M. F.-R., Díez, F., & Solabarrieta, J. (2021). The digital transformation of the talent management process: A Spanish business case. *Sustainability, 13*(4), Article 2264. https://doi.org/10.3390/su13042264

Matt, C., Hess, T., & Benlian, A. (2015). Digital transformation strategies. *Business & Information Systems Engineering, 57*(5), 339–343. https://doi.org/10.1007/s12599-015-0401-5

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). Sage Publications.

Monteiro, A. P., Vale, J., Leite, E., & Lis, M. (2024). Linking quality of accounting information systems and financial reporting to non-financial performance: The role of women managers. *International Journal of Accounting Information Systems, 54*, Article 100692. https://doi.org/10.1016/j.accinf.2024.100692

Monteiro, A. P., Vale, J., Leite, E., Lis, M., & Kurowska-Pysz, J. (2022). The impact of information systems and non-financial information on company success. *International Journal of Accounting Information Systems, 45*, Article 100557. https://doi.org/10.1016/j.accinf.2022.100557

Mota, L., Leite, E., & Ghasemi, V. (2024). Exploring the impact of climate change on lodging establishments: A systematic literature review. *Quality & Quantity*. https://doi.org/10.1007/s11135-024-01834-9

Organisation for Economic Co-operation and Development. (2018). *Going digital in a multilateral world*. OECD. https://www.oecd.org/going-digital/C-MIN-2018-6-EN.pdf

PECB. (2022, November 9). *Digital transformation challenges and how to overcome them*. https://pecb.com/article/digital-transformation-challenges-and-how-to-overcome-them

Pousttchi, K., Gleiss, A., Buzzi, B., & Kohlhagen, M. (2019). Technology impact types for digital transformation. In *Proceedings of the 21st IEEE Conference on Business Informatics (CBI 2019)* (Vol. 1, pp. 487–494). IEEE. https://doi.org/10.1109/CBI.2019.00063

Ribeiro, P. N. (2023). Liderança na transformação digital. *The Trends Hub*, (3). https://doi.org/10.34630/tth.vi3.5067

Schwartz, E. I. (2001). *Digital Darwinism: Seven breakthrough business strategies for surviving in the cutthroat web economy* (Rev. ed.). Broadway Books.

Sepúlveda, J. (2023). From big data to smart data: Opportunities for entrepreneurs using data space ecosystem approach. *Journal of Entrepreneurial Researchers, 1*(2), 87–96. https://doi.org/10.29073/jer.v1i2.19

Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Qi Dong, J., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research, 122*, 889–901. https://doi.org/10.1016/j.jbusres.2019.09.022

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