USE OF DIGITALISATION TO REDUCE WASTE IN MANUFACTURING

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Abstract

This paper discusses the challenge of waste in the manufacturing industry and how digitalisation can address this issue. Specifically, it explores the potential impact of digitalisation on waste reduction in the human and animal medicine manufacturing sectors. Digitalisation can reduce waste in medicine manufacturing through real-time quality control and predictive maintenance. The article emphasises the importance of collaboration and data-driven decision-making in implementing digitalisation. Manufacturing companies have historically adopted a culture of simplification and economies of scale, often conflicting with the biological realities of personalised medicine and rare diseases. The waste problem associated with this approach is explored in the context of the pharmaceutical industry. As digital technology evolves to meet public demand for personalised therapies, the industry must balance allo- and autotherapies to address diverse patient needs. The Risk of Missing Out (ROMO) concept is introduced as a critical consideration for future developments in healthcare. In the end, the article highlights how the personalised medicine trend can shift power from manufacturers to end-users and proposes a blockchain-based social network platform, the MedConnect Network, to empower end-users of medicines.

Keywords: MedConnect, cryptography, collaboration tools, empowerment tools, ROMO

A culture of simplification and economies of scale have long driven the pharmaceutical industry. This approach enables companies to manufacture large quantities of medicines at lower costs but often conflicts with the biological realities of personalised medicine, rare diseases, and precision therapies. As a result, the industry is confronted with a waste problem that needs to be addressed to meet the growing demand for individualised treatments.

Digital technology has the potential to revolutionise the pharmaceutical industry by enabling the development of personalised therapies. Patients increasingly demand tailored treatments, pushing the industry to rethink its traditional manufacturing paradigms. However, this shift raises questions about the role of biology in healthcare and whether patients are genuinely at the centre of the industry's focus.

The paper delves into the concept of MedConnect as a social network that could significantly benefit human and animal patients by providing a means of collective negotiation with drug manufacturers. As a platform designed to enhance collaboration and communication between healthcare professionals and patients, MedConnect aims to offer transparent and reliable information on medicines, empowering patients to make informed decisions about their healthcare.

Moreover, the platform can facilitate customer communication with drug producers and suppliers, streamlining the production and distribution process and reducing inefficiencies in the bio-economy.

By leveraging secure blockchain technology (Hallem A. *et al,* 2021), MedConnect has the potential to balance the power dynamic between medicine producers and users, enabling real-time quality control and data-driven decision-making. The platform's application of Artificial Intelligence -AI (Shabbir J., Anwer T., 2015) and other technologies, such as ChatGPT, can further reduce knowledge barriers and automate monitoring solutions while facilitating collaboration in this complex environment.

In line with the responsible innovation concept, we propose starting with animal care as the testing ground for MedConnect. This approach could mitigate the ethical impact of the technology and provide a clear path for gradual implementation towards human care. Ultimately, the transformative potential of MedConnect lies in its ability to empower patients and farmers, improve healthcare

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outcomes, and foster sustainable growth in the bio-economy through digitalisation.

MATERIAL AND METHOD

The rise of precision and personalised medicines should ideally place patients at the heart of healthcare. However, the historical emphasis on economies of scale has created a manufacturing bias that might hinder the realisation of this patient-centric approach. As the industry transitions to accommodate personalised therapies, it must also reconcile the debate between allogeneic (allo) and autologous (auto) therapies (Abraham E. *et al,* 2018). The debate between allo - and autotherapies is contentious, with some arguing that allotherapies are favoured because they align better with the traditional manufacturing construct. This manufacturing bias could limit the development of new therapies which might address distinct patient needs. A more balanced approach is needed, one that recognises the value of both allo- and autotherapies in addressing diverse biological challenges.

The Risk of Missing Out - ROMO (Kiskis R.) concept refers to the potential loss of life-saving biology and unmet patient needs that may never be realised due to the current industry paradigm. ROMO emphasises the importance of investigating and developing novel therapies, even if they challenge conventional manufacturing practices. By embracing digital technology and addressing the waste problem, the pharmaceutical industry can minimise ROMO and ensure a more patient-centric future. The traditional manufacturing models in the pharmaceutical industry often lead to excess supply, which, when multiplied by millions of pharmacies, results in a significant surplus for a demand that does not exist. This wasteful approach and logistics models that inherently factor in surplus and waste calculations, such as the bullwhip effect, are no longer acceptable in the current landscape. Factors driving the need for change include environmental concerns, net-zero targets, patient volume, digital data rights, resource scarcity, control mechanisms such as consent, and the increasing demand for precision medicine. The pharmaceutical industry must reconsider its logistics and manufacturing models to minimise waste and excess supply. Embracing digital technology can help streamline these processes, allowing for real-time monitoring of supply and demand and facilitating more targeted production. By incorporating digital tools and data analytics into logistics and manufacturing, the industry can optimise its operations to align with patient needs and reduce excess supply and waste. The push for net-zero targets and the scarcity of resources makes it increasingly urgent for the pharmaceutical industry to address its waste problem. Companies can reduce their environmental impact and conserve valuable resources by adopting more sustainable manufacturing practices and minimising excess supply. Digital technology can play a crucial role in enabling these sustainable practices by providing greater visibility into supply chains, enabling better decision-making, and facilitating data-driven approaches to resource management. Patient digital rights and consent become increasingly important as the pharmaceutical industry moves towards personalised medicine. Ensuring that patients have control over their data and are involved in decisions about their treatments is essential in fostering trust and driving the adoption of precision medicine. By leveraging digital technology to manage patient data and consent, the industry can maintain transparency, protect privacy, and adhere to regulatory requirements.

RESULTS AND DISCUSSIONS

Artificial Intelligence (AI) and Machine Learning (ML) have emerged as transformative technologies that can reshape various aspects of the pharmaceutical industry. In research and development, AI and ML (Bell J., 2022) can expedite drug discovery, refine clinical trial designs, and analyse vast data. By automating labour-intensive tasks and processing large datasets, these technologies can streamline the drug discovery process, cut costs, and reduce the likelihood of failure. Furthermore, AI can optimise manufacturing processes, decreasing waste and enhancing efficiency. Blockchain technologies hold promise for the pharmaceutical industry, particularly in supply chain management (Kuo TT., *et al,* 2017). By creating secure, transparent, and tamper-proof records of transactions, blockchain can improve traceability and reduce the risk of counterfeit medicines entering the market (LeewayHertz). This technology can also facilitate data sharing among stakeholders, enabling more efficient inventory management and minimising waste (Rolewicz-Kalińska A., 2016) due to stockpiling or expiration. In addition, blockchain can improve regulatory compliance and enhance patient safety by providing an immutable record of a drug's journey from production to consumption.

Telemedicine, which involves delivering healthcare services via digital communication platforms, is another digital solution that can enhance the accessibility of medicines. By allowing patients to consult with healthcare professionals remotely, telemedicine can bridge geographical gaps and ensure that patients in underserved areas receive the care they need. In the pharmaceutical industry, telemedicine can facilitate remote monitoring of patient's medication adherence, enabling healthcare providers to track treatment progress and adjust prescriptions as needed. This approach can improve health outcomes and

minimise waste caused by inappropriate medication use or overprescription.

Digital supply chain management can significantly improve efficiency in the pharmaceutical industry by integrating data from various stages of the supply chain, such as procurement, production, and distribution. Through real-time monitoring and predictive analytics, digital supply chain management (Agrawal P., Narain R., 2018) enables companies to optimise inventory levels, reduce lead times, and respond more effectively to fluctuations in demand. This improved visibility and control can help minimise waste and ensure that medicines are available to patients when needed.

Another way to increase efficiency in the pharmaceutical industry is to harness the power of the Internet of Things (IoT) for real-time data collection and analysis (Vippalapalli V., Ananthula S, 2016). IoT devices can monitor storage conditions, such as temperature and humidity, ensuring that medicines are maintained within appropriate parameters. By proactively identifying potential issues and optimising storage conditions, companies can reduce waste caused by spoilage or degradation of medicines (Diaz L.F. *et al*, 2008).

3D printing, also known as additive manufacturing, has the potential to revolutionise pharmaceutical production by enabling the creation of personalised medicines with precise dosages and formulations. This technology can help reduce waste by allowing manufacturers to produce medicines on-demand, eliminating the need for large-scale production and reducing the likelihood of excess inventory. In addition, 3D printing can improve accessibility to medicines by enabling localised production and reducing reliance on complex global supply chains.

Data analytics and predictive modelling can be employed to optimise pharmaceutical manufacturing processes, identifying inefficiencies and opportunities for improvement. By analysing historical data and using predictive algorithms, companies can anticipate fluctuations in demand, optimise production schedules, and adjust capacity as needed. This proactive approach can help minimise waste, reduce lead times, and ensure that medicines are produced in the right quantities at the right time.

Digital solutions such as AI, blockchain technology, telemedicine, digital supply chain management, IoT, 3D printing, and data analytics can significantly enhance efficiency in the pharmaceutical industry. By adopting these technologies, companies can reduce waste, improve accessibility to medicines, and create a more sustainable, patient-centric healthcare system.

The successful implementation of digital solutions within the pharmaceutical industry (Hole G. *et al*, 2021), such as AI, blockchain, telemedicine, and digital supply chain management, necessitates adopting innovative governance strategies. These strategies should foster a dynamic ecosystem of manufacturers, patients, and other stakeholders while promoting collaboration and competition to accelerate the adoption of viable solutions stemming from scientific, social, and economic research.

One of the primary challenges in adopting new digital solutions in the pharmaceutical industry is overcoming inertia, cultural resistance, and other barriers that hinder change. Governance structures for initiatives enabling complex ecosystems to evolve must be adaptive and flexible, encouraging a culture of continuous learning and improvement. This can be achieved by promoting open communication channels, fostering a culture of innovation, and supporting experimentation with new technologies and processes.

To ensure that collaboration and competition coexist in the pharmaceutical ecosystem, governance strategies should balance promoting cooperation among stakeholders and fostering a competitive environment. Sharing knowledge, data, and best practices can enable industry players to learn from one another and collectively address challenges, such as waste reduction and medicine accessibility. At the same time, competition can drive innovation and efficiency by motivating companies to develop new technologies and optimise their operations. Regulatory bodies and industry associations play a critical role in shaping the governance landscape within the pharmaceutical industry. They must work together to create a supportive regulatory framework that encourages the adoption of digital solutions while ensuring the safety and efficacy of new technologies. This may involve updating existing regulations, developing new guidelines, or implementing incentive programs to encourage innovation and collaboration.

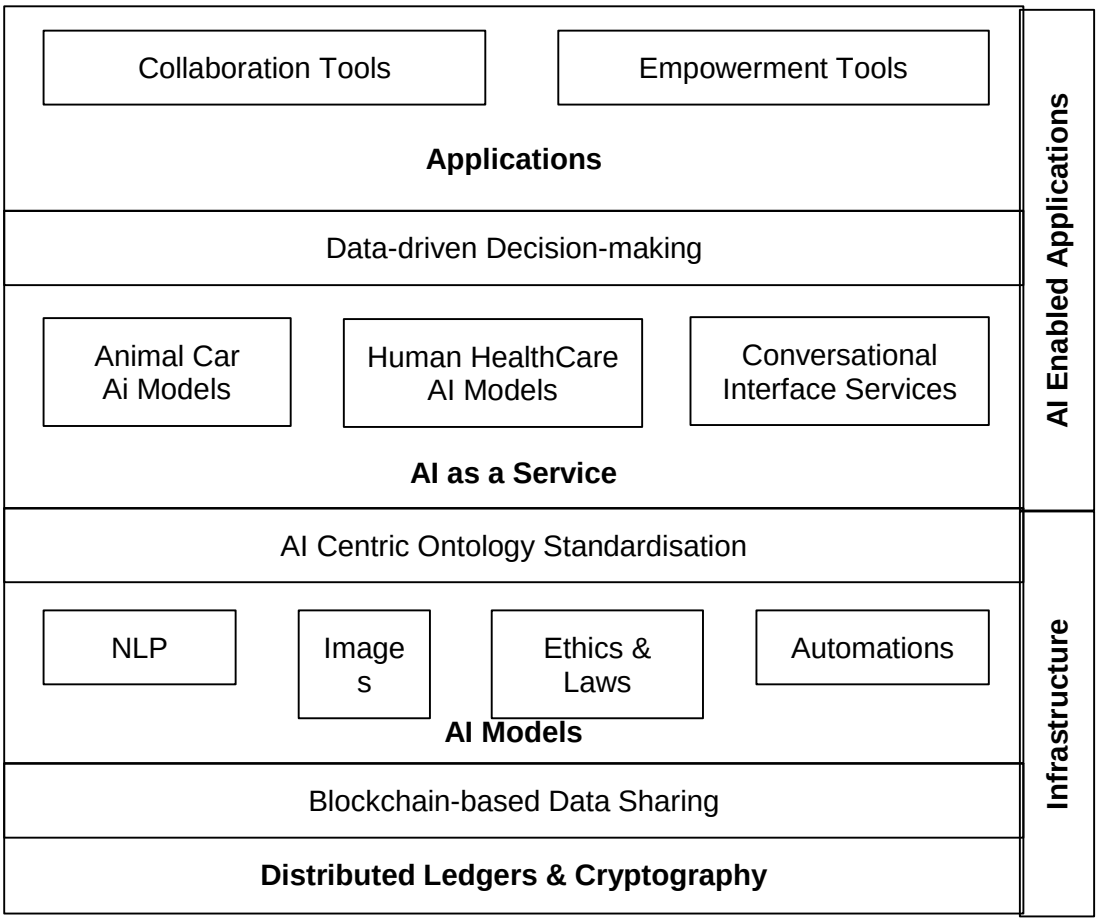

Figure 1 **Main layers of architecture MedConnect**

The foundation of MedConnect is a blockchain-based data-sharing platform that leverages distributed ledgers and cryptography to ensure the privacy, security, data provenance, and identities of all stakeholders involved in the healthcare ecosystem.

A blockchain-based platform allows for decentralised and secure data storage, where data is distributed across the network rather than stored in a central database. This distributed approach ensures that the data is transparent, tamper-proof, and immutable, which enhances trust and confidence in the system.

Moreover, using cryptography in MedConnect ensures secure communication and data transfer between stakeholders. Cryptography provides confidentiality, integrity, and data provenance, which are critical in ensuring that data is only accessible to authorised parties and that that is usable.

Additionally, MedConnect's use of cryptographic techniques ensures that identities are secure and data provenance is maintained, enhancing traceability and accountability.

The blockchain-based data-sharing platform of MedConnect ensures a secure, transparent, and trustworthy healthcare ecosystem where stakeholders can share data and collaborate seamlessly, leading to improved healthcare outcomes and a more efficient economy. The second layer of the MedConnect architecture is the AI-centric ontology standardisation layer, which provides predefined AI models for natural language processing - NLP (Liddy E.D., 2001), image processing, ethical and legal aspects of the social network, and other automation. This layer aims to standardise the use of AI within the platform and to provide efficient and accurate solutions to complex problems.

Through its NLP models, the AI-centric ontology standardisation layer of MedConnect can extract valuable insights from unstructured data, such as patient medical records and research papers, and present them in a structured format, facilitating data-driven decision-making. Similarly, image processing models can detect patterns and abnormalities in medical images, assisting healthcare professionals in making accurate diagnoses and treatment plans. Furthermore, the ethical and legal aspects of MedConnect's social network are addressed through AI models, ensuring the platform operates within legal and ethical boundaries. This includes privacy and security, data protection regulations, and other ethical considerations.

The third layer of the MedConnect architecture is the data-driven decision-making services layer, which offers services for the conversational interface exposed at the upper level. This layer is equipped with AI models that have been trained for both animal care and human healthcare. The data-driven decision-making services layer of MedConnect provides a range of services to support the conversational interface, such as personalised medicine recommendations, drug interaction alerts, and healthcare trend analysis. AI models drive these services trained on large datasets and can provide accurate and reliable insights into healthcare-related issues. Additionally, the AI models in this layer are trained specifically for animal care and human healthcare, ensuring that the recommendations and insights provided are tailored to the unique needs of each group. By providing data-driven decision-making services for animal and human healthcare, MedConnect aims to improve healthcare outcomes for all.

At the application level, we propose two instruments: “Collaboration tools” and “Empowerment tools”. Collaboration tools will facilitate the creation of content, typical social networks like a discussion and the co-creation of proposals for causes, laws, regulations, and other social initiatives that will impact manufacturers. The Empowerment tools will offer effective solutions to incentivise participation in the system's governance and demonstrate the community's power to external stakeholders. The governance instruments envisioned in the MedConnect proposal are based on the concept of "Decentralised brand," which avoids the use of voting but signals power through economic means like boycotts, promotion of specific products, or adherence to dynamic decentralised brands that reflect the power of a group or an idea. By decentralising the brand, we aim to enhance the power of the community, enabling them to co-create solutions tailored to their unique needs.

CONCLUSIONS

The pharmaceutical industry must embrace a cultural shift to address the increasing demand for precision medicine, environmental concerns, and digital patient rights. This requires rethinking traditional logistics and manufacturing models, historically focusing on economies of scale and simplification. The industry can mitigate waste and resource scarcity by combining ideas and opportunities offered by combining biology with digital and data architecture, fostering collaboration and cooperation, and adopting more sustainable practices.

Digital technology is crucial in driving this transformation, streamlining processes, and protecting patient rights and consent. Adopting a more patient-centric approach will help the industry move away from a "one size fits all" manufacturing mentality and therapy manufacturing bias, ultimately creating a more sustainable and patient-focused future.

MedConnect proposal presents a vision for a possible long-term approach to solve the waste problems in medicine manufacturing. The platform offers a range of instruments that enhance collaboration and empower stakeholders, including Collaboration tools and Empowerment tools. The governance instruments proposed are based on the concept of a "Decentralised brand," which enhances the power of the community and enables them to co-create solutions aligned with their needs. Additionally, MedConnect's data-driven decision-making services layer provides personalised and accurate insights powered by AI models trained on large datasets, ensuring that the services provided are tailored to the unique needs of each group. Overall, MedConnect's innovative approach has the potential to revolutionise the healthcare industry, creating a more efficient and equitable system for all stakeholders involved.

A crucial aspect of governance in the pharmaceutical industry is the development of strategic partnerships among manufacturers, technology providers, research institutions, and other stakeholders. These partnerships can facilitate sharing of resources, knowledge, and expertise, accelerating the adoption of digital solutions and enabling synergies that drive innovation and efficiency. Collaborative efforts, such as industry consortia or public-private partnerships, can help align stakeholder interests and bridge gaps between research and implementation.

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