Chapter 1
Internet of Things (IoT) and Blockchain Applications in Pharmaceutical Supply Chain Provenance to Achieve Traceability, Transparency, and Authenticity

Yuan Sun
Walvax Biotechnology Co., Ltd., China

Syed Imran Ali
https://orcid.org/0000-0002-6553-8210
University of Huddersfield, UK

ABSTRACT

A traceable, transparent, and authentic pharmaceutical supply chain (PSC) could provide a guarantee for drug safety, quality, and a better public health protection. A thorough review of the PSC and future research agenda are necessary to understand the IoT and blockchain applications in PSC provenance. A systematic review was conducted to study how IoT and blockchain could help to cope with the challenges faced by the current PSC. The descriptive and thematic analysis was conducted to reveal the research trends, chronological and geographical distribution of research, and themes. The main findings were focused on the challenges faced by the current PSC, opportunities for implementing IoT and blockchain in PSC, as well as the application of IoT and blockchain in pharmaceutical package and transportation processes. Additionally, the study summarizes the framework of IoT and blockchain integration in PSC.

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INTRODUCTION

Medicine supplies are one of the building blocks of healthcare systems (WHO, 2010). In the present health-conscious society, the satisfactory quality and regulatory compliance of drugs have gained enormous attention globally due to the significant risk of counterfeit and unqualified medicines that could pose to consumer health (Sylim et al., 2018). From manufacturing to consumption, there are multiple partners and intermediaries involved in the pharmaceutical supply chain (PSC). This brings about great traceability challenges in present centralized systems such as single point of failure, data manipulation, interoperability, security, stakeholder agreement, implementation cost, lack of standardization and regulations (Premkumar and C, 2020, Uddin et at., 2021). Operating with legacy information platforms could not assist the collaboration amongst multiple participants of PSC (Vecchione, 2017). It also could not support the tracking and tracing of sources required to ensure quality, regulatory compliance, and drug security.

Internet of things (IoT) and Blockchain technology have been brought to the forefront of global attention in different industries. The application of IoT in supply chain management could support real-time information update and monitoring (Premkumar and C, 2020). The blockchain technology could document everything related to the whole supply chain and allow information sharing across the distribution network in a secure manner (Bocek et al., 2017). Implementation of drug provenance across the whole PSC is essential to strengthen the governance and supervision of the pharma market (Sylim et al., 2018). Hence, the application of IoT and Blockchain in PSC would have a tremendous role in future pharmaceutical domain. The application of IoT and blockchain could help to achieve the target of track and trace capability, authenticity and transparency by improving the collaboration, as well as, information sharing amongst the PSC stakeholders.

BACKGROUND

Pharmaceutical Supply Chain

Supply chain is defined as a network of participants who cooperatively work together to convert basic materials into a specific finished product which is valued by end-customers (Settanni, Harrington and Srai, 2017). Supply chain also involves controlling, managing, and improving the flow of materials and information from suppliers to end-users (Harrison, et al., 2019, Uddin et at., 2021). Therefore, the PSC is a network between firms to produce, manage, distribute medicine and all the relevant information to the final buyer. The aim of PSC is aligning enterprises in enabling achievement of improving health status by pharmaceutical provision (Settanni, Harrington and Srai, 2017, Musamih et al., 2021). The PSC is complex, and its quality control process is strict (Vecchione, 2017, Ahmadi et al., 2020). From the aspect of involved participants, a typical PSC contains more than one participant. It not only includes the raw material suppliers, manufacturers, wholesalers, warehouse, distributors, retailers, and end-customers, but also the information agencies, government regulatory department such as Food and Drug Administration (FDA) (Sylim et al., 2018a, Uddin et at., 2021).

The distribution network and regulations of PSC are complex. There are two distribution levels in PSC. Firstly, pharmaceutical manufacturers supply medicine from the point of production to the wholesaler, and this is also called the first level of drug distribution. In the second level of drug distribution,