RETHINKING THE PHARMA SUPPLY CHAIN WITH BLOCKCHAIN
With the growth of personalized medicine and biotechnologies, it is becoming increasingly critical to ensure the traceability and quality of the treatments administered to patients. Cell or gene therapies are destined for a limited number of people and therefore ensuring the right product is delivered to the right patient is primordial.

According to the WHO, 10 to 30% of the drugs circulating around the world are counterfeit. This growing global scourge has serious and even dramatic consequences for the health of patients. Nearly 700,000 deaths each year are attributed to drug counterfeiting. This creates significant costs with a market that generates $200 billion a year.

These observations point to two important challenges for the pharmaceutical supply chain:

**On one hand, the need to ensure the quality of the product and the efficiency of distribution, and on the other the permanent fight against counterfeit medicines.**

The complexity of the pharmaceutical supply chain prevents pharmaceutical companies from ensuring complete and effective end-to-end traceability and product monitoring throughout the chain.

Nevertheless, the rise of "Distributed Ledger Technologies" such as blockchain, can represent an important asset in flow management but also in the identification, authentication and traceability of health products throughout the supply chain.
Main characteristics

Decentralized
A blockchain is a peer-to-peer system without a trusted third party: transaction validation and decision-making are decentralized.

The data recorded on the blockchain is distributed among all the nodes in the network.

Transparent and verifiable
A blockchain is an open source protocol.

All transactions are visible and traceable within the blockchain, thus maintaining the complete history of all executed instructions.

Reliable and secure:
All information is checked and can only be stored in the blockchain if the network members reach consensus according to established rules.

Each transaction is time-stamped and protected by different cryptographic processes so that it is impossible to modify them later.

There is no central point of failure as all participants have a copy of the register.
THE BLOCKCHAIN
PUBLIC BLOCKCHAIN VS PRIVATE BLOCKCHAIN

PUBLIC BLOCKCHAIN
• Fully decentralized without a central authority;
• Everyone can join the network and submit transactions;
• Different consensus algorithms are used, such as "proof of work" to ensure the authenticity of the recorded information.

CONSORTIUM BLOCKCHAIN
• A consortium of entities controls the authenticity of the ledger;
• Only registered participants can make a change;
• Information is shared across the consortium.

PRIVATE BLOCKCHAIN
• A central authority acts as the third party to monitor and verifies the authenticity of the recorded information;
• Only registered participants can join the network;
• Access rights determine the extent to which each participant can provide data to the network and access network data.
In the pharmaceutical industry, health products are subject to complex regulation. Indeed, a set of "good practices" must be respected throughout the life cycle of the drug, especially within the supply chain, such as Good Manufacturing Practices, Good Distribution Practices or Pharmacovigilance requirements. The pharmaceutical supply chain is the backbone of a laboratory, it allows to make the link between the latter and its market. As such, it is considered as one of the most complex in the world.

The pharmaceutical supply chain is global, located in different geographical areas and involves several stakeholders. In addition, it does not deviate from the rule of outsourcing, including manufacturing processes. This complexity implies a lack of visibility throughout the chain. Indeed, the management of supply and information flows between the various stakeholders is difficult to master. Thus, the variety of nodes in this supply chain are logistical challenges and breaches that a counterfeiter or a fraudster can borrow to bypass the drug circuit.
Under the impetus of the new European regulation supplementing the Falsified Medicines Directive (FMD) applicable on February 9, 2019 (except Belgium, Greece and Italy in February 2025), a new traceability model is born: serialization. It is a process of assigning a unique identifier for each sales unit gathering critical information on its origin, its batch number and its expiry date.

Two scenarios have been developed:

**Serialization alone**

This is a serialization on the secondary conditioning only with a systematic control on the place of dispensation. This is called the end-to-end system.

**Serialization and aggregation**

This is a serialization of all logistic units (sales unit, boxes, pallets), called the "track & trace". The control must be carried out systematically by each node of the supply chain along with the aggregation of the different logistic units. This system simplifies serialization management as all logistic units are linked between them.

The main challenge of serialization is to maintain traceability and transparency of its units, especially at the re-packaging or aggregation stages and at the disintegration steps.
1. Manufacturer sale notification (send)
2. Production Notification
3. Manufacturer sale notification (receive)
4. Reception notification
5. Wholesaler sale notification (send)
6. Wholesaler sale notification (receive)
7. Dispensing notification
8. Reception notification
9. Delivery information
10. Payment

SERIALIZATION IN TURKEY
THE BLOCKCHAIN
CASE STUDY IN THE PHARMACEUTICAL SUPPLY CHAIN

Improved supply chain management through end-to-end traceability of health products:

- The use of the blockchain will allow a better visibility of the flows and stakeholders through which the products transit. This could facilitate the optimization of these flows of material and information and thus an efficient stock management.

Reduced losses associated with counterfeiting and the gray market:

- A blockchain allows a more precise visualization of a health product’s journey from the supplier of raw materials to patients through the digitization of transactions. This would identify vulnerable links in the supply chain and reduce fraud and associated costs.

Accessibility to a single source of information for all stakeholders:

- This is ensured by registering all supply chain transactions in a secure, immutable and irreversible distributed registry.
By its intrinsic properties, the blockchain could help improve consumer trust and transparency by overcoming logistics challenges and thereby generate substantial gains.

THE BLOCKCHAIN CASE STUDY IN PHARMACEUTICAL SUPPLY CHAIN

Transparency to strengthen the accountability of supply chain actors:

- The receiving and sending of products throughout the supply chain are traced, as well as the actors that have been involved. Therefore, if a problem arises, it would be possible to identify the last intermediary by which the product passed through. A virtuous circle is thus created engaging the responsibility of the failing actors of the supply chain.

Efficient managing of batch recalls:

- The use of a blockchain would allow, on one hand, the identification of the exact location of the drugs and on the other hand, for each stakeholder to act on the basis of reliable information. The batch reminders will be carried out efficiently and quickly, maintaining increased safety and protecting patients’ health.

Decrease in paperwork and administrative procedures:

- The use of a blockchain requires a digitization of information allowing minimal or no use of paper within the supply chain.
TOWARDS A TRANSPARENT AND REACTIVE SUPPLY CHAIN

All steps of the supply chain are recorded on a blockchain. Each new transaction added to a block is immutable and time-stamped to track the end-to-end chain and ensure that the information is not modified. All stakeholders (supply chain actors, patients, regulatory authorities) could have access to this system and check the provenance and integrity of healthcare products.

At the same time, the implementation of smart contracts would enable the acknowledgment of receipt and dispatch of medicines and trigger the payment process initially defined. Indeed, smart contracts are programs based on "IF", "THEN" instructions, that trigger automatic transactions if all the predefined criteria are met. Product flows could also be correlated with the issuance and receipt of a token. The transmission of the latter and its acceptance would make it possible to materialize the flows but also to transfer the responsibilities to the new actor who receives and validates the goods.

A private blockchain would be interesting in the case of the pharmaceutical supply chain. Indeed, depending on the position of each stakeholder in the distribution chain, the rights granted will be different: the laboratories can register new drugs while wholesalers can only validate the passage of the product, thus allowing control and increased security. The blockchain is therefore an additional element of security and complementary to substitution technologies that currently exist as RFID chips or Data Matrix. It thus creates a secure and reliable framework for sharing information and is not intended to replace current technologies.
TOWARDS A TRANSPARENT AND REACTIVE SUPPLY CHAIN

1. The manufacturer sends the drugs to the wholesaler
   - The manufacturer produces the drug and makes it with a unique code
   - A hash is produced
   - The information is stored on the blockchain

2. The wholesaler sends the drugs to the pharmacist
   - The wholesaler verifies the origin of the product
   - The transaction between the manufacturer and the wholesaler is added to the blockchain

3. The pharmacist delivers the drugs to the patient
   - The pharmacist verifies the origin of the product
   - The transaction between the wholesaler and the pharmacist is added to the blockchain
   - The patient verifies the origin of the product
   - The transaction between the pharmacist and the patient is added to the blockchain
The cold chain is a supply chain that is sensitive to temperature variations, that is, to all logistical operations aimed at keeping products at a specific temperature to ensure their pharmaceutical quality. If it falls outside the allowed range, it can have a negative impact on patient safety, a significant loss of drugs creating, among other things, supply disruptions and significant financial losses. This temperature must therefore be closely monitored throughout the chain.

These are problems that the blockchain can contribute to solve. Indeed, it can not only verify the origin and authenticity of products, but also, coupled to a temperature sensor, trace the temperature and trigger alerts when the latter is outside the allowed range. Thus, the IoT makes it possible to build a bridge between the digital and physical world.

In addition, it would be possible to store and share the data collected by the temperature sensors on a blockchain. This would provide information in real time and increase the speed of intervention in case of problems. In the same way, this transparent, immutable and shared register saves a considerable amount of time in the event of an audit of the storage conditions of heat-sensitive products.

Finally, a significant advantage, the blockchain allows each stakeholder of the distribution chain to ensure the quality of the product received, without having to question the work done upstream. The chain of trust is maintained.
CASE STUDY: BLOCKCHAIN & IoT
COLD CHAIN TRACEABILITY

- IoT: sensor of temperature
- Temperature report
- Smart contract
THE BLOCKCHAIN

CHALLENGES

It is undeniable that the blockchain will play a major role in optimizing supply chain processes. However, it must overcome certain challenges for the implementation to be efficient. Indeed, it is an emerging technology whose technological and regulatory limits are significant, preventing it from going into production at the moment.

Link between the digital world and the physical world

The data stored on a blockchain only exist in the digital world. It is therefore necessary to insure that it is linked to real world information. This problem is studied by coupling blockchain technology with the use of IoT or tokens.

Volume of transactions

The volume of transactions that can be made per second is largely insufficient. With respectively 15 and 3 to 4 transactions per second, Ethereum and Bitcoin remain well below the transactional capacities required for the pharmaceutical supply chain.

Involvement of all stakeholders

The main feature of the blockchain is decentralization. It is essential that all nodes in the chain are involved for an efficient implementation of the technology. However, supply chain actors do not want to share their commercial and sensitive information. So, one of the difficulties, and not the least, is the acceptance of the solution within the whole community. To do this, each stakeholder must have mutual trust in their willingness to communicate correct information. The appropriate "incentives" for each stakeholder will determine the feasibility but also the risk of using this technology.

Scalability

It is the ability of the technology to scale up and to accommodate more and more users, transactions and data. This would require an increase computer power and energy.

Regulations

As seen above, the pharmaceutical supply chain uses regulatory standards such as Good Distribution Practices that frame the entire process. Thus, the implementation of the technology can be done largely thanks to the regulatory impulse with an evolution of these standards towards the decentralized system brought by the blockchain.
Currently, several solutions emerge allowing to partially or completely lift these constraints. For example, the combination of the blockchain with zero knowledge proof could be a solution concerning the diffusion of sensitive information. Indeed, this would prove the authenticity of an information without revealing more details about the transaction apart from the identity of the parties. However, it is important to take into account various issues to limit technical and regulatory defects in the project. A complete study of these constraints is the *sine qua non* condition for the successful implementation of the technology.
Upcoming regulation

In Europe, the new regulation on serialization will be applicable on the 9\textsuperscript{th} of February 2019. The objective of this system is to enable the identification and authentication of medicines guaranteed by an end-to-end verification of the supply chain of all medication. However in Europe, with the new Falsified Medicines Regulation (FMD), pharmaceutical companies will have to send the serial numbers of each medicine to a European hub. Then, these will be sent to the national databases of each country in which the drug is marketed. The hub is therefore the guarantee for the interoperability between all these databases and is a central authority, moving thus away from the principle of decentralization provided by the blockchain.
In parallel, in the United States, the Drugs Quality and Safety Act (DQSA) was promulgated by Congress on November 27, 2013. It outlines the steps to be taken to develop an interoperable electronic supply chain management system. This will strengthen the FDA's ability to protect consumers from exposure to drugs that could be counterfeit. Indeed, the law enforces the “T3” information system ("history, information and statement transaction") which prohibits the different actors of the supply chain (manufacturer, distributor, wholesaler, ...) to accept the drugs without these 3 types of data.

In addition, to strengthen the security of the drug distribution chain, the various actors (manufacturers, distributors, ...) are required to inform the FDA and other trading partners within 24 hours that a product is not allowed for sale.

Finally, we are moving towards global legislation, since besides Europe, serialization is coming to the United States, and is already in place in China, Saudi Arabia, Argentina and Turkey.
The future of the supply chain is disruptive

The portfolio of pharmaceutical companies has become more diversified in recent years with the advent of nanotechnology, tissue regeneration and stem cell research. These new products require a process of manufacture and distribution more complex and safer than conventional chemical molecules by their intrinsic characteristics.

In addition, the significant growth of emerging markets, the environmental pressures for sustainable development and the growing scrutiny by regulatory authorities (new regulations, broader risk management, etc.) support the idea that a new approach to manufacturing and distribution would be needed in future years to meet the needs of tomorrow.

Big Pharma’s position

Among the top 20 Big Pharmas, 70% are interested in blockchain technology. This interest takes many forms such as participation in workgroups, consortia or as investors in startups. In the supply chain, projects are at different stages of development. Below, an infographic illustrating this state of progress.

BIG PHARMAS
WHERE ARE WE NOW?

SUPPLY CHAIN MANAGEMENT
DATA INTEGRITY/TRACEABILITY
IOT
PRODUCT SERIALIZATION
There are obvious advantages to the use of blockchain technology in the pharmaceutical supply chain:
- Improved traceability;
- Reduced risk of fraud and counterfeiting;
- Improved visibility and compliance of subcontractors;
- Optimized data flows management;
- Reduction of administrative costs.

Blockchain technology is constantly evolving and must therefore mature to meet the different challenges of the pharmaceutical supply chain. As such, it is necessary to monitor the progress of this technology and learn about the impacts of blockchain in the pharmaceutical supply chain. Indeed, several limits and areas of improvement have been, are and will be discovered and developed.

In addition, the regulatory environment will have to evolve to support the implementation of the technology. It is therefore important to work in consortia by integrating Regulatory Authorities, pharmaceutical industries supporting organizations in order to establish concrete standards of application.

Finally, it is also necessary that all stakeholder gain a basic knowledge on the different aspects of the technology thus allowing them to identify the sensitive points of the project and the interest of an implementation. The training will also allow faster and easier adoption of blockchain within companies.
80% of Big Pharma willing to experiment with blockchain, consider that reaching a good level of understanding of the technology and the opportunities it offers is one of their main goals this year.

**Ideation**

Target the business areas where blockchain technology will bring the most added value. Define the specifications of the project and run a feasibility study.

**Implementation**

Bring together supply chain and IT experts to cover all the challenges that might appear during the project. Surround yourself with professionals of the sector to build secure, scalable and extensible solutions.
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ABOUT 23 CONSULTING

23 Consulting specializes in supporting healthcare organizations with their blockchain projects.

We are on a mission to bridge the gap between healthcare stakeholders and new technologies in order to improve patient outcomes.

Our team develops personalized training and consulting methods to identity opportunities and bring together the best experts in this field.

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