Ambrosus

PHARMACEUTICAL
GOODS QUALITY
ASSURANCE AND
LOGISTICS

I. THE CHALLENGE FOR TOMORROW

The pharmaceutical landscape is changing due to technological advancements, a cumbersome supply chain structure and escalating concern over human health problems. Disease outbreaks coupled with a multiplication of health risk factors dictate the need for broad public access to high quality medicines. With that in mind,cognizance of pharmaceutical industry developments at consumer level is gaining critical traction in the context of societal wellbeing. Another important factor accelerating the evolution of the pharmaceutical sector is an ageing population . The issue affects nearly every industrialized country in the world. Presently, the progressive growth of an ageing society poses a range of unprecedented challenges for the entire geriatric healthcare sector. One such challenge is lack of effective geriatric medicines; general purpose medicines no longer cover the specific needs of senior citizens. Despite this fact the process of discovery and market placement of new medicines is being drastically curbed by excessive production costs. (the cost of developing an effective drug nowadays exceeds USD 2.6 billion USD 179 million in 1970s). Against this backdrop of unsatiated public demand, the bottlenecks in deployment of new medicines inevitably lead to counterfeit. Based on recent statistics, at least 10-15% of all globally supplied pharmaceutical products turn out to be fake. As a result, the consumption of counterfeit pharmaceutical drugs causes over 100 000 deaths annually. Obviously, it can no longer be denied that the industry is in dire need of an end-to-end solution that could provide sufficient visibility and traceability of drug ingredients. Current monitoring and tracking systems simply do not prove to be effective. Moreover, they are extremely expensive. By vesting more trust into the quality of products through application of blockchain, Ambrosus supports drug manufacturers in securing their supply chain on one end and raises patients' awareness of false products on the other.

Importance of logistics

Pharmaceutical manufacturers face daily challenges concerning storage, distribution and importation of temperature-sensitive products. Perishable products such as vaccines and insulin require constant monitoring during transportation to prevent temperature abuse which can jeopardize the safety and integrity of the product batch. Good cold chain management which will ensure distribution of temperature sensitive medicine requires the integration of several processes. The latter is either enforced by legislation, adopted through guidelines or introduced as a completelynew and independent solution. An unbroken cold chain is an uninterrupted series of refrigerated production, storage and distribution activities, along with associated equipment and logistics, which maintain a desired low-temperature range. The 2017 edition of Pharmaceutical Commerce's annual Biopharma Cold Chain Sourcebook estimates that managing the transportation of temperature-controlled products (refrigerated and frozen) will total $13.4 billion this year, growing at a 5-6% rate, and representing a moderation of the 8–9%/yr growth rate of the past several years. At the same time, the value of temperature-controlled pharmaceuticals being shipped is projected to grow by 10.7% this year, suggesting that the industry is learning how to manage cold chain costs more efficiently[1]. This is the implementation of new digital solutions within the system framework.

Pharmaceutical industry and digitalization 4.0

One of the most powerful driving forces on the pharmaceutical market is thedigitalization trend. The companies are motivated to keep abreast of changes brought by digital technology. We will encounter more of those changes in the near future. Accenture analysis has revealed that digitization will be fuelling almost 1/3 of the growth and an estimated 40% of the profitability in the pharmaceutical industry by 2020[2]. In this regard, adoption of digitized

1   http://pharmaceuticalcommerce.com/supply-chain-logistics/pharmaceutical-cold-chain-logistics-13-4-billion-global-industry/

2   All to win? Or all to lose? Driving digitization in Life Sciences By Dr. Jan Ising & Kenneth Munie, Accenture 2015

business models can improve profitability by as much as 27%[3]. However, those who become "digital all-rounders" will derive maximum benefit out of this transformation and will build new business models that have a wider market outreach. **How can the pharmaceutical supply chain profit from digitalization?**

In the report "Digitization in pharma: Gaining an edge in operations" PwC identifies several changes that digitalization will trigger in the pharmaceutical landscape. The aforesaid changes will beclosely connected to the pharmaceutical supply chain. First of all, quality control and assurance can be guaranteed by improving the required level of security at all levels of supply chain with constant monitoring and an access to historical data. Real-time visibility of operations is achieved with the aid of robust sensor systems that also support faster decision making. Sensors transmit information on the ongoing basis which shortens lead time, reduces stockouts and ultimately saves patients' lives. The PwC report mentions that pharmaceutical plants typically experience high levels of downtime. Thanks to digitization and tracing of all processes, this downtime can be reduced by 40%. Another crucial issue is end-to-end supply chain integration and greater network scalability. Pharma companies have extremely complex supply chains, which are normally comprised of suppliers of raw materials, contract manufacturing organizations, third-party logistics providers, wholesalers, and distributors to hospitals, pharmacies, dispensing doctors, and patients. Through digitization, including cloud computing, companies can develop global integrated supply chain networks. Cloud-based networks make it much easier to link all players through a single integrated network, even those with different IT architectures or ERP systems, thus making the networks more scalable. Last but not least, manufacturing processes are becoming more efficient resulting in productivity gains. Digitization can deliver major manufacturing efficiencies in areas such as filling, loading, replenishing, and troubleshooting. Technological innovations can make decentralized production

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3   https://www.accenture.com/pl-en/insight-highlights-life-sciences-pharmaceutical-grow

cost-efficient even at low volumes. Ultimately, those advancements improve quality assurance and control of pharmaceuticals on every stage of supply chain providing safe pharmaceuticals for everyone around the globe.

Quality goods through supply chain integrity

Quality assurance is an essential practice in the manufacturing of pharmaceutical products. Since the quality of consumed products is crucial for the end-users, it should become an obligation of manufacturers to secure the integrity of pharmaceutical supply chains. Critical elements of quality assurance include quarantined and thoroughly inspected shipments, laboratory testing medicines that meet pharmacopoeial standards and specific tests for medicines with known bioavailability, critical medicines etc. There are no harmonized standards regulating the pharmaceutical market. Likewise,there are no universal quality standards for medicine. Unfortunately, this provides a "window of opportunity" for counterfeit drugs.

Fighting couterfeit

Counterfeit medicine is fake medicine. It may be contaminated or contain wrong ingredients or no active ingredient at all. Over the past years, it has become very difficult to track drug counterfeiting due to several reasons. One of them is inadequate tracking system of regulatory agencies, expensive and ill-performing monitoring system and lack of visibility and communication among pharma providers. Counterfeit drugs account for about 10% of the global pharmaceutical market share, that is, over $200 billion loss each fiscal year[4]. Consequently, the need for sophisticated anti-counterfeit technology is rising. In addition, counterfeiters' activities become increasingly advanced. It is impossible to detect fake medicines without equipment, tests, time and efforts.

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4   M. Schöner, D. Kourouklis, P. Sandner, E. Gonzalez, J. Förster, Blockchain Technology
     in the Pharmaceutical Industry, FSBC Working Paper, Frankfurt School Blockchain Center.

Compound pharmaceutical supply chain

Counterfeit is the consequence of ill-functioning global supply chain. This is mostly due to its complexity. The pharmaceutical industry operates in an intricate supply chain where drug manufacturers, distributors, group purchasing organizations and retail pharmacies work together to deliver high-quality products. However, nowadays it also involves numerous processing plants, suppliers, manufacturers, brokers, packagers and distributors. Tracking information is the key to manage this complex supply chain.

Most pressuring problems of supply chain according to the recent studies[5] include: lack of coordination - fragmentation and silos of the system due to complex divisions by product types, projects and the origins of manufacturers, inventory management that faces significant lack of information, order management affected by lack of reliable information and shipment visibility, expiration connected to safe disposal efforts along with lack of storage, warehouse management with poor storage in addition to organization and lack of designated areas for specific functions (e.g. storage for expired or damaged products), temperature control as well as high exposure towards hot and freezing temperatures or shipment visibility and inability to track products properly between the departure and arrival time to final destination.

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5   The top ten global health supply chain issues: Perspectives from the field, N. Privett, D. Gonsalvez, Operations Research for Health Care 3 (2014) 226–230.

II. AMBROSUS DESIGNED FOR PHARMACEUTICAL VALUE CHAIN

Ambrosus technology

Without an end-to-end solution that provides the visibility and traceability within the pharmaceutical supply chain, the companies will continue putting a lot of financial resources into different ways of securing the quality of the value chain. The mission of Ambrosus is to register proof of process, proof of storage conditions and perform analysis of environment, as well as traceability of products. It provides multiple blockchain-based technologies. Taken together, these technologies ensure the integrity of the pharmaceutical supply chain.

The core value proposition of assuring quality, safety and transparency of the pharmaceutical chain will be built through the use of Ambrosus core protocol and its software layer connected to the hardware system through Ambrosus API. The technology articulated around the Amber token serves as a medium of exchange for sellers, investors, and partners. It opens up opportunities which currently have no analogies within the pharmaceutical supply chain. It will be awarded to all active Blockchain participants of the network. Amber largely serves three key functions: firstly, it serves as the digital reflection of the product it is following: the token collects and links all sensor data about the product and its consumers – i.e.persons seeking/receiving medical treatment; secondly, it creates an incentive model for early adoption and growth of the network by allowing early users and developers to earn Amber while using or improving the network; thirdly, it serves as a unit to access the functionality of the platform.

The hardware is mainly composed of an interconnected **sensors** system. They permit a real-time continuous monitoring of fragile and sensitive products reducing waste in the cold chain. Sensors create an interconnected system providing a rapid, non-invasive and non-destructive analysis that supports decision-making processes. In addition, they ensure authenticity of products' external environment assessment, which sets base for the concept of Comprehensive Pharmaceutical Quality Assurance. Sensors

feed the supply chain management software with exact information about the products, specifically about their quality, location and security. The system is modular and may include both own, in-house-developed hardware or legacy hardware that is upgraded via embedded software or middleware to interact with our platform. Sensors can be mobile or stationary. The sensor system traces medicines and captures their quality parameters (e.g. temperature, pressure, humidity) throughout the supply chain (storage, transport etc.), simultaneously recording them on the blockchain.

The **software** provides continuous, real-time visibility throughout the supply chain, tracking people, products, and operations in full observance of the standards for controlled substances. It ensures indisputable auditing, robust open source integration capability, data sharing and reporting. Moreover, our software can be used for forecast management, sales and operations planning, collaboration, scheduling etc. The software provides input for enterprise level management including management of pharmacies, manufacturers and distributors. Our users do not have to know how the blockchain or smart contracts work; they simply know they can easily and conveniently create, review, execute and manage various commercial agreements on sale, storage and transportation of goods and stipulate the desired quality conditions. Our user interface (UI) allows simple and intuitive interaction with the blockchain for patients. For enterprises or logistics companies, we have advanced platforms that offer supply chain management tools and enterprise-ready blockchain integration.

The core protocol relies on the **blockchain**. With relevant quality parameters that are recorded on the public Ethereum, blockchain assures immutability of records and prevents disputes on quality and origins as well as manipulation of data. It provides a basis for traceability of drugs from manufacturers to end consumers, identifying at the same time where the pharmaceutical supply chain breaks. An undisputable advantage is that all transactions are documented and stored without the need of ex-post information tampering. Large datasets can be stored off-chain

on distributed storage solutions, while hashes or hashes of hashes are recorded on the blockchain, allowing scalability at little extra cost. Blockchain creates a protocol for communication and handling of data. Security, identity, communication and storage protocols and solutions already available on Ethereum can be integrated into our solution, allowing cross-operability. Additional functionality for cross-blockchain compatibility can ensure that companies integrating other blockchains into their operations can seamlessly interact with Ambrosus. Thanks to safe off-chain peer-to-peer channels, large volume of transactions will be processed and tracked.

The agreement terms and execution of orders are defined through **Smart Contracts**; they ensure high level and security of transactions and transparency at all stages of the supply chain. In addition, active monitoring of data supplied by sensors and execution based on the inputs received enables smart contracts to perform the function of a quality assurance controller and make supply chain monitoring and management an automated process to a large degree. Thereby, it provides real-time auditing, as well as automation of quality control and financial transactions. With immediate settlement of payments and instant detection of problems, lengthy disputes and costly recalls can become a thing of the past. Smart contracts provide integrity, traceability and transparency. Smart contracts make it possible to verify ownership of the drug source at any point in the supply chain and manage the contracts between different parties. We will offer a range of different templates to our initial users. This way, we will ensure unconditional access to commercial agreements that are guaranteed to be enforced. We also allow users to define the outcome of violation of contract conditions.

Solutions provided by Ambrosus

The aim of Ambrosus is to improve the quality of medicines, traceability, patient safety and regulatory compliance within the pharmaceutical supply chain. By offering software management and other instruments, Ambrosus significantly reduces costs of enhancing safety of the supply chains and proves 100% effectiveness. The scope of possible applications is limitless and we are already developing a variety of solutions.

First, we aim to develop a **dashboard for Supply Chain Management** permitting to get a complete overview of orders, contracts on offer and contracts entered. This solution provides trend analysis for inventory at a market level and with a multi-dimensional drilldown. Moreover, the dashboard brings a dynamic overview of delivery status and quality parameters as well as time inventory tracking and tracing for controlled drugs. Allowing for smooth management of contract execution process, our platform incentivizes manufacturers and customers to share information and build more transparent contractual relationships. It is worth noting that the platform is compatible with multi-currency wallets. Besides, the range of the platform's functionalities encompasses drawing invoices and conversion of data into legacy systems.

Another solution we are currently developing is a **Med Analysis App**. Owing to wireless connectivity, companies and customers can access real time tracking data whenever they require a quick overview of the whole history of a particular medicine, including its quality parameters, origins and quality assurance. The App will function as an information display and a scanner for products. By giving access to meaningful, real time data, the med app enables logistics providers to manage their cold chains more efficiently. Additionally, their employees will have direct access to real time medical data, which will improve the quality assurance, responsiveness and robustness of cold chains as a whole.

Furthermore, we develop **data collecting devices**. They are tracing sensors providing external parameters analysis (temperature, humidity, pressure, sunlight). Devices with longer battery life reduce costs of inefficient monitoring of supply chain. They remove the need for multiple devices, terminals and expensive processors. Many companies still utilize outdated legacy equipment that does not support even standard communications protocols.

A further solution that we have devised is the access to **data visualisation**, **analysis** and **projected analytics**. Sensors will generate a lot of data pertaining to supply chains, stock, and distribution of food. It will be possible to organize the data to focus on specific business areas and improve performance, as well as to explore large, multi-structured data sets. Simple interfaces with help to communicate automated data reports to the target user groups. In view of the need to process large data-sets we developed software that utilises this data to bring additional value to firms. Examples include enhancing operational decisions on account of sensor data visualization, measuring and monitoring productivity, data analytics tools to make supply chain management more efficient and predictive analytics that could automatically order certain products, or inform of shortages in advance, increasing compliance, compliance and allowing smooth operation of the supply chains.

In addition, we are now working on integration of **insurance services**. In any transaction, all parties to a contract wish to be protected against adverse circumstances (e.g. lost shipment). Insurance funds typically do not function properly due to significant data and statistical insights. With Ambrosus the level of insights into the supply chain and quality data from sensors in a unified system would be enough to provide insurance services to manufacturers and vendors to supply chain commercial transactions. Both parties in any transaction can pay a small fee to the Insur-

ance Fund in exchange for protection against adverse circumstances. Similarly, the Insurance Fund could also hedge against changes in commodity prices, giving more certainty to both the buyers and sellers about the expected prices despite the possible adverse shocks to price. The small fees charged as part of transactions will be allocated to the Fund to hedge against changes to commodity prices.

Furthermore, we are developing solutions for **Clinical Trial Management** as reproducibility, anddata sharing; personal data privacy concerns and patient enrolment in clinical trials are huge medical challenges for contemporary clinical research. Blockchain addresses those challenges by decentralizing the entire process. Decentralised secure tracking system for any data interactions that could occur in the context of clinical trials, with a peer-to-peer inclusive network enables data sharing on the research side and ensures all the needed transparency and care for privacy concerns on the patient community side.

Finally, we are preparing **electronic medical records** eliminating the middleman between the patient and the records. It secures data and implies a decentralized control mechanism that nobody exclusively owns. Additionally, blockchain links the access to the patient's medical records across the variety of their doctor's databases. By functioning as an interface between institutions' siloed health records, it has the potential to include personal sources of data. Medical records are secure from the increasing number of hacks and data ransom attacks against hospitals.

CONCLUSIONS

Ambrosus unchains processes that provide significant savings to the pharmaceutical supply chains, as well as more information about product quality, performance and safety requirements. This will lead to a major shift for pharmaceutical companies that used to control both the generation and dissemination of information about their products. Digital technologies have weakened that control, opening an array of new, independent information channels. Ambrosus strengthens this direction and provides a ground for a new and effective pharmaceutical supply chain.

Ambrosus

Many thanks for your attention.
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