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Market Determinants Impacting Distributed Ledger Technology, and AI-Based Architectures in the Healthcare Industry

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Abstract

Numerous state-of-the-art leaps in healthcare technology are gaining significant expansion, with the widespread impact of the digital revolution all over. Over the years, the healthcare sector has witnessed major digital transformation with a rise in urgency, previously seen only in consumer-related services (Weisman, 2021). Increasing advancements in technology bolster the need to integrate highly impactful and latest ways to enhance the operational efficiency, resilience, and reliability of health IT systems. The rising adoption of Blockchain as a Service (BaaS) and rising incidences of healthcare data breaches contribute significantly to the overall market demand for these technologies. The Distributed Ledger Technology (DLT) helps in facilitating the sharing of healthcare information, while at the same time maintaining the confidentiality and authentication of the data. With the open architecture of the programming code of this technology, several alternative uses are gaining traction. Incorporation of these technologies offers robust potential for several segments in the healthcare industry, with enhanced efficiency and security for different information and documents. With the businesses engaged in seizing such opportunities, the accessibility and quality of healthcare segments are expected to be completely revolutionised. However, the technology also poses certain vulnerabilities and weaknesses to determine its appropriateness for every application in the health IT systems. This paper discusses the different competitive advantages DLT offers in the healthcare sector, with the prime focus being on strategic decisions and models. The article discusses the market determinants (drivers, restraints, trends, and opportunities) impacting DLT, coupled with the analysis of the decentralised Artificial Intelligence (AI) architectures in the healthcare sector. The article also focuses on the in-depth and relevant information regarding new application areas in the healthcare systems, along with recent trends and developments in the market.

Keywords: Distributed Ledger Technology, Decentralised, Healthcare, Architecture, Artificial Intelligence (AI)

Introduction

In today's scenario, the healthcare sector is undergoing significant transformation, owing to the increasing adoption of the latest state-of-the-art technologies. The industry is largely suffering from the inability to securely access and share patients' sensitive information. The amalgamation of future proofing technologies with the compounding features of innovation is expected to bolster an era of modernisation and growth (Morey, 2021). Integration of technologies in the healthcare businesses enables the offering of effective solutions with a new creation of collaboration and trust among all the parties.

Healthcare companies are emphasising on several opportunities to minimise costs while augmenting the quality of care and services to the patients. Catering to these market changes and demand is significantly not possible without the inclusion of the latest technological developments backing up the healthcare industry.

Over the past few years, DLT-enabled solutions are witnessing a shift from trialing to commercialisation. DLT is an evolving technology, linked with the possibility to augment disintermediation, trust, and transparency (Roecka, 2019). The technology is considered an

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alternate design method that permits for an operational model and decentralised business, in comparison to the centralised, conventional, and existing design methods. The technology is expected to facilitate tailor-made directness while maintaining the safety standards for interoperability.

Implementation of DLT in healthcare enterprises enables the reduction of waste, and enhancement of the quality of care, to generate a reliable set of data/information. One of the most significant applications of this technology includes the fact that it eases one of the biggest challenges being faced by the industry: the spread of patient data without negotiating its security and privacy concerns. DLT thereby owes the potential to transform several industries (one being the healthcare industry), with a strong value proposition, to make the processes more efficient, transparent, and secure (Alderman, 2021).

Research Questions

What are the competitive advantages offered by DLT in the healthcare industry?

- How is artificial intelligence poised to impact the healthcare business strategies and models?
- What are the trend analysis and challenges for distributed ledger technology in the healthcare sector?

Purpose of the Article

Integration of novel technologies, such as artificial intelligence (AI), big data and analytics, DLT, and a few others in several industries, is expected to support and facilitate flexible and efficient services and processes. One such notable example is the healthcare industry, which is inclined towards witnessing a complete transformation.

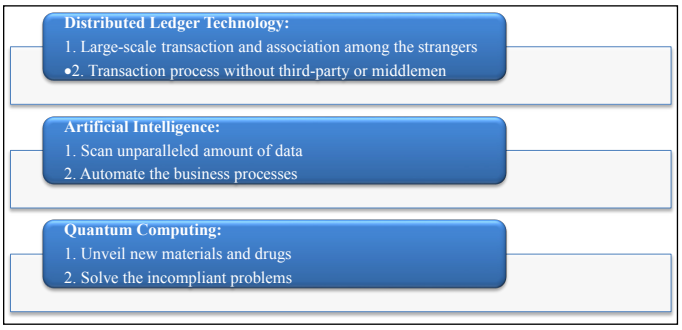
This article illustrates an overview of the DLT and decentralised artificial intelligence (AI) architectures in the healthcare industry. It also discusses the factors boosting and challenging the demand for DLT in the healthcare sector.

Key Findings in the Research

Integration of DLT and AI-based architectures in the healthcare segment is expected to completely revolutionise the centralised and conventional healthcare systems, thereby offering patients a user-centric model and solutions.

Literature Review

The energising force of digital technology has completely revolutionised business strategies and models. A growing emphasis on offering efficient services forced the market executives to venture into the latest technologies to reform their offerings. This transformation boosts the surge of several technologies in the industries to enhance their overall security, transparency, and performance, and offer extraordinary proficiencies when applied suitably. Distributed ledger technology (DLT), quantum computing, and artificial intelligence (AI) are a few such innovative creations, which can spur a change and enable businesses to redefine the whole healthcare industry.



Source*:* Safavi, The Post Digital Era Is Upon Us: Digital Health Tech Vision (2019).

Fig. 1: Technologies Implemented in the Healthcare Industry and the Abilities they Offer

Distributed Ledger Technology in Healthcare: An Overview

Decentralised ledgers in healthcare applications offer the prospects to generate secure and compatible environments, proving beneficial to the patients as well as healthcare professionals (Duca, 2017). The concept of distributed ledger/database acts as a key factor in addressing healthcare-related problems. Unlike the centralised systems (wherein, a single contributor upholds all the relevant data), the decentralised system removes the prerequisite for a hub-and-spoke style system, thereby enabling the information to be shared on a peer-to-peer basis. DLT refers to a fast-evolving and novel approach

for sharing and recording the data across several ledgers, wherein they have the same data records and are controlled and jointly maintained by a distributed system of computer servers known as nodes. Usage of encryption technology, smart contracts, and shared ledgers enables the medical device manufacturers and pharma companies to remove costly intermediaries, and ensures immutability, security, auditing, and transparency during the value chain processes (Government of Catalonia, 2020).

The distributed ledger technology helps store, facilitate, and distribute value exchange between the operators. DLT is an open technology for generating disseminated records. The disseminated nature of a distributed ledger (DL) requires the contributors in the network to attain an agreement related to the validity of the latest data admissions by catering to a set of rules. This can be attained through the consensus mechanism (specified in the algorithmic design of the DL), varying based on its nature, the underlying asset, and the relevant purpose. The process of DLT includes the usage of a private or public network, which potentially encompasses digitally characterised assets wherein the contributors in the network can easily record relevant data and verify the transactions in an encoded format.

In addition to this, the distributed ledger systems can either be permissioned or permissionless, with key differences between the two. The permissionless systems work with no central owner controlling the accessibility to the network. In a permissioned system, the nodes require permission from the chief entity to have accessibility to the network, and accordingly make variations to the ledger. In the case of the permission systems, the administrator or owner of the ledger has the authority to pre-select the network members and control the network accessibility (World Bank Group, 2017).

Indigenous features and advantages of DLT include traceability, accountability, and data integrity to encourage an atmosphere of confidence among the contributors and users. A few of these are listed below:

- Convergence with Other Technologies: Implementation of DLT helps attain long-term confluence with the Internet of Things (IoT) and also enables new technologies to be established in the forthcoming period.
- Longitudinal Patient Records: Compilation of disease registries, treatment procedures, and lab results can be easily attained via the implementation of blockchain technology, such as offering wearable data, inpatient ambulatory, and backing up the providers to offer enhanced quality of care to the patient.
- Claim Adjudication: The claims can mechanically be proven, wherein the network approves the execution of the contract. This can be attributed to the fact that this technology works on a validation-based exchange.
- Supply Chain Management: DLT technology owes the capability to assist healthcare firms to track the trade stocks and digital assets, as well as manage financial transactions (C).
- Controlling the Patient Indices: Even the presence of multiple keys and multiple addresses offer profit to the single-patient identification (Shashank, 2018).

Decentralised Artificial Intelligence (AI) Architectures in the Healthcare Industry

Major issues and risks in a conventional healthcare system are probabilities of malicious cyberattacks, single point of data alterations and failure, as well as higher cost of databases and data management which are not transparent. In addition to this, the healthcare industry nowadays is also burdened by a large amount of information/data. To cater to such issues, the government and healthcare sectors in several regions are emphasising on integrating machine learning (ML) and artificial intelligence (AI) in their business strategies and models.

For the advancement in medical studies and attaining patient-centric outcomes, it also becomes essential for the technology to create user-centric interfaces along with information-driven results for different data processing techniques and approaches (Sahoo, 2018). For instance, incorporating the concept of artificial intelligence (AI) in the healthcare sector helps in prioritising and identifying the patients for monitoring their drugs, which is critical for managing the production of drugs (Paul, 2021, January 26). AI is considered the science of developing systems that owe the capability to eradicate stress from

humans without seeking guidance. A few examples of the implementation of artificial intelligence in the healthcare sector are listed below:

- *Advanced Screening and Data Analysis:* Artificial intelligence helps detect irregularities in Magnetic Resonance Imaging (MRI) and X-Rays, conduct sequencing in genomics, and develop personalised therapies in precision medicine. The AI technology also has the potential to process all the unstructured and systematised patient-related information.
- *Bots in Healthcare:* Patient support segment, one of the latest concepts in the artificial intelligence segment, is expected to gain a significant surge in acceptance among healthcare provider companies. The bot is an artificial intelligence program, wherein the patients are entitled to communicate to gain support through a chat window on a mobile (Patel, 2020). Another usage of AI is the fact that the dependency on mental healthcare chatbots does not possess the transparency and reciprocity of treatment, which otherwise must occur between the healthcare professional and mental healthcare patients. Hence, the incorporation of bots in the healthcare sector offers benefits such as mental health assistance, easy scheduling of medical appointments, and handling of insurance inquiries.
- *Virtual Advisor for Personal Health:* Systems with influential artificial intelligence technologies allow the likes of Siri and Cortana. AI, when paired with healthcare applications, offers immense value. In the case of the absence of healthcare personnel, the usage of AI seems to have an enormous impact on supporting and tracking patients with any type of requirements.

Uses of Artificial Intelligence in Healthcare

Suki: It is a voice-enabled, AI-powered solution introduced for healthcare professionals. It operates via Suki Assistant and Suki Speech Platform. It helps solve problems more easily, thereby making its users productive. The company emphasises reimagining the healthcare tech stack, thereby making it both assistive and invisible. Suki delivers precise and quick voice experiences in machine learning and natural language processing (Suki, 2022).

Ten3T: Ten3T is a Bengaluru-based clinical insight and data-driven company engaged in using its patented platform of AI-enabled analytics and medical-grade wearables. The company helps in regular monitoring of health, thereby enabling effective, proactive, and predictive clinical decisions. The company focuses on transforming patient care by building an intelligent, pervasive, and comprehensive platform. This platform integrates electronic, chemical, and biological sensors, thus offering predictive analytics for real-time information, whether outside or within the hospital (ten3T, 2019).

SigTuple: SigTuple, a Bengaluru-based company is engaged in creating a platform that helps in the detection of various diseases via machine learning software. It offers a complete analysis of medical images and information to aid the diagnosis. The company focuses on enabling artificial intelligence-assisted reviews that are unobstructed by global boundaries (SigTuple Technologies, n.d.).

The Amalgamation of Distributed Ledger Technology and Artificial Intelligence

In today's scenario, one of the latest creative developments in the healthcare sector focuses on the integration of DLT and AI-based solutions to offer enhanced decentralised governance (Alruwaili, 2020). The confluence of artificial intelligence and DLT paves way for several innovative approaches in the healthcare industry, to attain secure, resilient, and smart ways of handling patient-relevant information. It creates one of the most reliable technologies, enabled by the decision-making system, which is tamper-proof and offers strong insights. Innovativeness in the compliance systems and audits, transparency in the government models, intelligent predictive analysis, and enhanced business data models are a few of the benefits offered by the integration of AI in healthcare businesses. Further, the confluence tends to create a diversified set of data/information and optimises efficiency and productivity, thus offering enormous advantages while storing valuable data.

Applications of the distributed ledger technology offer solutions that require complete replacement or substantial changes to the business processes or the existing systems. It therefore becomes an essential factor for the firms to

accordingly strategise the overall transition processes, to facilitate growth in the businesses (Laurent, 2016).

Factors Driving the Demand for Distributed Ledger Technology in Healthcare

Increasing Emphasis towards the Adoption of Automated Healthcare Solutions

Increasing medical supply chain complexities and operational costs, coupled with the growing demand for patient-centric solutions, are expected to augment the presence of narrow-specialised software healthcare solutions (Teo, n.d.). Implementation of technologies such as distributed ledger technology enables programming conditions that are mechanically executed on certain conditions. This is discussed as 'Smart Contracts'; this can be done in the conventional centralised ledger systems, which essentially require such actions to be incorporated only upon the consent of the concerned parties for the underlying transaction in the system. The smart contracts technology consists of a code that can be fulfilled in a DLT setting. DLT-based smart contracts refer to a self-executable protocol or program which is expected to offer trust and security in the healthcare domain. These are executed in a mechanised manner, wherein the next step can be catered upon, only when a predefined state is attained (Devdiscourse, 2021).

Smart contract technology enables the advancement of decentralised apps (DApps), which can directly interrelate with the support of on-chain storage and blockchain. The incorporation of DLTs with smart contracts augments the prominence of quality compliance of temperature-sensitive pharmaceutical logistics. With the help of these self-executing contracts, tracking the entire process of the supply chain is expected to become transparent and easier, thereby preventing the counterfeiting of drugs as well.

Hence, the merger of DLT with DApps and smart contracts is further expected to cater to several issues in the healthcare networks, such as patient-centric authentication and recognition, multi-centre training with the mechanised patient acquisition by smart contracts, pharmacy surveillance, and healthcare compatibility (Schnitzbauer, 2021).

Growing Demand for High-Level Data Transparency

In today's scenario, accuracy and data transparency seem to be more significant in the healthcare sector than ever. Healthcare providers need accessibility to the best probable data while taking decisions about the patients. These data are usually found via electronic health records and other sources. Lack of data transparency impacts different investors, which include physicians, insurance firms, healthcare staff, and patients (PiTech, 2021).

The inclusion of DLT in medical records is expected to offer a high level of data transparency and accuracy via a decentralised and distributed ledger. The members of the healthcare company or the providers will be given a full copy of the ledger (which is encrypted). Accessibility to such electronic records is expected to enhance the overall quality of treatment and services to the patients at an optimal cost. Changes to the records can be done upon the establishment of a consensus, wherein they can easily be broadcasted across the entire network on a real-time basis. The need for data transparency in healthcare can be attributed to the different benefits offered by the same. A few of these include:

- *Cost-Effectiveness and Enhanced Service Quality:* Transparency of data in the healthcare sector helps enhance the service quality and optimise the costs by allowing the patients to enhance their decisions relevant to the care and expenses on their treatment.
- *Improved Trust and Enhanced Innovation:* The knowledge increased due to data transparency is expected to allow the researchers to discover correlations amid varied healthcare treatments and conditions. Such findings are expected to lead to customised treatment options for the patients on an individual basis, enhanced clinical trial methods, and improved drug therapies.

Challenges in the Implementation of DLT in Healthcare

The distributed ledger technology is still in its developing stage, wherein several legal and regulatory topics are yet to be resolved.

Uncertain Regulatory Status

Even though the distributed ledger technology (DLT) systems cater to several traditional regulatory governance issues, they tend to pose several systemic risks as well (Benedict, 2021). In the healthcare sector, distributed ledger technologies are expected to face a lot of challenges in their widespread adoption by different companies and potential customers if the regulatory scenario remains unsettled. Several questions need to be fixed by the regulators, particularly in terms of their condition for initial offerings, money, or assets, and their exploitation of the transaction processing platforms. It thereby becomes necessary for the healthcare policymakers to consider their alliance with the industry to realise and ease the growth of the ecosystem within the limits of existing policy objectives and regulatory frameworks (Krawiec, 2016).

The different sections of laws discovered comprises legislation catering to the distributed ledger technology systems, such as intellectual property and code; uses, for instance, crypto-currency governance; legislation catering to different layers of DLT structures; consumer law; privacy concerns; and anti-money laundering, token economy, along with consortia and civil liability (ICTs, 2019).

Research Methodology

This article is a comprehensive market research-based study, with a major emphasis on the market analysis impacting the implementation of DLT in the healthcare sector. The data for the study has been derived from secondary sources, such as company annual reports, press releases, government and non-government agencies, journal articles, research reports, websites, and a few others.

This research includes an assessment of distributed ledger technology and decentralised artificial intelligence in the healthcare industry. The analysis used in the article offers a detailed description of the factors impacting the overall market. It also caters to the different factors hindering the market, along with the different opportunities for distributed ledger technology (DLT) in the healthcare sector across the different regions in the world over the forecast period. The forecast analysis will be in terms of revenue at the global and regional levels, with the key trends varying for 2019-2028 (forecast period). Market forecasting and share analysis enable both small-size and large-size healthcare businesses to cater to the strategic decision-making processes and assess the overall industry positions in terms of different market segments.

Research Objectives

The objectives of the research study are:

- To evaluate the current scenario of the market and estimate the forecasts for 2019-2028.
- To emphasise on the future aspects, challenges, and implications of decentralised AI and DLT in the market.
- To recognise the factors bolstering the growth of DLT businesses across the healthcare industry verticals over the forecast period.

Inclusions

- Geographical segments such as North America, Europe, Asia Pacific, Latin America, and Middle East and Africa.

Scope of the Study

The article contemplates the current scenario of the global DLT market in the healthcare segment for the forecast period 2019-2028. The study focuses on region- and segment-wise revenue for assessing the overall market in terms of share analysis.

Data and Forecast Analysis

The study comprises market size and estimates of the DLT in the healthcare market in terms of revenue over the forecast period, as well as segmentation based on regions covering North America, Europe, Asia Pacific, and the Rest of the World (RoW). It further emphasises on the different factors engaged in bolstering the market growth and restraining the same over the projected period.

The data can be analysed with the help of:

- Current developments and trends in the market across the different regions.
- Future aspects and opportunities offering insights on commercialisation as well as expansion in different regions.

This helps gain holistic information and understand the current market scenario as well as future trends of the same, thereby enabling the companies to accordingly strategise the launch of the patient-centric models, plans, and policies.

Method of Analysis

The data has been categorised based on varied parameters, such as region and type insights. Methodologies to study the gathered data are:

- *Top-Down Approach:* The top-down method encompasses a wider range of variables. The data are collected for the global scenario and are then separated into different entities (which include type/region).
- *Bottom-Up Approach:* The data are collected and estimated for regional segments and are then combined to obtain the global numbers.

Findings and Analysis

Global Market Analysis

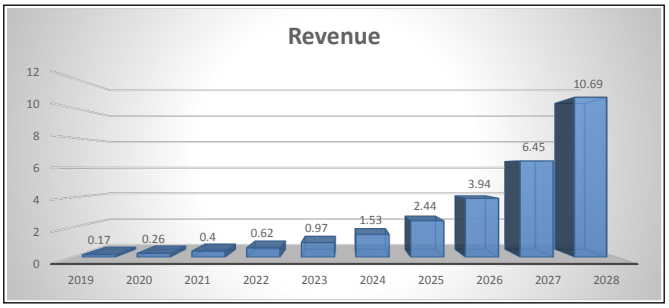
In today's scenario, the advent of technology enables healthcare enterprises to uphold experience-driven relationships with people in ways not possible before. Healthcare analytics is founded on the data sets which include genetic, IoT, medical, demographic, insurance, and financial information collected from several databases. Owing to the diversity of these sources, data standardisation seems to be the means for efficient usage of the information, which enhances the collaboration among healthcare providers, professionals, government agencies, insurers, and patients.

DLT is an emerging concept that offers patient-related market applications and insights. Healthcare providers, pharma companies, and insurance payers are the significant adopters of the DLT systems.

Integration of DLT in the healthcare industry helps minimise waste, enhance the quality of care, and optimise costs, thereby generating a trusted set of data, so that it becomes easier for the people to act on the information rather than emphasising on its source to verify the authenticity (Safavi, Digital Health Tech Vision, 2019). The ledger technology is expected to be leveraged by leading vendors, such as Amazon, Microsoft, and Google, to monetise analytical services with several innovative patient-centric models and strategies which have larger chances of accessibility among the patients.

The profitability potential is driving the vendors to invest in the market. The rising number of mergers and acquisitions, along with collaborations among the leading market players helps maximise varied economic benefits, and thereby offer enhanced profitability and operational efficiency to their businesses.

Distributed ledger technology in the healthcare market was valued at USD0.17 billion in 2019 and is expected to witness a significant surge over the projected period. The market was expected to be valued at USD10.69 billion in 2028.

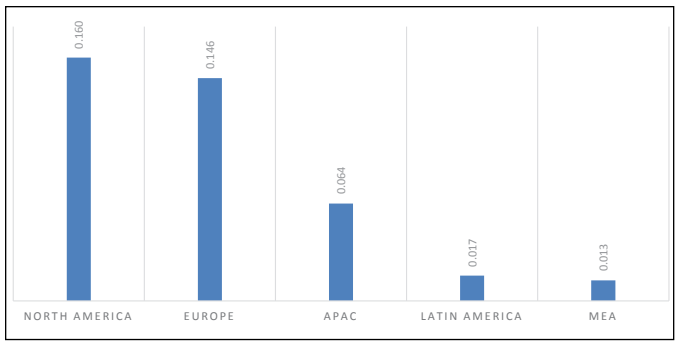


Source: Result of the analysis.

Fig. 2: Global Distributed Ledger Technology in Healthcare Market 2019-2028 ($ billion)

Regional Analysis

Based on geographies, the market can be categorised into North America, Europe, Asia Pacific, Latin America, and Middle East and Africa. North America accounted for a market share of nearly 39.92 per cent of the overall market. This can mainly be attributed to the increasing preferences for transparency in identity detection solutions, smart contracts, payment solutions, and a few others in the healthcare businesses.



Source: Result of the analysis.

Fig. 3: Geographical Analysis of Global Distributed Ledger Technology in Healthcare Market in 2021 ($ billion)

Europe accounted for nearly 36.56 per cent of the total share in 2021, thereby witnessing considerable growth along with the Asia Pacific regions as well. The increasing presence of a large number of players with their strategic initiatives, growing collaborations with the companies, as well as investments in research and development is expected to boost the overall market demand. The venture capital investors emphasise on the identification of features offered by the DLT technology for optimising medical care expenses, improving patient care solutions, and expanding the scope of healthcare services. The regions of the Middle East and Africa and Latin America are also expected to witness considerable growth over the forecast period.

Conclusion

DLT and AI-based models are significantly gaining traction in setting newer standards in terms of patient care. These technology-enabled solutions are expected to be the digital backbone of the Internet of Medical Things (IoMT), mHealth, and eHealth applications (Technologies, n.d.). Easy traceability, disintermediation, integrity, lower transaction costs, and simplified workflow in the ecosystem are a few of the benefits offered by the integration of DLT in the healthcare industry (Laurent, 2017). Growing applications of the technology can be attributed to decentralisation and inherent encryption. The technology offers a higher level of security owing to its innovative storage systems in the database spread throughout the network. This can be attributed to the fact that these systems are impossible to be hacked or tampered with or altered (Berman, 2021).

Incorporation of such pioneering technologies enables the patients and healthcare providers to reap the profits of the same, in terms of minimising the constant breaching of data/information, putting a check on the inefficient practices being carried out by the healthcare workers, the exponential rise in the costs of treatments of the patients, and a few more.

The COVID-19 pandemic has largely exhilarated the healthcare industry like no one could ever predict. For the benefit of public health across the world, key market players are emphasising on leveraging the best-in-class latest technologies to cater to the needs of the patients and the changing ecosystem. The inclusion of DLT in the life sciences industry seems to be impactful in completely revolutionising the way patients are taken care of and the way the healthcare services are witnessing an augmentation.

Key Takeaways from the Study

- Distributed ledger technologies account for high growth potential in the healthcare sector.
- Pharma companies, healthcare providers, and health insurance payers are anticipated to be the early adopters in comparison to the other industry investors.
- The concept of DLT is expected to be leveraged by several tech giants and telehealth vendors, such as Amazon, Apple, Microsoft, and Google, to monetise the analytical and data science services with the implementation of advanced strategies.

Limitations

The study includes an in-depth evaluation and analysis of secondary research. Primary research was not conducted.

Future Research Directions

One of the most interesting aspects of the DLT technology is the extent of modularity and growth that it offers.

The features and benefits offered by the technology are expected to bolster industry-wide advancements over the projected period.

To realise the exact potential of DLT, the healthcare industry needs to prioritise the establishment of the blockchain consortia/working groups to endorse a collaborative environment for developing and exploring the focused governance standards and use for growth and scalability over the forecast period (Sullivan, 2019). Emphasising more towards developing patient-centric care models for business segments to enhance profit margins and sales are expected to play a vital role among healthcare companies in the future.

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