13

Cloud Manufacturing and Focus on Future Trends and Directions in Health Care Applications

Ravi Prasad Thati[1]* and Pranathi Kakaraparthi[2]

[1]Department of Computer Science and Engineering, School of Technology, GITAM (Deemed to be University) Hyderabad, Telangana, India
[2]Department of Computer Science and Engineering, Malla Reddy Engineering College, Hyderabad, Telangana, India

Abstract

Cloud manufacturing is a modern topic in terms of manufacturing method that uses cloud computing technology to provide support in healthcare services. This chapter discusses six aspects of cloud manufacturing. They are, first, key benefits of cloud manufacturing in healthcare sector such as cost-effectiveness, efficiency, customization etc., are explained. Second, importance of challenges and considerations involved in cloud manufacturing for healthcare domain integration were provided. Third, future trends and directions in cloud manufacturing for healthcare sector are discussed. Fourth, presents the conclusion and remarks of the current work like medical cloud manufacturing and its advantages.

***Keywords*:** Cloud manufacturing, health care, future trends and directions in healthcare manufacturing, benefits and advantages of cloud manufacturing

13.1 Introduction

Cloud manufacturing has several advantages in utilizing cloud production in the healthcare sector. This includes improving the performance of all the operations, ability to reduce the costs, and develop customized

**Corresponding author*: rthati@gitam.edu

P. Pavan Kumar, Grandhi Suresh Kumar, Ajay Kumar Jena, Sandeep Kumar Panda and S. Balamurugan (eds.) Adaptive Artificial Intelligence: Fundamentals, Challenges, and Applications, (359–380)

healthcare solutions. This section focuses on these benefits, focusing on cost-effectiveness, efficiency, customization, scalability and adaptability [1].

Improve Efficiency and Cost-cutting:
Cloud manufacturing significantly improves the productivity and decreases costs of medical production through collaboration of modern technology, automation and data-driven decision-making [2].

13.1.1 Operational Quality Simplifying the Process

Cloud manufacturing solutions automate and integrate a variety of industrial processes, streamlining workflows and eliminating manual involvement. This centralization improves collaboration at all stages of production, from prototyping and modeling for manufacturing and assuring quality. Hence, programs become more streamlined and efficient, shortening production cycles and shortening time to market [3].

Real-Time Data Analysis:
The cloud domain furnishes real-time data analysis, allowing the manufacturers to continuously examine and improve the manufacturing processes, scrutinize data from sensors, IoT devices and production systems to identify potential issues, bottlenecks and inabilities. This dynamic approach facilitates fast adjustments and advancements, ultimately minimizing intermissions and increasing productivity [4].

Maximum Resource Utilization and Increased Throughput:
Cloud manufacturing also has the benefit of efficient resource management thereby facilitating a better performance. Producers can make use of all the predictive analytics and demand forecasting methods and procedures to improve the use of raw materials, labor, and equipment. This not only avoids waste but also assures efficient usage of resources and saves costs [5].

13.1.2 Reduce Costs

Reduce Capital Investment:
One of the major issues in reducing cost is the reduction of capital investment. Traditional manufacturing systems always require prominent capital investments in machinery, infrastructure and IT systems. Cloud production reduces costs by moving much of the infrastructure to cloud-based platforms. This typical pay-as-you-go pricing, reduces the need for significant

upfront costs thereby making it more affordable for healthcare producers, most importantly to small and medium-sized enterprises (SMEs).

Reduce Maintenance Costs:
As cloud service provider is responsible for maintaining and updating the infrastructure, these solutions reduce the need for on-site maintenance and IT assistance by reducing the need for in-house IT staff; hence, it lowers overall maintenance costs. Additionally, cloud systems also include automatic upgrades and patches to ensure you always have the latest features and security measures.

Supply Chain Optimization:
Cloud manufacturing increases supply chain visibility and integration. This allows companies to efficiently manage and maintain the production planning, inventory levels, and shipping. Hence, the costs associated with overproduction, excess inventory, and expedited shipping are considerably reduced. Cloud manufacturing enables just-in-time production and deployment, minimizing working capital needs and enhancing the cash flow.

Customization and Personalization:
Due to the growing needs of patients, specific treatments and equipment are required and the healthcare industry is looking forward for customized and personalized solutions. This level of personalization is primarily achieved through cloud manufacturing.

13.1.3 Personalized Medicine Customized Treatment

Personalized medicine makes use of genetic, phenotypic and environmental information and provides tailored treatments based on the information. Cloud platforms can perform functions such as storing, analyzing and integrating large data sets such as medical history, genetic data, and lifestyle information. This substantial data analysis helps the healthcare professionals in developing personalized treatment plans, ultimately improving the results.

Precision Pharmaceutical Manufacturing:
Making use of Cloud in pharmaceutical manufacturing leads to the creation of precise medicines customized to the specific characteristics of an individual patient or patient population. This approach would be really advantageous and very valuable in oncology, allowing drugs to be customized

according to the specific mutations associated with each patient's cancer. Cloud-based infrastructure supports the rapid development and scalability of these personalized medicines by ensuring patients timely access to their medicines [6, 7].

13.1.4 Customized Medical Equipment

3D Printing and Additive Manufacturing:
Additive manufacturing technologies makes use of 3D printing, thereby revolutionizing the production of personalized medical devices. The Cloud platforms provide the equipment and data management systems needed to create and produce devices customized to each patient's anatomy. For example, prosthetics, orthotics, and implants can be adjusted to achieve a precise fit and improve comfort and functionality [8].

Digital Twins and Simulations:
To create virtual medical device models that can be tested and adjusted before actual manufacturing, we make use of digital twins. This ensures that the final product meets the exact needs of the patient and decreases the possibility of rework or replacements. To ensure the safety requirements and effectiveness, digital simulations predict how the gadget will perform in different scenarios [9].

13.1.5 Patient-Centered Care Enhance Patient Engagement

By supporting patient-centered care, cloud-based solutions facilitate communication and collaboration between patients and healthcare professionals. By providing personalized health information treatment plans and guidance materials, patients can become active participants in their health care process. This participation can help increase adherence to treatment plans and improve health outcomes [10, 11].

Remote Monitoring and Support:
Through this feature, patients with chronic conditions can benefit by making use of remote monitoring and assistance. Real-time data on patient health parameters and vital signs can be collected using IoT sensors and wearable technology. This data is tracked and analyzed with a cloud platform. Health professionals can use this information to change treatment options, coordinate care, or intervene early if problems arise [12].

Scalability and Adaptability
The medical manufacturers can adapt to ever changing market conditions and evolving healthcare needs only because of the unparalleled scalability and flexibility of cloud manufacturing [13].

13.1.6 Scalability

Resilient Infrastructure:
Cloud platforms give the facility of flexible infrastructure that can scale up or down based on the need. As demand may change due to the approval of new treatments, this adaptability is particularly useful in the manufacturing of healthcare products, public health emergencies, seasonal fluctuations, and more. The cloud systems can fill these modifications without significantly increasing the economy of physical infrastructure [14].

Global Expansion:
To support global operations, cloud manufacturing systems enable companies to collaborate with suppliers, partners, and customers around the world.

Resource Allocation:
To present the manufacturers the ease and comfort to allocate storage, processing power and other utilities as required, the cloud-based systems apply the concept of dynamic resource allocation. This flexibility helps attain critical functions such as data analysis and quality control; and so, they will have all the necessary tools they need during peak times while decreasing costs incurred during times of less demand.

13.1.7 Flexibility

Adapting to Latest Technologies:
As cloud manufacturing platforms are constructed in such a way that they can easily combine and integrate new advancements and technologies, this feature guarantees manufacturers in the health care industry to collaborate with the latest technologies such as artificial intelligence, machine learning and the Internet of Things without causing any kind of disruptions to current operations. For example, manufacturers can use AI-driven information to enhance the quality of processes, perform predictive maintenance and more [15, 16].

Rapid Product Development:
Cloud manufacturing can quickly habituate itself to any new technologies to enable you to fastly develop new prototypes. Manufacturers can quickly create, evaluate and improve new manufactured products, reduce the time and cost required to bring new healthcare solutions to market. This flexibility is complex to adapting to new possibilities and challenges in healthcare.

Corporate Compliance:
Stringent regulations are posed on manufacturing companies and organizations of healthcare products. Cloud solutions provide us with the needed facilities to adapt to ever changing rules and laws, assuring ongoing compliance. This work includes the ability to track regulatory updates, update the documentation, and make necessary modifications to production procedures and quality control.

13.1.8 Conclusion

Cloud manufacturing is used in a variety of ways in the healthcare industry. Cloud manufacturing is uplifting the design, manufacturing and deployment of healthcare manufacturing products, thereby issuing scalability and flexibility and personalization capabilities, budget compliance and increased productivity. Despite making healthcare more adoptable and of good standard, this will also make it easy for manufacturers to transform the market conditions and technological upgrades. As cloud technology continues to rule, it will have a very huge and significant effect on driving innovation, medical manufacturing and raising the standard of patient care around the world [17].

13.2 Challenges and Considerations in Cloud Manufacturing for Healthcare

Cloud manufacturing has the ability to transform and change the healthcare industry, but there are numerous concerns that need to be worked upon to ensure a smooth work flow. This chapter covers important topics such as data security and privacy, regulatory compliance, healthcare industry integration and interoperability challenges. Understanding these hardships is very essential in designing strategies that work effectively to reduce risk and optimize the performance of cloud technologies in the healthcare industry [18].

Data Security and Privacy
Data security and privacy are two non-trivial issues in the healthcare industry since patient information is very private and regulated. Moving to cloud-based systems exacerbates these problems because of the reason that data is pre-processed and shared among many locations [19].

13.2.1 Data Breaches and Cyber Security Threats

The healthcare industry has become a major target for cyber attackers because of the huge utility of medical information. The potential ill effects of a data breach include access made to medical data by unauthorized persons, theft of intellectual property, and financial losses. The distributed nature of cloud architecture can make it very difficult to secure data across the globe [20, 21].

Q2 **Key Considerations:**

13.2.2 Data Privacy and Patient Consent

Data security problems have become really intriguing in the medical care industry (PHI) due to the fact that individual wellbeing data has to be known. To safeguard patient rights and keep up with privacy, cloud fabricating stages should comply to severe data security rules.

Key Considerations:

Data Anonymity: Data anonymity and pseudonymization are two methods that assist us in not violating the patient's privacy even after utilizing the data to be used for research and analysis.
Data Localization: To handle legal issues, cloud providers must assure and guarantee to obey with these requirements because some countries have data localization rules that need certain data types to maintain their boundaries. Agreeing to their data protection regulations is compulsory.
Description: Organizations in the field of medicine are subjected to various data protection laws and amendments which includes the European Union's, U.S. Health Insurance. Portability and Accountability Act (HIPAA), and General Data Protection Regulation (GDPR). These rules state very strict rules regarding privacy, patient rights, and data security [22].

Important Considerations:
Breach Notification: Data Retention and Deletion: Clear information maintenance and erasure rules ought to be set up to ensure that information is securely annihilated when presently not needed and isn't held for any more than needed.

Corporate Compliance
The medical industry is strictly monitored to ensure quality products, patient privacy and is made sure that it follows ethical standards. Healthcare cloud manufacturing needs maintaining a complex rule-based environment that monitors everything from data management to product creation.

13.2.3 Health Care Product Regulatory Standards

Description: Healthcare products, including drugs and medical devices, must meet strict regulatory requirements to ensure safety and effectiveness. The U.S. Food and Drug Administration (FDA) and European Medicines Agency (EMA) are the two regulatory agencies that govern the agreement and surveillance of these products.

Key Considerations:

Product Quality and Safety: Cloud manufacturing platforms must implement a strict quality management system (QMS) to ensure that goods comply with regulatory requirements which include adhering to Quality Assurance (QA) and Good Manufacturing Practice (GMP) guidelines.
Documentation and Record Keeping: Complete and correct documentation is important in order to comply with the rule. Cloud services should facilitate proper record keeping, including traceability of raw materials, industrial processes and outcomes.
Post-Market Surveillance: Cloud platforms can aid in post-market surveillance and help manufacturers meet regulatory reporting obligations by collecting and evaluating data on product performance and safety, Compliance Challenges in Cloud Environments [23].
Description: When it comes to ensuring that programs and data comply with legal requirements, cloud environments present unique compliance issues. The shared responsibility paradigm that exists between cloud service providers and healthcare organizations will even more complicate compliance efforts.

Key Considerations:

Shared Responsibility Model: It is not trivial to understand the distribution of responsibilities between the cloud provider and healthcare organization. It is the responsibility of the provider to ensure the cloud infrastructure security. Data and applications on the cloud belong to the company.
Data Storage and Jurisdiction Issues: Laws governing data storage and transfer are very different from country to country. In particular, organizations must ensure that their cloud providers adhere to these standards when leveraging global cloud services.
Verification and Validation: Cloud-based systems and procedures may require verification and validation by regulators which mean checking the completeness and accuracy of data and programs, as well as ensuring that cloud solutions comply with certain regulatory standards.

13.2.4 Global Regulatory Changes

Description: Healthcare product manufacturers who operate internationally must manage a number of regulatory environments and standards. These differences may make it more complex for multinational companies to deploy cloud manufacturing systems.

Key Considerations:

Harmonization Efforts: The International Medical Device Regulators Forum (IMDRF) and The International Council for Harmonization of Technical Requirements for Human Use (ICH) are two among the companies which are working to comply with the rules and regulations and promote cross-border compliance.
Cross-Border Data Transfers: It is essential to monitor cross-border information transfers in coordination with local laws (such as GDPR data transfer restrictions). This data transfer can be done by using some tools such as Standard Contractual Clauses (SCC) or by collecting the data subject's explicit consent.
Interoperability and Integration
Effective adoption of cloud manufacturing in the industry is only achieved through smooth integration of cloud-based systems with current healthcare. Problems with interoperability can hinder teamwork, data communication, and overall efficiency [24].

13.2.5 Integrate with Existing Systems

Description: Old fashioned and infrastructure and traditional systems won't work with modern cloud computing services but only those are provided by the healthcare organizations. To make sure that they deliver consistent and efficient operations, the idea is to collaborate these systems with cloud manufacturing environment.

System Compatibility: System compatibility is an important factor to consider because it's the only way to ensure that your cloud solution is compatible with your current hardware and software systems. For this process the usage of middleware or APIs is needed to negotiate and perform the data transfer [25].

13.2.6 Data Standardization and Interoperability

Description: The term interoperability is defined as the ability of different devices and systems to work together and share the information. It is complex to achieve interoperability in the healthcare industry due to the difference in data formats, the diversity of systems, and standards [26].

Key Considerations:

Data Integration and Exchange: Examples of medical systems which need flawless communication with data and data transfer are electronic health records (EHRs), laboratory information systems (LIS), and imaging systems. They are given by cloud platforms.

13.2.7 Supplier Lock-In and Flexibility

Key Considerations:

Multi Cloud Plan: By working on a multi-cloud approach that distributes services across multiple cloud providers, we can decrease the risk of reliance on a single vendor. This in turn can increase activeness. This approach improves robustness and provides reliability. While cloud manufacturing possesses many advantages for the healthcare industry, there are also minuses and side effects that are needed to be managed. Ability to work with other devices, compliance for rules and regulations, data security are important topics that require a timely scheduling. Pharmacy industries have the ability to fully influence the cloud technology to resolve these hardships to improve patient care, efficiency, and spur innovation in healthcare production. Effective collaboration of cloud manufacturing

depends on a balanced strategy that takes into account the advantages and limitations of this disruptive technology as the industry continues to evolve [27, 28].

13.3 Future Trends and Directions in Cloud Manufacturing for Healthcare

With the rise of latest technologies cloud manufacturing got the ability to transform the medical industry. This chapter throws light on the potential trends of cloud manufacturing in pharmacy industry, focusing on innovations such as artificial intelligence, block chain and machine learning. It also tells us about the potential global impact of cloud manufacturing [29].

Advanced Technology:
It is fascinating to know that new technologies will have a great effect on the construction of cloud manufacturing in the medical field. These technologies will not only raise the abilities and functioning of cloud platforms but also open up new roads for previously undone applications, problems and solutions.

13.3.1 Artificial Intelligence (AI) and Machine Learning

Outline: By making use of advanced data analysis, automation, and decision-making, artificial intelligence (AI) and machine learning make the future of the medical care sector. These technologies have the ability to enhance product quality, streamline processes and improve patient results at cloud manufacturing sites [30].

Applications in Cloud Manufacturing:
Predictive Empirics: To predict the equipment crashes, enhance the maintenance plans, and increase production, vast amounts of data from the industry processes are analyzed through artificial intelligence and machine learning algorithms. This predictive capability can reduce expenses and can also reduce the failure time.

Quality Control:
For real-time quality control, flaw detection, and product adherence to compliance with strict regulations data analysis and image recognition powered by artificial intelligence (AI) is used. This is specifically crucial in manufacturing medical devices and pharmaceuticals.

Future Directions:
AI-Driven R&D: There is a need for AI to be increasingly involved in R&D activities, specifically in the medical device manufacturing and discovery of drugs. Machine learning algorithms can help analyze complex data to greatly enhance the layout of clinical trials, thus finding promising drug candidates.

Futuristic Manufacturing:
To design a real time futuristic manufacturing system that can independently modify production processes, a combination of artificial intelligence and IoT devices is needed. This also assures maximum efficiency and quality.

13.3.2 Block Chain Technology

Abstract: Because of its ability to enhance the safety of the data, ability to trace the data and interoperability blockchain technology is becoming increasingly popular in the pharmacy industry. Blockchain is known for its security and transparency.

Applications in Cloud Manufacturing:

Supply Chain Transparency: From procurement of raw material to the product delivery blockchain technology provides an unchanging record of the entire supply chain. In the fight against forged medicines this openness is critical for ensuring the security and effectiveness of medicines [31].
Data Privacy: Because of its decentralized organization and transferring of plain text to cipher text capabilities, blockchain ideally protects sensitive medical data to make sure that the data is accessed and mutually used in accordance with patient wishes and legal obligations in managing consent of the patient.

Our Goal:

Decentralized Clinical Trials: By securely storing patient information, consent forms, and trial procedures, blockchain technology has the potential to facilitate decentralized clinical trials. While increasing openness and trust in the clinical trial process this protects patient privacy.
Blockchain-Enabled Digital Twins: By providing a transparent and secure log of all changes and updates performed to the virtual model blockchain

technology has the potential to increase the trustworthiness of digital twins. Hence, the accuracy and completeness of numerical descriptions of real-world systems and products can also be improved.

13.3.3 Internet of Things (IoT)

Overview: The Internet of Things is defined as the process of connecting physical systems and gadgets to the Internet so that they can communicate and collect data. IoT has the ability to enhance the product quality and operational efficiency in the medical manufacturing industry.

Applications in Cloud Manufacturing:

Real-Time Monitoring: Tasks such as monitoring equipment conditions, environmental variables, and industrial process in real-time can be done easily by IoT devices. You can optimize production parameters, meet quality requirements and avoid equipment failures by analyzing this data.
Asset Tracking: Real-time visibility into the location and condition of goods, equipment, and materials throughout your supply chain is given by IoT-enabled asset tracking systems. This decreases the chance of product theft or loss and improves inventory management.
Patient Monitoring and Care: To monitor patient health data in real time, IoT devices can be integrated with wearables and medical devices. For analysis, enabling remote patient monitoring and personalized treatment, this data is sent to a cloud platform.

Our Goal:

IoT Smart Factory: Realizing real-time monitoring and optimization of the manufacturing process and promoting the smooth integration of digital and physical systems can be possible with the development of IoT smart factory, [32].
Remote Diagnostics and Maintenance: Facilitating remote maintenance and diagnostics of medical equipment, minimizing the need for on-site repairs and ensuring device functionality can be easily done with IoT devices.

Future Applications and Innovations
To bring new medical applications and advancements, cloud manufacturing and future technologies are expected to combine. These developments will lead to better patient care, creation of new products and services, and increased operational efficiencies.

13.3.4 Personalized Medicine and Customized Treatment

Overview: The goal is tailoring treatments to each patient's genetic makeup and lifestyle and customized medicine. This progress has been greatly facilitated by cloud manufacturing, which enables rapid production of medical devices and personalized treatments.

Innovation:

3D Printed Implants and Prostheses: Facilitating the design and manufacture of 3D printed implants and prostheses that match the patient's anatomy can be done by cloud-based systems. This ensures increased improved functionality, cloud-based systems and improved fit [33].
Customized Drug Formulations: With cloud manufacturing it's easier to create custom drug formulations that fit each patient's unique needs and genetic profile. In medical specialties such as cancer, where personalized treatments can give great results to affected persons this strategy is specifically important.

13.3.5 Advanced Telemedicine and Telemedicine

Overview: Since the COVID-19 outbreak the use of tele care and telemedicine has increased. Future developments in these areas are expected to leverage cloud manufacturing and other technologies [34].

Innovation:
Virtual Consultation and Diagnosis: By providing virtual consultation and diagnosis our state-of-the-art telemedicine system allows patients to receive treatment in the comfort of their own homes. Cloud-based AI technology helps medical professionals diagnose and treat patients remotely.

Tele surgery and Robotics: Remote surgery is possible by merging both robotics and cloud computing where doctors can perform surgeries from remote locations using robotic equipment This increases access to specialized surgical knowledge, especially in underserved and rural areas [35].

13.3.6 Regenerative Medicine and Bio Printing

Overview: Replacing or repairing damaged tissues and organs is taken care by the frontier fields of bio printing and regenerative medicine.

As it facilitates the creation of complex biological structures and biocompatible materials cloud manufacturing is critical to the advancement of these technologies.

Innovation:
Tissue Engineering: For regenerative therapies cloud-based platform facilitates the creation and fabrication of artificial tissues. This includes creating bio printed tissues, scaffolds and cell cultures to replace or repair damaged organs.
Organ Printing: Complex donor organs can be produced by cloud computing and advanced data analytics, combined with bio printing technology. Even though this technology is still in the experimental stage, it is evident that it can transform organ transplantation and alleviate organ shortages.

Impact on Global Healthcare
By lowering prices, increasing accessibility, and facilitating the rapid dissemination of medical advances cloud manufacturing has the potential to revolutionize the healthcare industry.

13.3.7 Accessibility and Coverage

Abstract: By allowing medical products and services to be manufactured and distributed around the world cloud manufacturing has the potential to democratize high-quality healthcare. This is especially important for underserved groups and areas.

Influence:

Global Supply Chain: To ensure medical equipment and supplies reach underserved and remote areas, cloud-based systems make it easier to create efficient international supply chains. This includes providing to ensure medical equipment and supplies reach underserved and remote areas, necessary medicines and diagnostic supplies.
Expansion of Telemedicine: The advancements of telemedicine services provided by cloud technology will improve access to healthcare for patients living in rural and remote areas. The cloud platform facilitates secure data transmission and storage, enabling remote medical consultation, testing and treatment.

Reduce Costs and Increase Efficiency:
Abstract: By the elimination of the infrastructural requirements, improving production methods, and optimizing the utilization of resources, the cloud manufacturing offers a budget friendly environment. These efficiencies can minimize the budget for patients and providers in the medical field.

Influence:
Affordable Healthcare Products: By reducing manufacturing and shipping costs cloud manufacturing can decrease the price of healthcare items and make these products available to more users. This also includes the needed medications, vaccinations, medical as well as the diagnostic equipment.

Q4 **Operational Efficiency:**

13.3.8 Innovation and Collaboration

Overview: Manufacturing gives rise to a platform for exchange of data, research and development which encourages creativity and teamwork. Latest medical technologies and treatments can be implemented and distributed quickly in this collaborative atmosphere.

Influence:

Global Research Collaboration: The cloud platform provides global integration between professionals who belong to the medical field and researchers on data sharing for research activities. This international collaboration has the potential to improve and standardize the patient care and speed up the medical innovation.

Rapid Diffusion of Innovation: The rapid diffusion of medical advances is provided by the cloud systems, ensuring that patients and healthcare professionals around the world have immediate access to new treatments, diagnostics and technologies.

Conclusion:
Hence, we can conclude that cloud manufacturing in healthcare has a bright future with cutting-edge applications, new technologies and a global vision for off-the-shelf and affordable products.

13.4 Conclusion

The conclusion to this book's chapter summarizes the key ideas, considers the implications for various stakeholders, and provides an outlook on the future of this cutting-edge technology. In this section, we summarize our main conclusions and thoughts on how cloud manufacturing affects the healthcare industry.

Summary of Key Points
This book explores the use of cloud manufacturing in the healthcare industry, highlighting its innovative potential and the technological foundations that underpin it. Important topics covered include:

13.4.1 Overview of Medical Cloud Manufacturing

Cloud manufacturing is defined as the practice of using cloud-based technology to manage and optimize manufacturing processes. Healthcare industry will be able to produce pharmaceuticals, medical devices and customized healthcare solutions more efficiently by using cloud manufacturing.

13.4.2 Technical Basis

Basis of cloud manufacturing is formed by the technologies such as the Internet of Things (IoT), big data analytics, artificial intelligence (AI), and cybersecurity form. These technologies enable data-driven decision-making, secure operations, and real-time monitoring.

Current Status of Healthcare Manufacturing:
Traditional technologies which were used in the medical field face challenges like high expenditures, no flexibility, and complexly designed frameworks. Cloud manufacturing provides scalable, adaptable, and leveraged solutions to these hardships.

Cloud Manufacturing Integration in Healthcare:
Cloud-based technology makes use of digital twins for maintaining personalized medical devices and telemedicine. The advantages and real time applications of these technologies are explained in detail by the case studies.

Advantages of Cloud Manufacturing in the Healthcare Field:
The notable advantages are data security, scalability, customization, cost reduction, and increased efficiency. Cloud production will also give us facilities such as advanced procedures and personalized medicine.

Hurdles: Potential problems such as ability to work with other devices, data security and regulatory compliance require immediate attention.

Agreeing with all the rules, system compatibility and powerful cyber security precautions are some of the strategies to solve these issues.
Future Directions: Advanced technologies such as block chain, artificial intelligence, and machine learning pave the way for future advancements in cloud manufacturing. These modern developments improve patient care, speed up processes, and make healthcare reachable to all the people on the planet.
Effect on Stakeholders: The cloud manufacturing integration with the medical industry has notable effects on multiple stakeholders, including manufacturers, patients, regulators, and healthcare providers. To maximize the benefits and address the barriers associated with this technology, understanding these impacts is critical.

13.4.3 Healthcare Provider

Access to Advanced Technology: To boost the results, treatment plans and diagnosis healthcare providers make use of big data analytics and cloud-based artificial intelligence. Telemedicine and remote monitoring technologies strengthen access to medical services, especially in economically backward areas.

Manufacturer:

Increased Adoptability and Scalability: Based on demand and supply, decrease waste and increased utilization of resources, manufacturers can adjust production levels. Cloud-systems smooth the way out for the production of individually customized medicines and medical devices.
Agreeability to Rules and Quality Control: Cloud creation assists in real-time quality monitoring and improvised regulatory compliance. The cloud producer can decrease the occurrence of recalls and nonconformities by maintaining product security and performance.

Patient:

Customizable and Accessible Medical care: Patients will be definitely benefitted from specially designed medical devices which are specially designed for them. Telemedicine which is fueled by the cloud technology, allows patients to receive medical attention from all the parts of the world. **Improved Outcomes and Engagement:** Modern artificial intelligence and data analytics facilitate you to trace and treat patients more precisely, improving results. Patients can also play a dynamic role in their treatment by making use of digital health technology and remote monitoring.

Regulators and Policymakers:
Ensuring Data Security and Privacy: It is essential that regulators ensure cloud manufacturing systems about respecting patient privacy and comply with data protection laws. By forming proper guidelines for controlled access, encryption and data security this can be accomplished.

Safety
Promote Innovation and Compliance: By forming an innovative regulatory framework that can ensure the patient safety, lawmakers can pave the way for the adoption of cloud production. This includes the collaborative work between the border legislation and providing support on latest technologies.

13.4.4 Final Thoughts

Utilizing cloud manufacturing in medical care is a paradigm shift that could transform the industry. Cloud manufacturing offers great ideas for creativity, effectiveness, and patient-centered healthcare by utilizing latest technologies such as blockchain, IoT, and artificial intelligence. There are many potential benefits like being budget friendly and standardizing access to medical care across the globe, improving patient results and customization of treatments. However, realizing that—this potential requires careful consideration of many issues, including data security, system compatibility and regulatory compliance; stakeholders need to work together to address these issues and ensure the efficient and safe implementation of cloud manufacturing. In the future, because of the continued development and use of the cloud in healthcare we may see further advancements in patient care and medicine. As these technologies develop, they will become more deeply integrated into the world's healthcare infrastructure, ushering in a new milestone of customization and digital health.

AI disclosure statement: The author acknowledges the use of AI-based tools for minor language editing or grammatical correction. However, all intellectual contributions, analyses, and conclusions presented in this chapter are entirely the author's own.

References

1. Simeone, A., Caggiano, A., Boun, L., Grant, R., Cloud-based platform for intelligent healthcare monitoring and risk prevention in hazardous manufacturing contexts. *Procedia CIRP*, 99, 50–56, March 2021, doi: 10.1016/j.procir.2021.03.009.
2. Wei, W., Zhou, F., Liang, P.F., Product platform architecture for cloud manufacturing. *Adv. Manuf.*, 8, 3, 331–343, 2020, doi: 10.1007/s40436-020-00306-1.
3. Fisher, O., Watson, N., Porcu, L., Bacon, D., Rigley, M., Gomes, R.L., Cloud manufacturing as a sustainable process manufacturing route. *J. Manuf. Syst.*, 47, 53–68, April 2018, doi: 10.1016/j.jmsy.2018.03.005.
4. Stergiou, C., Psannis, K.E., Kim, B.G., Gupta, B., Secure integration of IoT and Cloud Computing. *Future Gener. Comput. Syst.*, 78, 964–975, December 2018, doi: 10.1016/j.future.2016.11.031.
5. Sinha, R., Data Analysis and Sentiment Analysis on Amazon Reviews. *Int. J. Res. Appl. Sci. Eng. Technol.*, 9, 12, 2200–2206, 2021, doi: 10.22214/ijraset.2021.39725.

Q5 6. Al-Shura, M.S., Zabadi, A.M., Abughazaleh, M., Alhadi, M.A., Critical Success Factors for Adopting Cloud Computing in the Pharmaceutical Manufacturing Companies. *Manag. Econ. Rev.*, 123–137, November 2018, doi: 10.24818/mer/2018.12-01.

7. Shiau, W.-L., A unified framework of the cloud computing service. *J. Electron. Sci. Technol.*, 11, 2, 150, 2013, [Online]. Available: https://www.researchgate.net/publication/288970100.
8. Baumann, F.W. and Roller, D., Additive manufacturing, cloud-based 3D printing and associated services-overview. *J. Manuf. Mater. Process.*, 1, 2, 1–60, 2017, doi: 10.3390/jmmp1020015.
9. Hu, L., *et al.*, Modeling of Cloud-Based Digital Twins for Smart Manufacturing with MT Connect. *Procedia Manuf.*, 26, 1193–1203, 2018, doi: 10.1016/j.promfg.2018.07.155.

Q6 10. A.H.A. and G.A., Cloud Computing and Healthcare Services. *J. Biosens. Bioelectron.*, 7, 3, 2016, doi: 10.4172/2155-6210.1000220.

11. Morais, D., Pinto, F.G., Pires, I.M., Garcia, N.M., Gouveia, A.J., The influence of cloud computing on the healthcare industry: a review of applications, opportunities, and challenges for the CIO. *Procedia Comput. Sci.*, 203, 2021, 714–720, 2022, doi: 10.1016/j.procs.2022.07.106.

12. Aazam, M., Khan, I., Alsaffar, A.A., Huh, E.N., Cloud of Things: Integrating Internet of Things and cloud computing and the issues involved. *Proc. 2014 11th Int. Bhurban Conf. Appl. Sci. Technol. IBCAST 2014*, pp. 414–419, 2014, doi: 10.1109/IBCAST.2014.6778179.
13. Fernández-Cardeñosa, G., De La Torre-Díez, I., López-Coronado, M., Rodrigues, J.J.P.C., Analysis of cloud-based solutions on EHRs systems in different scenarios. *J. Med. Syst.*, 36, 6, 3777–3782, 2012, doi: 10.1007/s10916-012-9850-2.
14. Rezaei, H., Karimi, B., Hosseini, S.J., Effect of Cloud Computing Systems in Terms of Service Quality of Knowledge Management Systems. *Lect. Notes Softw. Eng.*, 4, 1, 73–76, 2016, doi: 10.7763/lnse.2016.v4.226.
15. Alam, G., Ihsanullah, I., Naushad, M., Sillanpää, M., Applications of artificial intelligence in water treatment for optimization and automation of adsorption processes: Recent advances and prospects. *Chem. Eng. J.*, 427, 130011, 2022, doi: 10.1016/j.cej.2021.130011.
16. Liu, Y., Wang, L., Vincent Wang, X., Cloud manufacturing: Latest advancements and future trends. *Procedia Manuf.*, 25, 62–73, 2018, doi: 10.1016/j.promfg.2018.06.058.
17. Miah, S.J., Hasan, J., Gammack, J.G., On-Cloud Healthcare Clinic: An e-health consultancy approach for remote communities in a developing country. *Telemat. Inform.*, 34, 1, 311–322, 2017, doi: 10.1016/j.tele.2016.05.008.
18. Harteloh, P.P.M., The Meaning of Quality in Health Care: A Conceptual Analysis. *Healthc. Anal.*, 11, 3, 259–267, 2003, doi: 10.1023/B:HCAN.0000005497.53458.ef.
19. Yamin, M.M., Ullah, M., Ullah, H., Katt, B., Weaponized AI for cyber attacks. *J. Inf. Secur. Appl.*, 57, 1–35, 2021, doi: 10.1016/j.jisa.2020.102722.
Q7 20. Rao, G.S., Cyber Security Laws: With Reference to Cloud Computing Paradigm Implementation there of in Telangana Region. 5, 2, 733–738, 2020.
Q8 21. Shaddeli, A., Soleimanian Gharehchopogh, F., Masdari, M., Solouk, V., An Improved African Vulture Optimization Algorithm for Feature Selection Problems and Its Application of Sentiment Analysis on Movie Reviews. 6, 4, 2022, doi: 10.3390/bdcc6040104.
22. Gai, K., Qiu, M., Zhao, H., Xiong, J., Privacy-Aware Adaptive Data Encryption Strategy of Big Data in Cloud Computing. *Proc. - 3rd IEEE Int. Conf. Cyber Secur. Cloud Comput. CSCloud 2016 2nd IEEE Int. Conf. Scalable Smart Cloud, SSC 2016*, pp. 273–278, 2016, doi: 10.1109/CSCloud.2016.52.
Q9 23. Helali, L. and Omri, M.N., A survey of data center consolidation in cloud computing systems. *Comput. Sci. Rev.*, 39, January 2021, doi: 10.1016/j.cosrev.2021.100366.
24. Manekar, A.K. and Pradeepini, G., Cloud Based Big Data Analytics a Review. *Proc. - 2015 Int. Conf. Comput. Intell. Commun. Netw., CICN 2015*, vol. 1, no. 1, pp. 785–788, 2016, doi: 10.1109/CICN.2015.160.

25. Zhao, W., Melliar-Smith, P.M., Moser, L.E., Fault tolerance middleware for cloud computing. *Proc. - 2010 IEEE 3rd Int. Conf. Cloud Comput. CLOUD 2010*, no. July, pp. 67–74, 2010, doi: 10.1109/CLOUD.2010.26.
26. Mourad, M.H., Nassehi, A., Schaefer, D., Newman, S.T., Assessment of Interoperability in Cloud Manufacturing. *Robot. Comput.-Integr. Manuf.*, 61, 101832, 2020.
27. Petcu, D., Multi-cloud: Expectations and current approaches. *MultiCloud 2013 - Proc. Int. Work. Multi-Cloud Appl. Fed. Clouds*, pp. 1–6, 2013, doi: 10.1145/2462326.2462328.
28. Moghaddam, M., Silva, J.R., Nof, S.Y., Manufacturing-as-a-Service - From e-work and service-oriented architecture to the cloud manufacturing paradigm. *IFAC-PapersOnLine*, 28, 3, 828–833, 2015, doi: 10.1016/j.ifacol.2015.06.186.
29. Nguyen, D.C., Pathirana, P.N., Ding, M., Seneviratne, A., Integration of Blockchain and Cloud of Things: Architecture, Applications and Challenges. *IEEE Commun. Surv. Tutor.*, 22, 4, 2521–2549, 2020, doi: 10.1109/COMST.2020.3020092.
30. Wei, L., *et al.*, Artificial intelligence (AI) and machine learning (ML) in precision oncology: a review on enhancing discoverability through multiomics integration. *Br. J. Radiol.*, 96, 1150, 1–13, 2023, doi: 10.1259/bjr.20230211.
31. Baltatescu, I., Cloud Computing Services: Benefits, Risks and Intellectual Property Issues*. *RESER Conf.*, 2, 1, 230–242, 2012, [Online]. Available: http://search.proquest.com/openview/2f6b2cba38c1019cb33e4a85253e1044/1?pq-origsite=gscholar.
32. Salierno, G., Leonardi, L., Cabri, G., The future of factories: Different trends. *Appl. Sci.*, 11, 21, 1–18, 2021, doi: 10.3390/app11219980.
33. Ravikumar, N., Metcalfe, N.H., Ravikumar, J., Prasad, R., Smartphone Applications for Providing Ubiquitous Healthcare Over Cloud with the Advent of Embeddable Implants. *Wirel. Pers. Commun.*, 86, 3, 1439–1446, 2016, doi: 10.1007/s11277-015-2999-5.
34. H.J.C. and H.M.W., A cloud computing based 12-lead ECG telemedicine service. *BMC Med. Inform. Decis. Mak.*, 12, 77, 2012, [Online]. Available: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emed11&NEWS=N&AN=22838382.
35. Wang, S., Zhang, C., Liu, C., Li, D., Tang, H., Cloud-assisted interaction and negotiation of industrial robots for the smart factory. *Comput. Electr. Eng.*, 63, 66–78, 2017, doi: 10.1016/j.compeleceng.2017.05.025.

Answer all Queries (Q) in the margin of the text. When requested, provide missing intext reference citation as well as intext reference for figure/table. Please annotate the PDF and read the whole chapter again carefully. Careful proofing is key to optimal output.

Author Queries

Q1 Short running title was provided. Kindly check if OK. If not, please provide a short running title with a maximum of 45 characters (including spaces) per Scrivener guideline.

Q2 Please check if there's any missing data under "Key Considerations:". Else kindly advise how to proceed with this.

Q3 Please check if section 13.3.5 title was captured correctly.

Q4 Please check if there's any missing data under "Operational Efficiency:". Else kindly advise how to proceed with this.

Q5 This reference is missing information such as volume number: 6. For consistency and completeness, please provide this information if possible. If it cannot be provided, we will retain the reference details as they are.

Q6 This reference is missing information such as authors complete name and page number: 10. For consistency and completeness, please provide this information if possible. If it cannot be provided, we will retain the reference details as they are.

Q7 This reference is missing information such as journal title: 20. For consistency and completeness, please provide this information if possible. If it cannot be provided, we will retain the reference details as they are.

Q8 This reference is missing information such as journal and page number: 21. For consistency and completeness, please provide this information if possible. If it cannot be provided, we will retain the reference details as they are.

Q9 This reference is missing information such as page number: 23. For consistency and completeness, please provide this information if possible. If it cannot be provided, we will retain the reference details as they are.