



Digital transformation and artificial intelligence strategies for Herbal industry in Nigeria: Applications, Opportunities and Challenges

BY

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Abstract:

With the current application of artificial intelligence (AI) technology in herbal Industry in Nigeria has improve the work efficiency of herbal practitioners and patients as well. AI in herbal industry empowers intelligent devices and improves labour efficiency through application of software systems. This paper gives the details digital development of the herbal industry in Nigeria compare to countries like USA, India, China, and other Asian countries. It analyzes the current status and shortcomings of digital development in Nigeria's herbal industry and leads to the proposing digital development strategies for Nigeria's herbal industry. The development of the domestic internet has drastically promoted the reform and progress of the herbal, though the policy development of digital applications needs to catch up through National Agency for Food and Drug Administration and Control (NAFDAC). The digital transformation of the herbal industry faces a lot of challenges such as the need for digital technology support for new medicinal plant research and development, herbal efficacy, medical data security challenges, and the need for service platform construction for herbal practice enterprises. This paper provides feasible suggestions for the better application of AI technology in Nigeria's herbal industry by reviewing the research status, development trends, and development problems of AI technology in this area.

Keywords: Digitization; Artificial intelligence; Herbal industry; Development strategy; Management; Medicinal plant; Medical field

1. Introduction

With the advancement in technology and digitalization, process in herbal industries are undergoing a digital transformation (Ogirima et al 2021, Shoukat, *et al.*, 2022 and Niaz A, Shoukat, *et al.*, 2021 and Shoukat, *et al.*, 2023). The implementation of medical digital technologies can provide better accessibility and flexibility of healthcare for the public. It encompasses the availability of open information on the health, treatment, complications, and recent progress on biomedical research (Senbekov et al; 2020). Due to the utilization of digital technologies along with other peripherals devices, it is eminent to digitize all pertinent data within the value chain. This includes the entire spectrum, starting from the raw medicinal plant farm to the herbal bio-product maker, such as those in the herbal farms that preprocess the herbs extract or herbal industries, and later to the consumers (patients) (Ogirima, et al; 2014, Ogirima et al., 2019 and

Ogirima, et al; 2021). The herbal industry focuses on the research of intelligent production systems and processes as well as the realization of networked, distributed production facilities and the production logistics management, human-computer interaction, and the digital technology in the herbal industrial production process of the entire herbal industry enterprise(Ogirima, et al; 2019).

The application of artificial intelligence (AI) enterprises entered the herbal industry just started for a quite short time ago in Nigeria and provides employment to the people of Nigeria for provision for cure of health issues from the populace. This also generates revenue that can be obtained from the supply side, the market size of Nigeria through NAFDAC. With the improvement of technological advancement capabilities, the herbal industry has in increased drastically in the business enterprise in Nigeria. In terms of the application distribution of AI in various aspects of the herbal industry, intelligent herbs warehousing and intelligent

herbs involve a relatively large-scale application of transportation. The landing environment for intelligent healthcare delivery has yet to mature, and the current scale is relatively small, but there is excellent room for imagination in the future. The intelligent customer service application scenario is relatively simple, with a minor proportion in each link. The process of realizing this conceptualization research “Collaborative and tediagnosing application” as showed in Figure 3 though Figure 5.

Figure 1 shows the four main steps toward realizing the ideal of collaborative tediagnosis and prescription in herbal medicine (CTPHM), including automation of herb discovery and design processes using machine learning, full automation of pre-laboratory research, AI-powered laboratory trials and other ethnomedical research, and complete digitization of manufacturing and supply chain. However, the key would be developing general-purpose AI capabilities to learn and automate tasks across the entire herb development life cycle with minimal human intervention. Achieving this level of autonomy is still a long-term goal, but the above steps lay the groundwork to reduce human involvement progressively. As a new driving force for the transformation and upgrading of the herbal industry, AI is nurtured in a very favorable development environment, although it has entered the field for a relatively short time Ogirima, et al; 2023.

The digitalization of the herbal industry is centered on the collection, storage, and analysis of medicinal plant data, using the application of digital technology as a means to achieve digital management and deep application of digital technology in business processes in fields such as medical diagnosis, Herb (drug) evaluation, and regional herbal development. Therefore, how to organically integrate the herbal industry with digital technology is an urgent problem to be solved. This paper aims to achieve the following objectives:

- a. To review the digitalization development of the herbal industry in China, India, United States, some European Union (EU), and Japan, and to analyze the current situation of digitalization development in Nigeria’s herbal industry.
- b. To propose a development strategy for digitalization in Nigeria’s herbal industry.
- c. To discuss AI applications and challenges in the herbal industry of Nigeria.

2. Related works

Many leading countries are into the exploration and development of digital technology in healthcare industry extensively that utilized information technology (IT) which helps significantly in contributions to the construction of digital healthcare by integrating healthcare and information communication with highly developed science and technology.

United State is one of the leading countries in the exploration and development of digital technology since 1980s, American medical institutions has extensively applied IT and automation technology to pharmaceutical industry, starting

the beginning of digital pharmacy construction (Miller, *et al.*, 1993). In 2011 and 2017, the US Food and Drug Administration (FDA) and FDA Center for Medical Devices and Radiation Health issued a draft on regulating mobile medical applications and released the digital health innovation action plan respectively Barton, 2012 and Cortez, 2019. In 2020, the FDA later announced the launching of the Digital Health Center of Excellence, which aims at promoting the strategic development of digital health technology and promoting digital medical innovation (Han and Lee, 2021). Though, the digitalization transformation in the US is mainly on modern medicine.

Presently there is rapid integration of digital hospital construction, the information industry, and medical institutions. In the construction of digital pharmacies, the system interfaces with pharmacy information to identify individual patient medication records and uses wireless radiofrequency devices to transmit patient medication data to the computer system. This help helps in provision of accurate medication information and allocation records to medical practitioners in facilitating the analysis the medication data and reduction of error rates.

Japan has begun investing seriously in the construction of digital medicine (Coates, *et al.*, 2003). In 2008, Japan proposed the development of electronic private bookcases to facilitate patient referrals and medical research known as “internet technology policy roadmap”. During the COVID-19 epidemic in 2020, a “new way of daily life” based on the prevention and control of the disease was created to reduce the infections and death rate (Nawaz, *et al.*, 2021). This enhances Japan to promote the “three-line digitization” process of healthcare services and management. This make Japan to focuses in the digital construction for the pharmaceutical industry in the areas of digitizing household health equipment and utilizing technologies; creating a cloud-based personal database where patients or individuals access their medical information; creating hospital communication software to improve diagnosis and treatment efficiency; establishing and improving electronic health records and remote medical projects, on a real-time implementation in tracking and feedback and developing digital drugs to modify patients’ medication compliance and reduce drug expenses.

India Digital Medicine aims to harness the transformative potential of digital innovations to improve healthcare access, quality, and affordability for all citizens of India. By embracing these technologies, India can build a more resilient and efficient healthcare system that meets the needs of its diverse population. In the late 1990s, members of the European Commission have embarked on researching digital healthcare (Chadwick and May, 2003). In 2004, the European Union initiated the “digital healthcare action plan” and made a huge investment in the research and development of this aspect in 2011. In 2020, the “digital medical pilot program” was launched, reflecting the EU’s emphasis on the development of digital medicine.

Currently the EU is continuously innovating in the following four areas:

- (i) Strengthening medical information standards and norms: In terms of technical standards, integrating the Healthcare Enterprise has integrated many institutional standards, such as Digital Imaging and Communications in Medicine standards, International Organization for Standardization standards, and Health Information Exchange (HL7) standards.
- (ii) Strengthening the technical level: An electronic prescribing system was created to achieve instant, accurate, and safe collection of all patient information.
- (iii) Developing remote medical services and fully utilizing medical resources.
- (iv) Establishing a personal health database and using appropriate organizational methods and governance structures to achieve medical data-driven and innovative goals.

In China, telemedicine services have been implemented in tertiary hospitals in China with a promising prospect, but the sustainability and further standardization of telemedicine in China are still far from accomplished. Although previous studies have analyzed the utilization of telemedicine in a certain region, the overall development of telemedicine in China has not yet been studied, especially in terms of network construction, security measures, and hardware and software facilities. This study investigated the implementation and application of telemedicine from a national perspective, which will provide people with a comprehensive, multilevel, and multifaceted understanding of telemedicine development in China. The factors influencing the effectiveness of telemedicine in multiple dimensions, including human resources, funding, management and service modes, networks, and charging, which will supply a reference for telemedicine planning (Cui, et al., 2020).

2.1. Policies related to the promotion of digital healthcare services in Nigeria

Nigeria has currently introduced important policies to support the development of digital medicine (telemedicine), which includes electronic medical records, online diagnosis and treatment, and mobile healthcare services to the citizen of the country to promote digital healthcare vigorously (Ogirima and Adigun, 2023). These policies, digital healthcare, and digital medicine will increase in new development opportunities. The legislation in herbal medicine and health technology in Nigeria is being gradually strengthened through NAFDAC. It is important to enact law that will safeguard the populace in the efficacy, medication, and dosage of herbal drugs.

2.2. Diversified development of mobile healthcare

Mobile healthcare, such as medical apps and e-commerce platforms, has rapidly developed (Pantelimon, et al; 2020 and Ogirima and Adigun, 2023). In addition to traditional online physician consultation services, it has also brought convenience to the interaction between patients and physicians. For example, through e-commerce platforms,

patients can obtain advice on medical supplies and purchase healthcare products. Despite the advantages and convenience, Ogirima, *et al*; 2023 identified apparent or hidden hazards connected with these new technologies, predicting the potential emergence of legal conflict in the future and emphasizing the need to establish regulatory frameworks to facilitate the development of CTPHM Industry.

2.3. Ongoing improvement of electronic medical records

The formulation and promotion of standardized standards for electronic medical records have provided policy support for the application of electronic medical records. More and more medical institutions have begun adopting electronic medical records to improve the efficiency and accuracy of medical services and to enable instant access to medical records.

3. Approach to digital development

This study was organized within a multidisciplinary framework. This incorporated the field survey and medical application of technology for tediagnosis and prescription in herbal medicine. Therefore, methontology framework was used because it allows ontology to be developed from scratch, and suggests the reuse of the concepts from the existing meta-ontologies. In this methodology, the ontology development was done in phases.

3.1. Framework construction

The overall perspective architectural framework of the entire herbal industry is crucial to the digital development of the herbal industry. It integrates multiple technologies in the digital platforms to be developed, which need to be optimized holistically as shown in Figure 1 (Ogirima et al; 2017). The process of manufacturing plant extracts (transforming freshly harvested medicinal plants into extract) (Ogirima *et al.*, 2014) is as shown in Figure 2. However, one of the characteristics of oriental herbal medicine preparations either presenting as single herbs or as collection of herbs in composite formulae, is that they are extracted with boiling water during the decoction process. This may be the main reason why quality control of oriental herbal drugs is more difficult than that of western drug, as pointed in "General Guidelines for Methodologies on Research and Evaluation of Traditional Medicines" (World Health Organization, 1976) and.

In general, one or two markers or pharmacologically active components in herbs or herbal mixtures are currently employed for evaluating the quality and authenticity of herbal medicines, in the identification of the single herb or herbal medicine preparations, and in assessing the quantitative herbal composition of an herbal product. Most of these multiple constituents may work 'synergistically' and could hardly be separated into individually active parts. Moreover, the chemical constituents in component of herbs in the herbal medicine products may vary depending on harvest seasons, plant origins, drying processes and other factors. Thus, it seems to be necessary to determine most of the phytochemical constituents of herbal products in order to ensure the reliability and repeatability of pharmacological and clinical activities, to understand their bioactivities and possible side

effects of active compounds and to enhance product quality control (Ali *et al.*, 2005, Schoop *et al.*, 2006; and Shrivastava *et al.*, 2007).

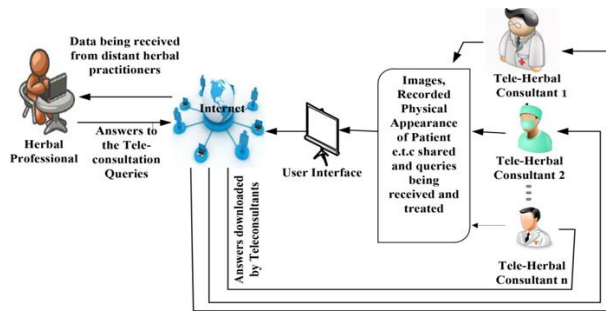


Figure 1: collaborative herbal teleconsultation architecture (Ogirima et al; 2017).

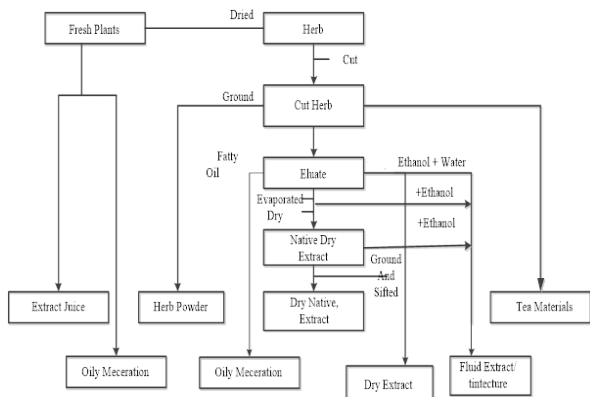


Figure 2: Transforming process of medicinal plant (Ogirima, et al., 2014).

The developed application CTPHM was created to store the information about herbs, diseases, medications, prescriptions, images, and recorded video during telediagnosis among the herbal teleconsultants. Figure 3 through Figure 6 shows how the application can be access by herbal teleconsultants as a gateway means of usage through an online means. This enhance the effectiveness of herbal medication, rather it is based at improving decision-making of herbal telediagnosis and prescription among herbal practitioners.



Figure 3: CTPHM Home page

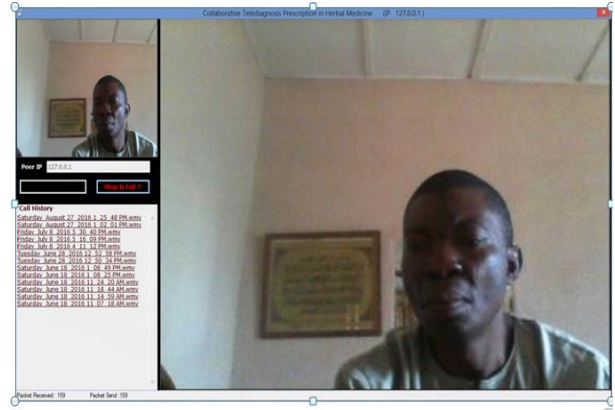


Figure 4: Collaborative telediagnosis and Medication



Figure 5: Herbs information

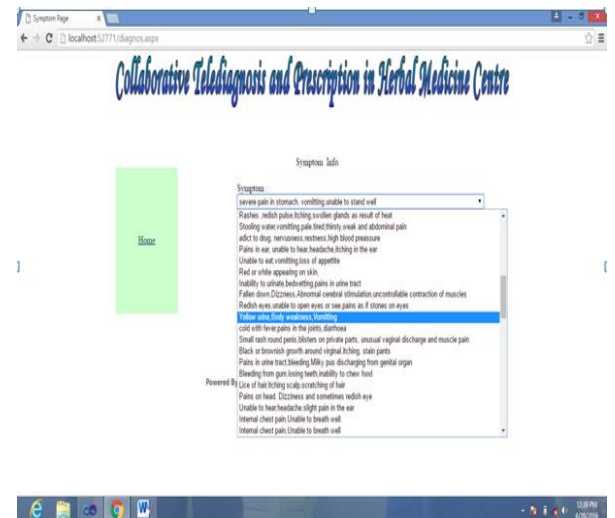


Figure 6: Client's symptoms for medication

It is shown in Figure 2 that empowering scientific research can lower the cost of drug development and improve success rates. The current digital technology has been maturely applied to the digitization of clinical management, but there is still room for improvement in the application of CTPHM. Digital transformation of herbal medicine enterprises has become a hot topic in recent years, but in digital reconstruction, accurate positioning should be made according to its characteristics and the environment before appropriate digital transformation is executed. Therefore, how to

accurately position the digital transformation of enterprises is a fundamental aspect required attention. Digital diagnostic and medication healthcare services are of two major aspects in which involved the patient experience in medical digital technology is therefore anticipated. The deployment of this digital technology will helps in relieving the workload of the herbal practitioners and improves the general consultation experience for the patients as compared to the traditional online consultations.

3.2. Digital education and cultivating

Digital education is somehow beneficial for developing digitalization in the herbal industry as it is to pharmaceutical industry that will be good for herbal practitioners, accelerating the evolution of IT to data technological applications in the industry. The implementation of digital education requires organizations such as communities, social institutions, and universities carrying out an integrated “online and offline” education approach. This opened a green channel for herbal healthcare services and integrating digitalization into daily life in terms of medical insurance. Therefore, the new idea with digital education will defiantly fill the gap in the digital development of the herbal medicine industry. Build a digitalized plant that is highly digitalized and networked, realize big data integration, and promote the implementation of manufacturing execution systems and enterprise resource planning systems (as shown in Figure 3).

3.3. Digital Design and coordinate level

Digitalization of the herbal industry is not limited to digital medicine, digital medical insurance, and digital healthcare services but different digital directions and the needed design for pool centralized control to efficiently that will promote the development of digitalization in the herbal industry. This will allow remote digital medical healthcare services in patient information sharing among the herbal practitioners, based on the support of It infrastructure network technology, so that herbal practitioners on the server side can provide convenient medical services for patients based on the uploaded data as in Figure 3. As time goes on, there will be an improvement of collaborative telediagnosis, the IT network technology can be applied among populace in the six geographical region of Nigeria, which will form a wider biosensor area and enable more patient data to be uploaded.

At this level herbal industry supervision under the tele-herbal consultants, the construction of administering the herbs as multi-regional intelligent supervision. This will help to promote the establishment of Nigeria’s herbal traceability system. Building the CTPHM will introduce an innovative and integrated solution, opening up data network among the herbal centres, allocating resources, capacity, improving utilization, and realizing intelligent production in the CTPHM centre as show Figure 3.

In future, the technologies like 5G, 6G, blockchain, and AI can be combined to strengthen the construction of top-level digital design in the herbal industry. More so, the internet system can be used to create a multi-level regulatory platform for the country, industry, and society that can uniformly

monitor, schedule, and manage all patients’ data, thereby building a more comprehensive regulatory system for better regulatory decision-making among herbal practitioners.

4. AI applications in the Herbal industry

In Nigeria, herbal medical data resources are somehow scattered, and due to the particularity of the data and its low openness, it becomes challenging to fuse and analyze a large amount of data. Therefore, AI technology needs more data (Big data) support in herbal medical research.

4.1. Self-improvement ability

As a structure of intelligence deliberate only based on application programs. Therefore, AI is based on a large amount of data (big data), and the quality of the data will directly affect the judgment of AI results. If the herbal practitioners cannot correctly judge whether patients have suffered from sexual-related diseases, the distortion of big data will lead to errors in the spontaneous judgment of herbs. Therefore, in herb development, it is vital to first screen the quality of the data to avoid database errors that would affect the entire herb. There is a steady trend in the adoption of cloud platforms and cloud computing data management methods in AI herbs. Currently, the storage and analysis of data are outside the monitoring scope of herbal centres. Therefore, ensure that there is data security and avoidance of illegal use of data that are vital issues which the AI enterprises need to focus on in future herbal product design.

4.2. Modern herbal industry

The most significant difference between the “AI + herbal medicine” logistics and the traditional logistics industry chains is that the upstream and downstream relationships are unclear or that the “AI + logistics” industry chain is not yet mature. AI companies, logistics enterprises, and e-commerce platforms are essential in the industry chain. AI companies provide downstream customers with “AI + Industries” related products and technical services through direct customer models and integrator channels. Logistics enterprises and e-commerce platforms also study the application of AI technology in various aspects of logistics by establishing CTPHM teams and technology subsidiary stakeholders, and there is a relationship of cooperation and potential competition among them.

4.3. Technology, cost, and benefits

AI has great application potential in the areas of transportation and distribution field of herbal logistics, but due to insufficient technological stability and mismatched costs and benefits, unmanned herbal delivery with the modern technology is still in its infancy. Although most important the domestic R&D platforms use the order sorting system for immediate healthcare delivery, AI software and hardware suppliers are yet to make a profit from this modern technology.

4.4. Herbal Centres and herbs

Utilization of 5G technology will definitely enhance video resolution during telediagnosis, increase research efforts on

intelligent recognition, and minimize the impact of objective conditions on AI as much as possible. Therefore, big data platform can be adopted to increase data openness, and AI can be trained to conduct comprehensive analysis and application of data in an effective and reasonable manner in herbal industry. AI can be trained in different scenarios to enhance its autonomy, enhance medical cognition through core technologies, optimize AI algorithms, and reduce the time that it takes to continuously explore potential associations with diseases. A good cloud database is crucial, as scattered data are challenging to work with.

4.5. Herbal enterprises

For herbal logistics enterprises, the main criterion for deciding whether to introduce AI into its existing production and operation systems is the degree to which integrating AI technology with its own business can improve cost-effectiveness. Herbal logistics enterprises can establish CTPHM teams and strengthen cooperation with AI technology exporters to achieve breakthroughs in cutting-edge applications, such as intelligent medical robots

5. Challenges facing herbal industry in Nigeria

The digital revolution in healthcare is facing many challenges and questions. "It encompasses the need for building tools and services supporting the digital environment and for restructuring the current traditional medical systems and classic approaches." At this point not only for developing countries like Nigeria but includes the Western world as well. Another question is what are the actual benefits derived from digital health technologies for herbal healthcare workers and patients as well? In Nigeria, most people do not believe in herbal medicine because efficacy and acceptability as a result in lack an evidence base. Furthermore, some herbal digital health products available on the market are not able to clearly demonstrate clinically efficacy, benefits for medical professionals and will digital health technologies optimize and enhance the effectiveness, speed, quality, acceptability, and affordability of healthcare? The challenges facing herbal industry in Nigeria includes:

- **Lack of digital technology:** The late start of digital construction in Nigeria's Herbal industry has stalled the progress in implementing digital transformation in the herbal industry because the technology is still in an infant stage. The scientific research, efficacy and acceptance level of herbal usage is very low talk-less of using the modern technology for its application. However, herbal industries like Yemkem, OgiHerbs, and Oko Ologun enterprises primary medical information system is still in the popularization and construction stages. These enterprises are constrained by data communication barriers in production and CTPHM usage need mature digital means to support its application. Therefore, to achieve digital transformation, knowledge need to be learn from advanced nation like USA, China, and India development path, late integrate herbal medicine enterprises and

institutions with the information industry, narrow the digital transformation gap, and accelerate CTPHM at all levels.

- **Security issues regarding patient's information:** From the perspective of the digital development of the Nigerian herbal industry, patient's information breach has always been a potential risk in digital transformation. Creating and using patient's details are the essence of the transformation, but privacy and security issues regarding herbal information are always a challenge. In this regard of digital transformation, the protection of patient details contributed by herbal medicine enterprises and stakeholders has always been a crucial aspect. Therefore, it is significance for Nigeria to improve and refine the measures to ensure patients information privacy, but difficult to ensure total data security when practitioners or patients in the herbal medicine industry uses modern technologies.
- **Lack of service platform construction:** The trend in the development of the CTPHM or herbal industry is digitization, convenience, and efficiency. Like in India and Japan focuses on building remote and precise medical services, achieving this goal requires efficient operation of service platforms and the rapid development of related industries. Therefore, Nigeria needs herbal medicine enterprise service platforms, and certain areas are set to be improved in terms of the integration and development of related industries. It is challenging to realize remote and precise medical services if instant access to patient electronic medical record data is not made possible and the information given to herbal practitioners and patients is asymmetric. Herbal industry business in Nigeria needs to expedite the process of transformation, construct a primary interactive platform, and incorporate complex development principles to secure significant progress in the future.
- **Cultural resistance, religious beliefs, and values:** Herbal industries share data and change traditional ways of working is a common management challenge to adopting digital transformation. Medical practitioners need to consider patients' cultures, religion, and other related values on attitude toward digitization in healthcare Services. For example, religious leaders preach against the usage of technology for the diagnosis and treatment of patients for fear of hacking their private information.
- **Management:** The main challenges include lack of trust in data security and privacy by stakeholders, organizational inertia, loss of governance, and uncertain provider's compliance. Concerns arise when sensitive data and mission-critical applications move to digital transformation paradigm where providers cannot guarantee the effectiveness of security and privacy controls.

6. Limitations of the Study

This study was designed for digital transformation and artificial intelligence strategies for Herbal industry in Nigeria with its applications, opportunities and the drawback in an online herbal healthcare delivery in Nigeria. The digital transformation of herbal medicine is limited to herbal practitioners in the Southwestern Nigeria.

7. Conclusions

The Cost-effectiveness in digital and AI solutions facilitate the achievement of flexibility, optimal resource utilization, and enhanced shareholder values and profitability. Extensive application of AI technology in healthcare services like in tediagnosis, herbal industry personnel, and AI developers believe that AI technology can encourage innovation and transformation in the herbal industry. Although most herbal practitioners and patients see this AI technology in healthcare services as disruptive technology that may take a lengthy development and application process before its acceptability. The perspectives in this paper show that there is positive impact social change through the enhancement of AI within the herbal industry. With this technology there will be reduction in medical, that will offers the community affordable healthcare delivery. From the study's results obtained show the positive impact derived by herbal practitioners. Therefore, these findings will definitely provide valuable insights into sustainable modern digitalization herbal industry strategies that herbal practitioners can utilize.

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