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Assessing the Actuarial Implications of Gene Therapy and Personalized Medicine in Nigeria: A Case Study of Cancer Treatment

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ABSTRACT

This study investigates the actuarial implications of gene therapy and personalized medicine in cancer treatment in Anambra State, Nigeria. The research design was a descriptive survey, with 60 patients diagnosed with cancer from 20 general hospitals in Anambra State selected using purposive sampling. The questionnaire, titled "Questionnaire on Actuarial Implications of Gene Therapy and Personalized Medicine for Cancer Treatment" (QAIGPMCT), was structured and validated. The Cronbach Alpha Method was used to determine internal consistency and descriptive statistics of mean were used to answer the research questions posed. The findings revealed that patients in Anambra State, Nigeria, agreed on the cost-effectiveness of implementing personalized medicine and gene therapy for cancer treatment. They also noted that these treatments positively impacted financial outcomes for both patients and healthcare providers. Insurance policies and actuarial risk assessments were also influenced by these treatments. The study suggests that actuaries should assess financial risks associated with personalized medicine and gene therapy, considering factors like treatment effectiveness uncertainty, cost fluctuations, and reimbursement policy changes.

Keywords: Actuaries, Gene Therapy, Personalized Medicine, Cancer

INTRODUCTION

Globally, cancer is now one of the main causes of disease and mortality. Globally, 20 million new cancer diagnoses and 9.7 million deaths are predicted for 2022 (World Health Organization, 2024). 53.5 million People were expected to live five years after receiving a cancer diagnosis. Approximately one in five people will get cancer at some point in their lives; one in nine men and one in twelve women will die from the disease (WHO, 2024). In 2050, there will likely be more than 35 million new cases of cancer, a 77% increase from the projected 20 million cases in 2022 (WHO, 2024). The steadily increasing universal occurrence of cancer is the consequence of modifications to contaminants exposure, many of which are connected to advancement in society, population growth, and aging.

Approximately 70% of deaths in low- and middle-income countries (LMICs) are caused by cancer, making it the second leading cause of death worldwide (You & Henneberg, 2018). On the other hand, 78,899 deaths and an expected 124,000 new cases were recorded in Nigeria in 2020. With over 250 million people, Nigeria is the most populous country in Africa. Of its 2024 budget, just 4.47% went toward healthcare (Abubakar, George-Opuda, Augustine, Adline, & Elekima, 2024). These data indicate that cancer is a prevalent and challenging illness in Nigeria, posing serious issues for both the populace and the healthcare system. The word "cancer" describes a broad spectrum of diseases characterized by the body's aberrant cells growing and spreading out of control. These aberrant cells can spread to other areas of the body, grow into tumors, and infiltrate nearby tissues. The World Health Organization (2024) defines cancer as a class of disorders characterized by aberrant cellular development that has the potential to spread to other parts of the body. Not all malignancies, spread through lymph or bloodstream to other parts of the human system.

Commonly diagnosed malignancies include breast cancer, cervical cancer, prostate cancer, colorectal cancer, and liver cancer. The several cancer types in the country illustrate the varied nature of the disease burden by providing unique challenges for diagnosis, treatment, and management. Table 1 shows the five most common

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malignancies in Nigeria. According to the numbers presented in Table 1, breast and cervical cancers account for approximately 50.3% of all cancer cases in Nigeria. When compared to other nations, Nigeria's cancer mortality incidence rate poses a unique issue. In Nigeria, for instance, 51% of breast cancer patients result in mortality, which is quadruple the US average (19% of cases) (Federal Ministry of Health in Nigeria, 2023).

Table 1: Top five cancers of greatest burden in Nigeria

Male	**Female**	**Both sexes**
Prostate	Breast	Breast
Liver	Cervix uteri	Cervix uteri
Non-Hodgkin Lymphoma	Liver	Liver
Colorectal	Colorectal	Prostate
Pancreas	Non-Hodgkin Lymphoma	Colorectal

Globacan 2022 Data

Regrettably, a significant portion of Nigerians exhibit the illness's clinical signs without realizing that the illness is gradually taking their lives. It is impossible to overestimate the incidence and seriousness of cancer in Nigeria. The fatality rate, numbers are overwhelming and rapidly increasing (Njaka, 2016). The author continued by stating that there has been a concerning trend in the increasing incidence of cancer and its detrimental effects on public health, and that lots of households in Nigeria have suffered the agony of losing loved ones to the disease at an early age.

Nigerian cancers have several causes, including a complicated interplay of lifestyle, environmental, and genetic factors. The main risk factors for the development of cancer in Nigeria include genetic predisposition, exposure to carcinogens like nicotine, drinking, a sedentary lifestyle, being overweight, lack of regular physical activity, infections like hepatitis B and C viruses and human papillomavirus (HPV), and the exposure to atmospheric chemicals (Siegel, Giaguinto, & Jemal, 2023). In Nigeria, cancer has far-reaching effects on individuals, families, communities, and the nation's healthcare system. Due to the high costs associated with diagnosis, treatment, and after-treatment care, cancer has a significant financial impact on patients and their families (Choi, Lee, & Han, 2019). Moreover, it is impossible to overstate the emotional and psychological toll that cancer takes on patients and their loved ones.

It is important to emphasize how personalized medicine and gene therapy have revolutionized cancer treatment and given rise to new expectations for targeted and more potent medications. It is imperative to understand the actuarial implications of these novel medicines in Nigeria, where cancer continues to be a significant public health issue. The insertion, deletion, or alteration of genetic material into a person's cells to treat and prevent disease is known as gene therapy. Gene therapy offers great promise for treating cancer by enabling more specialized and effective methods. Gene therapy offers new ways to address the complexity of cancer and is a revolutionary frontier.

Because gene therapy targets cancer cells precisely, it can target malignant cells with therapeutic effects while protecting tissue that is healthy and minimizing collateral damage. This is why gene therapy is valuable and significant in the treatment and overall control of cancer (Rousseau, Beurdeley, Revaud, Voisin & Chiavaroli, 2023). Conventional medicines generally fail to cure tumours; however, gene therapy, such as CAR-T cell therapy, can reorganize the body's defenses to specifically target cancer cells, hence evading resistance mechanisms (Stemer & Stemer, 2021). Luxturna is one of the gene therapy procedures that corrects defective cancer genes with particular genetic abnormalities, such as retinal illnesses connected to the RPE65 gene (Food and Drug Administration, 2017).The ability of gene therapy to lessen the toxicity and adverse effects of traditional chemotherapy treatments is a significant advantage (Emran, Shahriar, Mahmud, 2022). With the potential to improve patient outcomes, the development of gene therapy represents a paradigm change in the treatment of cancer. Gene therapy is changing the face of cancer care by directly targeting the genetic causes of

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the illness, enhancing the immune system's response, and creating individualized treatment regimens (Stemer & Stemer, 2021).

Precision medicine, often known as personalized medicine, tailors medical care to each patient's requirements. This strategy considers elements such as genetics, environment, and lifestyle to deliver more personalized and effective therapies. Genomic testing for mutations and biomarkers is a typical use of personalized medicine in cancer treatment. These data can help guide the selection of specific medications. According to Collins and Varmus (2015), personalized medicine has the potential to significantly improve treatment outcomes by concentrating on the unique biological pathways associated with a specific patient's condition. Using a person's genetic, proteomic, and environmental data, personalized medicine is a cutting-edge field of medicine that prevents, detects, tracks, and treats diseases (McGonigle, 2016). According to McGonigle (2016), it can offer tailored medical solutions that maximize positive health outcomes while reducing harmful side effects. The foundation of this approach to sickness prevention and/or treatment is an appreciation of each person's distinctive qualities (Collins & Varmus, 2015). The idea of personalized medicine is supported by science as it allows for the broad analysis and application of genetic data at the individual level in both clinical practice and the creation of healthcare policies for the public.

The introduction of gene therapy and personalized medicine, particularly in cancer treatment, requires the incorporation of actuarial principles due to the significant changes these treatments bring to the landscape of healthcare. According to Adeniji, Dulal, and Martin (2021), actuaries in the healthcare sector use data analysis to predict future trends, assess risks, and estimate the costs of health interventions. They evaluate the probability and financial impact of health events, guiding insurance companies in setting premiums. They also assess the cost-effectiveness of new treatments and technologies, guiding decisions on coverage and reimbursement. They also ensure the financial sustainability of health insurance schemes by projecting future claims and expenses.

The long-term benefits of better health outcomes and cost savings may outweigh the initial, unreasonably high costs associated with incorporating these technologies. Actuaries will be essential in providing legislators, medical professionals, underwriters, and insurance companies with data-driven insights to assist them in making informed decisions on the introduction of tailored medicine and gene therapy into the healthcare system. Adeniji, et al. (2021), Ogamba, Roberts, Ajudua, Akinwale, Jeje, Ibe, Afolayan, and Kuyinu (2023) conducted research investigations that demonstrated the potential of gene therapy and personalized medicine to substantially decrease cancer deaths and illnesses through more efficient and focused medical care. Research by Abubakar, George-Abubakar et al. (2024) has demonstrated that cancer patients' standard of existence and survival rates can be enhanced by targeted therapy. For example, the use of CAR-T cell therapy, a subset of gene therapy, has demonstrated impressive efficacy in treating specific forms of lymphoma and leukemia, with certain individuals reaching permanent remission. Thus, the necessity for this investigation was guided by the background data.

Statement of the Problem

The current scenario in Nigeria poses various hurdles to the acceptance and implementation of gene therapy and customized medicine for cancer treatment. Limited infrastructure, a shortage of trained medical practitioners, budgetary restrictions, and insufficient data on the actuarial consequences of these technologies all impede their wider use. As a result, access to cutting-edge therapies is limited, and the potential benefits of gene therapy and personalized medicine are underutilized in Nigeria's healthcare system. This backdrop confirms Ogamba et al.'s (2023) findings that many medical institutions in Nigeria, particularly in Anambra State, lack the essential equipment and technology to undertake sophisticated genetic therapy and personalized treatment.

There is a substantial paucity of studies and awareness of the actuarial implications of gene therapy and customized medicine in cancer treatment in Anambra State. Patients covered by the Anambra State Health Insurance Agency may not have access to these cutting-edge treatment choices, resulting in possible discrepancies in care quality and results. This study examines the present environment, including the availability, cost, and effectiveness of gene therapy and customized medicine, to estimate the actuarial

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implications of these treatments in cancer treatment in Anambra State, Nigeria. Specifically, the study assessed:

1. The possible cost-effectiveness of using personalized medicine and gene therapy in the Anambra State healthcare system for cancer treatment.
2. The financial effects of gene therapy and customized medicine in cancer treatment on patients and healthcare providers.
3. How Anambra State's cancer patients' insurance policies and actuarial risk assessments are affected by gene therapy and customized treatment.
4. Whether incorporating gene therapy and customized medicine into cancer treatment within Anambra State's present healthcare system is feasible and sustainable.

Research Questions

1. What is the potential cost-effectiveness of implementing personalized medicine and gene therapy in the Anambra State healthcare system for cancer treatment?
2. How do personalized medicine and gene therapy impact the financial outcomes for both cancer patients and healthcare providers in Anambra State?
3. How are the insurance policies and actuarial risk assessments for cancer patients in Anambra State influenced by the inclusion of gene therapy and personalized medicine in treatment?
4. Is it feasible and sustainable to integrate gene therapy and personalized medicine into cancer treatment within the current healthcare system of Anambra State?

MATERIALS AND METHODS

This study adopted the descriptive survey research design. The population of this study comprised all patients diagnosed with cancer in the 20 general hospitals in Anambra State, Nigeria. The purposive sampling technique was used to select 60 patients diagnosed with cancer and who are enrolled with the Anambra State Health Insurance Agency (ASHIA). Patients who are registered with ASHIA were selected because of the vast knowledge they possess of insurance coverage on health-related issues and actuarial implications. The instrument for this study was a structured and validated questionnaire. The questionnaire is titled "Questionnaire on Actuarial Implications of Gene Therapy and Personalized Medicine for Cancer Treatment" (QAIGPMCT). The questionnaire is divided into four clusters for the purpose of the study.

The questionnaire was trial-tested to determine the internal consistency. Cronbach Alpha Method was used and co-efficient values of 0.77, 0.73, 0.88 and 0.78 were obtained respectively for clusters I – IV. The paper included patients diagnosed with cancer in Anambra State and registered under the Anambra State Health Insurance Agency (ASHIA), those who have undergone gene therapy or personalized medicine, and those of all ages and genders. Exclusive criteria include those who have not undergone such treatments, those unwilling or unable to provide informed consent, patients with existing medical conditions, those residing outside Anambra State, and those currently undergoing other experimental cancer treatments. Descriptive statistics such as mean and standard deviation were used to analyze data to answer the research questions. The criterion mean of 2.50 served as the benchmark for making decisions. Any mean score below 2.50 criterion mean score was rated disagreed while any mean score above 2.50 criterion mean score was rated agreed.

RESULTS AND DISCUSSION

Table 2: Respondents' ratings on the potential cost-effectiveness of implementing personalized medicine and gene therapy in the Anambra State healthcare system for cancer treatment

S/N	Items	X	SD	Remarks
1	Implementing personalized medicine and gene therapy for cancer treatment in Anambra State healthcare system would lead to cost savings	2.55	0.58	Agree

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2	Personalized medicine and gene therapy are more cost-effective than traditional cancer treatments	2.87	0.82	Agree
3	The initial cost of gene therapy is worth the long-term savings	3.11	0.52	Agree
4	Investing in personalized medicine and gene therapy for cancer treatment would reduce long-term healthcare costs in Anambra State	2.69	0.69	Agree
5	Health insurance coverage for personalized medicine and gene therapy promotes better cancer care outcomes in Anambra State	2.53	0.88	Agree
6	Gene therapy and personalized medicine offer a cost-effective alternative to conventional cancer treatments.	2.59	0.49	Agree
7	The financial resources required for personalized medicine are justified by the expected outcomes.	3.20	0.93	Agree
	Cluster Mean	**2.79**		**Agree**

Data in Table 2 revealed that all items (1 – 7) with their respective mean scores of 2.55, 2.87, 3.11, 2.69, 2.53, 2.59, and 3.20 were all rated agreed. The cluster mean of 2.79 summarized that patients diagnosed with cancer agreed on the potential cost-effectiveness of implementing personalized medicine and gene therapy in the Anambra State healthcare system for cancer treatment.

Table 3: Respondents' ratings on personalized medicine and gene therapy impacting the financial outcomes for both cancer patients and healthcare providers in Anambra State

S/N	Items	X	SD	Remarks
8	Implementing personalized medicine and gene therapy leads to cost savings for patients diagnosed with cancer in Anambra State	2.77	0.82	Agree
9	Personalized medicine and gene therapy will result in better financial management for cancer patients in Anambra State	2.61	0.52	Agree
10	Healthcare providers can achieve better financial sustainability by adopting personalized medicine and gene therapy for cancer treatment	2.59	0.62	Agree
11	Investing in personalized medicine and gene therapy can enhance the financial viability of healthcare providers in Anambra State	3.12	0.64	Agree
12	Increased access to personalized medicine and gene therapy can positively impact the financial burdens of cancer care in Anambra State	3.29	0.62	Agree
	Cluster Mean	**2.86**		**Agree**

Data in Table 3 reveals that all the items (8 – 12) with their respective mean scores of 2.77, 2.61, 2.59, 3.12, and 3.29 were rated agreed. The cluster mean of 2.86 summarized that patients diagnosed with cancer agreed that personalized medicine and gene therapy positively impacted the financial outcomes for both cancer patients and healthcare providers in Anambra State.

Table 4: Respondents' ratings on insurance policies and actuarial risk assessments for cancer patients in Anambra State influenced by the inclusion of gene therapy and personalized medicine in treatment

S/N	**Items**	**X**	**SD**	**Remarks**
13	Including gene therapy in my treatment will make my insurance more affordable	2.63	0.54	Agree
14	Personalized medicine will lower my insurance premiums	2.52	0.61	Agree

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15	I am willing to pay higher premiums if gene therapy is included in my insurance coverage	2.04	0.62	Disagree
16	Personalized medicine will reduce my out-of-pocket expenses for cancer treatment	2.68	0.71	Agree
17	Gene therapy is a cost-effective option for my cancer treatment according to my insurance policy	2.82	0.68	Agree
18	Personalized medicine will lead to fewer unexpected medical expenses for me	2.98	0.69	Agree
	Cluster Mean	**2.69**		**Agree**

Data in Table 4 reveal that item 15 with a mean score of 2.04 were rated disagreed. This means that patients are not willing to pay higher premiums if gene therapy is included in their insurance coverage. More so, items 13, 14, 16, 17 and 18 with their respective mean scores of 2.63, 2.52, 2.68, 2.82, and 2.98 were rated agreed. The cluster mean of 2.69 summarized that patients agreed on insurance policies and actuarial risk assessments for cancer patients in Anambra State influenced by the inclusion of gene therapy and personalized medicine in treatment.

Table 5: Respondents' ratings on sustainability to integrate gene therapy and personalized medicine into cancer treatment within the current healthcare system of Anambra State

S/N	Items	X	SD	Remarks
19	I believe that integrating gene therapy and personalized medicine into cancer treatment in Anambra State will enhance patient care	2.58	1.01	Agree
20	Personalized cancer treatment, tailored to individual genetic profiles, is a step towards more effective and precise healthcare in Anambra State	2.59	1.04	Agree
21	I feel confident that the healthcare system in Anambra State is equipped to adopt and utilize gene therapy and personalized medicine for cancer treatment	2.07	1.03	Disagree
22	The healthcare system can sustainably fund gene therapy for cancer treatment	1.86	1.06	Disagree
23	The current healthcare policies support the sustainable inclusion of personalized medicine	2.56	0.99	Agree
24	The financial resources of the healthcare system can sustain gene therapy treatments.	2.12	1.02	Disagree
	Cluster Mean	**2.29**		**Disagree**

Data in Table 5 reveal that 21, 22, and 24 with their respective scores of 2.07, 1.86, and 2.12 were rated as disagreed while items 19, 20, and 23 with their respective scores of 2.07, 1.86, and 2.12 were rated as agreed. The cluster mean of 2.29 summarized that patients disagreed on the sustainability of integrating gene therapy and personalized medicine into cancer treatment within the current healthcare system of Anambra State.

DISCUSSION OF FINDINGS

The finding in research question one revealed that patients diagnosed with cancer agreed on the potential cost-effectiveness of implementing personalized medicine and gene therapy in the Anambra State healthcare system for cancer treatment. This indicates that patients diagnosed with cancer in Anambra State have recognized and accepted that using personalized medicine and gene therapy might be a cost-effective method of cancer treatment within the state's healthcare system. Adeniji et al. (2021) concluded that customized medicine, which entails modifying treatment approaches based on individual patient characteristics, resulted in improved results for cancer patients. Personalized medicine can lead to more effective and efficient treatment choices by

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targeting particular genetic abnormalities or biomarkers unique to a patient's cancer, minimizing the chance of ineffective therapies and needless side effects. Abubakar et al. (2024) found that investing in customized medicine and gene therapy can be cost-effective in the long run. While these therapies may initially be more expensive, the potential advantages in terms of better patient outcomes, shorter hospital stays, and fewer problems might result in overall cost savings for the healthcare system.

The finding in research question two revealed that patients agreed that personalized medicine and gene therapy positively impacted the financial outcomes for both cancer patients and healthcare providers in Anambra State. This result was consistent with Nutu and Isacescu's (2022) conclusion that gene therapy and tailored medicine offered certain cancer patients long-lasting or even curative treatment alternatives. Gene therapy has improved treatment responses and may lessen the need for ongoing cancer management by focusing on and altering the genes that drive the growth and progression of cancer. This could save money for patients and healthcare providers by reducing the need for supportive care, follow-up treatments, and hospital stays.

The finding in research question three revealed that patients agreed on insurance policies and actuarial risk assessments for cancer patients in Anambra State influenced by the inclusion of gene therapy and personalized medicine in treatment. This implies that the way insurance companies create their plans and evaluate the risks associated with treating cancer patients is affected by the integration of cutting-edge treatment alternatives like gene therapy and customized medicine. This study supported the findings of Owolabi, Adam, and Adebiyi (2023) that gene therapy and personalized medicine are effective treatments that improve cancer patients' health outcomes at a reasonable cost. As a result, insurance companies may decide to modify their risk estimations to account for the potential advantages of paying for these cutting-edge treatments. As a consequence, Anambra State cancer patients in need of gene therapy and customized medication now have better insurance coverage.

The finding in research question four revealed that patients disagreed on the sustainability of integrating gene therapy and personalized medicine into cancer treatment within the current healthcare system of Anambra State. This indicates that patients are unsure about the long-term sustainability and practicability of implementing these cutting-edge therapeutic options. This result corroborated the findings of Khamkat, Barik, Barik, Mohapatra, and Kar (2022), who found that patients had concerns over the accessibility of resources, including cutting-edge medical technology, qualified medical personnel, and the infrastructure required to enable gene therapy and customized medicine. The effective integration of these cutting-edge medicines into the healthcare system may be hampered by a lack of resources.

CONCLUSION

Long-term patient outcomes and cost savings by incorporating cutting-edge therapies like gene therapy and customized medicine are possible. However, the long-term viability of incorporating these cutting-edge methods into the existing healthcare system presents issues with limited resources, budgetary concerns, legal barriers, equality, and education. To overcome these obstacles and move toward a more equitable and sustainable healthcare system that promotes the integration of gene therapy and personalized medicine in the treatment of cancer, Anambra State stakeholders must work closely together going forward.

RECOMMENDATIONS

The recommendations focus on integrating personalized medicine and gene therapy into cancer treatment in Anambra State. Actuaries should conduct cost-benefit analyses to assess the financial implications of these advanced treatments, considering factors like treatment costs and long-term savings. They should also evaluate financial risks associated with these therapies, developing strategies to manage uncertainty and improve financial outcomes. Collaboration with insurance companies is advised to create tailored insurance packages that address the specific needs of cancer patients undergoing these new treatments. Additionally, healthcare providers are encouraged to engage with patients, incorporating their preferences into decision-making to foster trust and align treatment plans with individual goals.

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