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Harnessing New Technologies in Prevention, Diagnosis and Treatment of Cancer Patients in India

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ABSTRACT

Cancer care in India is highly concentrated in urban areas, with limited access to quality care in rural areas. The health and wellbeing of those who have cancer have been severely compromised by the huge gaps in cancer care resulting from the lack of access to early detection and treatment for cancer, the absence of facilities with qualified cancer specialists in rural regions, and the high expense of cancer treatment. India needs to harness emerging technologies to transform the cancer care landscape. The goal of India's cancer screening program is to include screening for breast, cervical, and oral cancers. This can be accomplished through extending the scope of cancer screening programs, constructing additional cancer treatment facilities, and offering financial aid to people who cannot afford medical treatment. Cancer screening aids in early detection and reduces mortality and morbidity. Once diagnosed, the doctor will discuss the treatment options with the patient. A form of cancer treatment called curative care tries to eradicate the disease from the body. The availability and cost of cancer therapy in India are both undergoing a paradigm change as a result of technology. Remote cancer screening and prevention services are accessible through telehealth. In order to increase access to cancer care in India, new hybrid cancer care delivery models have evolved over time. A network of smaller community-based clinics connected to a larger cancer center is offered via the hub-and-spoke approach. This model facilitates in increasing care coordination and cut down on patients' travel expenses and time. India may make major strides in the fight against cancer by following these suggestions.

Keywords: *Cancer screening, National Cancer Registry, Artificial Intelligence, Curative Care, Immunisation, Hub and spoke model*

INTRODUCTION

Cancer is a leading cause of death worldwide, accounting for nearly 10 million deaths in 2020, or nearly one in six deaths. The most common cancers are breast, lung, colon, rectum, and prostate cancers. Globally about one-third of deaths from cancer are due to tobacco use, high body mass index, alcohol consumption, low fruit and vegetable intake, and lack of physical activity.[1] The story is no different with India, having about 8.8 lakh new cases and 6.6 lakh deaths in 2020. Early diagnosis, prevention and treatment are key to improving cancer outcomes, and new technologies are playing an increasingly important role in this area.

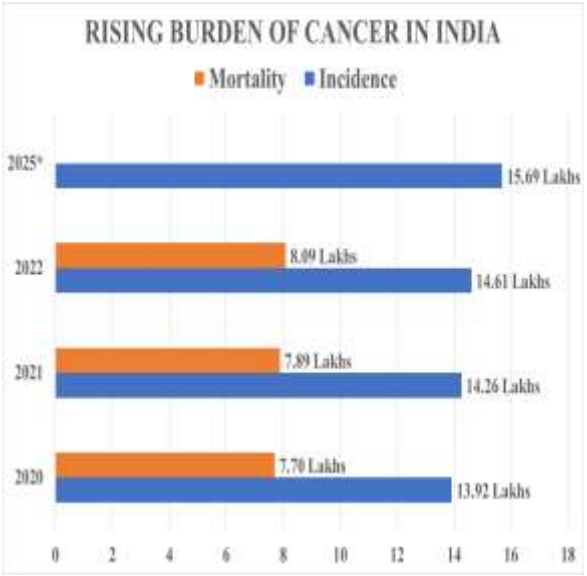
This article reviews some of the new technologies that are being used to improve early diagnosis, prevention, and treatment of cancer in India. The article begins by discussing the Cancer incidence and the critical gaps in Cancer Care in India, and then discusses the potential interventions required to address the critical gaps in Cancer Care and the associated challenges to address such gaps. The article further emphasizes on various prevention and early detection modalities, curative care, and

technology adoption in making quality cancer care accessible at affordable rates. The article then provides a detailed overview of some of the latest and promising new technologies, including liquid biopsies, artificial intelligence (AI), genome editing, telehealth, and robotics. Then the article finally discusses various hybrid business models which have evolved over the past few years and how they are working towards improving the availability and accessibility of cancer care to a larger stratum of the population. The article concludes by discussing the implications of these new technologies for cancer care in India and the way forward in improvising care to the Cancer patients.

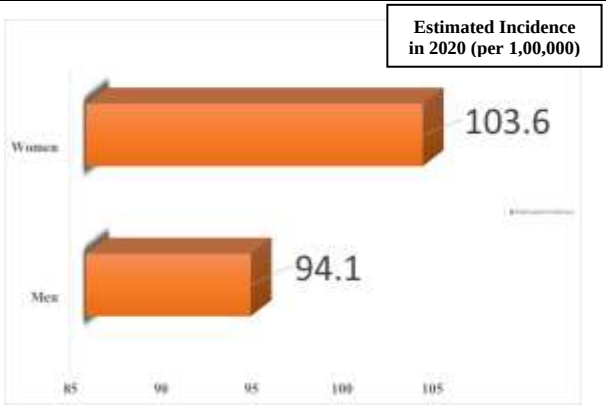
CANCER INCIDENCE IN INDIA

India, which has a population of over 1.42 billion people but is low on the global health security index, places healthcare as a top national priority. Despite the enormous efforts made by the Indian government and the private sector under the National Health Mission, the nation still faces significant obstacles, such as a dearth of healthcare professionals, inadequate healthcare infrastructure, low public spending on healthcare, and a significant disparity in access to healthcare between urban and rural areas. In parallel, the prevalence of cancer in India is predominantly rising annually due to factors like dietary and lifestyle changes, as well as population ageing.

According to the National Cancer Registry Programme 2020 of the Indian Council of Medical Research (ICMR), the incidence of cancer cases in India by different states and Union territories in 2020 was 13,92,179 and it increased to 14,26,447 in 2021 and 14,61,427 in 2022.[2] It is projected that the number would further increase to 15.69 lakhs by 2025. Lung and breast cancers were the leading sites of cancer in males and females respectively



Source: National Cancer Registry data extracted from the ICMR National Centre for Disease Informatics and Research study; *Estimated incidence



COMMON SITES

	Lung, mouth, prostate, tongue, and stomach (36% of all cancers)
	Breast, cervix, ovary, uterus, and lung (53% of all cancers)

To address these complex challenges that the healthcare ecosystem is facing today, we must harness emerging technologies to transform India's cancer care landscape. India needs a more comprehensive model which deals from prevention through treatment to palliative care, and to meet this end, we need to optimize our resources to do more with less efforts and costs.

In terms of cancer, a revolution is taking place. Thanks to breakthroughs in screening, targeted therapy and immunotherapy, big

data, computational approach, and major new knowledge of cancer biology, the ways in which we detect, diagnose, treat, prevent, and survive cancer are evolving. The pursuit of individualised cancer treatment is made possible by these developments. Despite these advances, more effort is required to create better tools and methods to lessen the threat of cancer to public health.

CRITICAL GAPS IN CANCER CARE

Cancer care in India is highly concentrated in urban areas, with limited access to quality care in rural and remote areas. Various factors like lack of access to cancer screening for early detection of cancer, lack of trained cancer specialists and facilities in rural areas and the high cost of cancer treatment have created huge gaps in cancer care have significantly impacted the health and well-being of people with cancer in India. These factors are also responsible for the late diagnosis, poor treatment outcomes, and even death amongst the rural population. Overall if we evaluate the healthcare domain with specific reference to Cancer Care, we can broadly classify the following seven parameters as the gaps in providing Cancer care.

Inaccurate Patient Data in the National Cancer Registry

The National Cancer Registry Programmed (NCRP) in India is a network of cancer registries that collect data on cancer patients across the country. The data collected by the NCRP is used to track the incidence and mortality of cancer in India, and to identify trends in cancer care. However, there are several factors for the shortfalls in the patient data collected by the NCRP which include incompleteness, inaccuracy, and lack of uniformity of the data it collects. Such shortfalls in patient data can limit the usefulness of the data collected by the NCRP. In addition to the above-mentioned shortfalls, the NCRP also faces several other challenges, such as lack of resources, lack of political support and lack of coordination with other cancer control programs. This can make it difficult to share data and resources and to implement effective cancer control programs. For example, reported incidence of cancer during the year 2022 is around 15 lakhs but the real time incidence could be about three times higher than the reported cases.

Late Diagnosis

Late diagnosis of cancer is yet another critical gap in cancer care and it can lead to worse outcomes for patients, including lower survival rates and increased risk of death. There are a few of factors that contribute to late diagnosis of cancer, like lack of patient awareness of the early signs and symptoms of cancer and thereby delay in seeking medical attention, lack of access to healthcare, long wait times for appointments, and financial barriers can all contribute to late diagnosis of cancer.

Late diagnosis of cancer is a serious problem, and needs to be addressed by raising awareness of the early signs and symptoms of cancer, and by improving access to screening and diagnostic tests, we can help to ensure that more people are diagnosed with cancer early and have the best chance of survival. By taking these steps, we can help to close the gap in cancer care and ensure that more people are diagnosed with cancer early and have the best chance of survival.

Inadequate Knowledge and Skills

India faces critical gaps in cancer care, including a shortage of qualified pathologists, inadequate training in cancer pathology, inadequate physician training, and limited access to clinical trials. These gaps can result in delays in cancer diagnosis and treatment, suboptimal treatment decisions, and a lack of support for patients and their families. To address these gaps, India can provide more scholarships, training opportunities, modern equipment access, training in cancer care, funding for clinical trials, increased support for physicians, and more counselling services. By addressing these gaps, India can improve

the quality of cancer care and ensure that all patients have access to the care they need.

Financing the Care

India faces high out-of-pocket expenditure on healthcare, causing catastrophic financial hardship for millions of patients and their families. Distress financing, including borrowings, selling assets, and contributions from relatives and friends, is abnormal across both public and private health facilities. Distress finance is used by more than 40% of households to pay for cancer treatment at public hospitals. India is behind the rest of the globe in terms of insurance coverage for diagnostic tests, medications, and other OPD treatments. Covering OPD costs under publicly funded health insurance programs could increase patient access, uptake in the private sector, and make it more feasible for private facilities to offer these services.

Socio-economic disparities

Socioeconomic disparities are critical gaps in cancer care in India, affecting cancer incidence, mortality, and access to care. People from lower socioeconomic status groups are more likely to be exposed to risk factors, have less access to preventive care, and lack health literacy skills. This leads to higher cancer mortality rates and poorer outcomes. To address these disparities, India can raise awareness about cancer risk factors and prevention measures through public education campaigns and outreach programs. Expanding the reach of cancer screening programs and making them more affordable can provide more access to cancer screening services. Government subsidies or health insurance coverage can make cancer treatment more affordable, while improving the quality of cancer care can be achieved through training more providers and providing more resources for cancer care facilities. By addressing these disparities, India can improve the quality of life and outcomes for people with cancer.

Public funding in Health Infrastructure

Public funding in health infrastructure is a critical gap in cancer care in India, causing a lack of facilities, equipment, and trained personnel. This hinders access to treatment, particularly in rural areas, and can lead to delays in diagnosis and treatment. Additionally, the high cost of cancer care can be a major barrier for those without health insurance or who cannot afford it. To address this gap, the Indian government should increase spending on health, partner with the private sector, expand insurance coverage, and support community-based programs that provide cancer screening, education, and support. By addressing this gap, India can improve access to cancer care and ensure that all patients receive the care they need.

Human Resources

The shortage of human resources in cancer care in India is a critical gap, causing delays in diagnosis and treatment, suboptimal treatment decisions, and increased workload for nurses. Additionally, there is a shortage of other healthcare professionals, such as pathologists, social workers, and radiologists making it difficult to provide comprehensive care. To address this gap, the Indian government can provide more scholarships and training opportunities for oncologists, nurses, and other essential professionals. Additionally, the government can support continuing education programs and establish cancer care training centres in rural areas.

By addressing these gaps, India can make cancer care more accessible, affordable, and effective for all its citizens. Physicians, payers, patients, health care providers, and industry all have roles to play in promoting development of meaningful quality measures for use in accountable care measurement

INTERVENTIONS REQUIRED AND CHALLENGES TO ADDRESS

There are several ways to address the critical gaps in cancer care in India which

include strengthening the primary healthcare systems, expanding the cancer screening, improving access to care, providing supportive care, and raising awareness among others. It is also important to address the social and economic factors that contribute to cancer disparities in India. Poverty, lack of formal education, and social marginalization are among these issues. Addressing these factors will require a multi-pronged approach that involves government, civil society, and the private sector. Broadly, we can classify the interventions under three heads which are discussed in detail below.

Patient centric interventions

There are several patient-centric interventions that can be used to address the gaps in cancer care in India. These interventions include:

- Patient awareness and education: Increasing patient awareness about cancer risk factors, symptoms, and prevention measures can help to improve early diagnosis and treatment. Campaigns for general education, school-based initiatives, and community engagement initiatives can accomplish this.
- Providing access to services: Improving access to cancer screening, diagnostic, and treatment services can help guarantee that all patients receive the care they require. This can be done by expanding the reach of cancer screening programs, building more cancer care facilities, and providing financial assistance to patients who cannot afford care.
- Patient navigation: Patient navigation is a service that provides patients with personalized support and guidance throughout their cancer care journey. This can help patients to navigate the complex healthcare system and to access the care they need.
- Palliative care: Palliative care is a type of care that focuses on providing comfort and support to patients with cancer and their families. This can help patients to manage their symptoms, to cope with the emotional and practical challenges of cancer, and to live as well as possible.
- Survivorship care: Survivorship care is a type of care that focuses on the needs of cancer survivors. This can include providing support for physical and emotional health, helping survivors to return to work or school, and providing information about long-term cancer risks.

These are just a few of the patient-centric interventions that can be used to address the gaps in cancer care in India. By implementing these interventions, India can improve the quality of life and outcomes for people with cancer.

Provider centric interventions

There are several provider-centric interventions that can be used to address the gaps in cancer care in India. These interventions include:

- Telemedicine: Telemedicine can be used to provide cancer screening, diagnosis, and treatment services to patients in rural areas and remote locations. This can help to improve access to care and to reduce the need for patients to travel long distances for care.
- Bringing care nearer to the patient: This can be done with mobile clinics, outreach programs, and telemedicine. This can help to improve access to care and to reduce the financial burden on patients.
- Palliative care: Palliative care can be provided through telemedicine or through mobile clinics. This can help to improve access to care and to ensure that patients have access to the support they need.
- Remote management: Remote management can be used to monitor patients' progress and to provide support and guidance. This can help to improve the quality of care and to reduce the

need for patients to travel to hospitals for follow-up appointments.

- Digital health support: Digital health tools can be used to provide patients with information about cancer, to support self-management, and to connect patients with other cancer survivors. This can help to improve the quality of life for patients and to reduce the burden on healthcare providers.
- Clinical decision support (Tumor Boards): Tumor boards can be used to provide expert guidance on cancer care. This can help to improve the quality of care and to ensure that patients receive the most appropriate treatment.
- Quality of care / follow-up: Quality of care can be improved by standardized treatment guidelines, patient tracking systems, and quality improvement programs. This can help to ensure that all patients receive the same high-quality care.
- Automation of records: Records can be automated to improve efficiency and reduce the risk of errors. This can help to free up time for healthcare providers to focus on patient care.

These are just a few of the provider-centric interventions that can be used to address the gaps in cancer care in India. By implementing these interventions, India can improve the quality of life and outcomes for people with cancer.

System based/Governance related interventions.

There are a few system-based and governance-related interventions that can be used to address the gaps in cancer care in India. These interventions include:

- Enhancing knowledge and skills of healthcare workers: Healthcare personnel' knowledge and abilities can be improved with the use of training programs, workshops, and other educational activities. This can assist in ensuring that all healthcare professionals have the information and abilities required to offer top-notch cancer care.
- Private insurance: Private insurance can help to reduce the financial burden of cancer care for patients. This can make it more likely that patients will seek and receive early diagnosis and treatment.
- Public funding in health infrastructure: Public funding can be used to build and maintain cancer care facilities, to provide equipment and supplies, and to train healthcare workers. This can help to improve access to cancer care and to ensure that all patients can receive the care they need.
- Cancer registries: Cancer registries can be used to collect data on cancer incidence, mortality, and risk factors. This data can be used to improve cancer prevention and control programs.
- Cancer control plans: Cancer control plans can be used to set goals and priorities for cancer prevention and control. These plans can help to ensure that resources are allocated in a way that meets the needs of the population.
- Public awareness campaigns: Public education about cancer risk factors, symptoms, and prevention strategies can be accomplished through the employment of public awareness campaigns. This may enhance early detection and treatment.
- Collaboration between government and non-governmental organizations: Collaboration between government and non-governmental organizations can help to pool resources and expertise to address the gaps in cancer care. This can help to improve the quality and availability of cancer care in India.

Implementing cancer care interventions in India faces several challenges, including lack of funding, human resources shortages, infrastructure shortages, technology and training shortages, lack of awareness, political will, bureaucracy inefficiency, corruption, lack of data, and cultural barriers. These factors contribute to the high cost of cancer care and low priority given to

cancer prevention and control. Additionally, the Indian bureaucracy can be slow and inefficient, making it difficult to implement new policies and programs. Corruption can lead to misuse of funds and resources, impacting the quality of cancer care. Furthermore, there is a insufficient data on cancer incidence, mortality, and risk factors, making it difficult to plan and implement effective cancer prevention and control programs. Addressing these challenges is crucial for improving cancer care access and addressing the emotional challenges associated with cancer.

Despite these challenges, there are several organizations working to improve cancer care in India. These organizations are working to raise awareness, to provide funding, and to advocate for policies that will improve the quality and availability of cancer care. By working together, these organizations can make a significant difference in the lives of people with cancer in India. These are only a handful of the system-based and governance-related measures that could be employed to close the gaps in cancer care in India. India can enhance the quality of life and outcomes for cancer patients by implementing these strategies.

PREVENTION AND EARLY DETECTION

Timely detection through screening and education along with preventing the population from consumption of cancer-causing agents such as tobacco and related products, vaccination against some cancers, is the way forward. The biggest challenge today in India is that all major cancers get detected at advanced stages. This affects the clinical outcomes, cost of treatment and overall mortality and morbidity. The most effective way to change the outcomes in cancer is through combination of awareness, prevention, early detection, and comprehensive care.

Immunisation – HPV Vaccination

Immunization is a crucial tool in reducing the cancer burden, as it helps prevent infection with viruses like HPV, HBV, and EBV. HPV vaccines significantly reduce the risk of developing HPV-related cancers, while HBV vaccines reduce the risk of liver cancer. EBV vaccines are being studied for potential prevention. Immunization also reduces the risk of other diseases like pneumonia, meningitis, and measles. By increasing vaccination rates, the cancer burden can be reduced, and the number of people diagnosed with cancer can be reduced. Overall, immunization is a powerful tool that saves lives and improves global health.

The human papillomavirus (HPV) is most common root cause in cervical cancers amongst females. HPV vaccine is a safe and effective way to protect against HPV infection, which can cause various types of cancer, including anal, cervical, and penile cancer. It is recommended for all males and females aged 9 through 45, starting at age nine. The HPV vaccine does not protect against all types of HPV. There are over 100 types of HPV, and the vaccine protects against only a few of the most common types that cause cancer.

Mass population Health Screening

Cancer screening aids in early detection to slow the progression of the condition and reduce mortality and morbidity. By administering a test to persons who are asymptomatic but may have the disease or early indicators of the same, screening aids in the identification of an undiagnosed condition. Majority of nations have started and put into place cancer screening programmes for malignancies that have a high incidence, a high propensity to spread less quickly, or a high likelihood of lowering death if found early. Three major cancers viz. oral, breast, and cervical qualify as prerequisites for the implementation of a nationwide screening programme. Some industrialised nations with large GDP expenditures on healthcare prioritise

colorectal, lung, and prostate cancer screenings.

India's cancer screening programme aspires to fully cover oral, cervical, and breast cancers, however the amount of coverage that has been accomplished so far is quite low in comparison to other nations. According to the National Program for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases, and Stroke,[3] the government has focused on screening for oral, cervical, and breast cancers as part of population-based screening. This is due to the prevalence and rising number of cancer cases in India.

Some of the commonly used screening tests based on the cancer type are depicted in the below table:

Cancer Type	Recommended Screening Tests
Breast cancer	Clinical Breast Exams and Mammograms.
Cervical cancer	HPV tests and PAP tests.
Colorectal cancer	Colonoscopies and stool tests.
Lung cancer	Low-dose CT scans
Oral Cancer	Dental X-ray or CT scan
Stomach and Intestinal Cancers	Endoscopy

However, with the advent of new AI enabled technologies, new products have been designed to be patient friendly, with features like no radiation, portability, etc. Some of the new technological products include Sascan's for Oral cancer screening (Figure1) and Niramai's for Breast cancer screening (Figure 2).

Figure 1- Sascan Oral Cancer Screening (OralScan)

Figure 2 - Niramai Breast Cancer Screening (Thermogram)

Sascan[4] and Niramai[5] are two companies that have developed innovative technologies for oral and breast cancer screening.

- Sascan has developed a handheld device that uses artificial intelligence (AI) to detect oral cancer. The device uses a camera to capture images of the oral cavity, which are then analyzed by AI algorithms to identify potential signs of cancer. Sascan's device has been shown to be as accurate as traditional methods of oral cancer screening, such as visual inspection and biopsy.
- Niramai has developed a non-invasive breast cancer screening technology that uses thermal imaging. The device captures images of the breast using a thermal camera, which can detect changes in temperature that may be indicative of cancer. Niramai's technology has been effective in detecting breast cancer at an early stage.
- Both Sascan and Niramai are in the early stages of deployment and their technologies have the potential to revolutionize cancer screening. These technologies have made cancer

screening more accessible and affordable.

Here are some of the advantages of using Sascan and Niramai for oral and breast cancer screening:

- Non-invasive: Since neither technology requires the use of needles or incisions, they are both non-invasive. Patients find them more comfortable as a result, and the danger of infection is decreased.
- Early detection: Both technologies can detect cancer at an early stage, when it is most treatable. This can lead to better outcomes for patients.
- Affordability: Both technologies are relatively affordable, which makes them accessible to a wider range of patients.

However, there are also some limitations to these technologies:

- Accuracy: Both technologies are still under development, and their accuracy has not yet been fully established.
- Availability: Both technologies are not yet widely available, but they are expected to become more available in the future.
- Acceptance: Both technologies are new, and it is not yet clear how patients and healthcare providers will accept them.

Overall, Sascan and Niramai are promising new technologies for oral and breast cancer screening. They have the potential to make cancer screening more accessible, affordable, and effective. However, more research is needed to confirm their accuracy and to assess their long-term impact.

Awareness and Education

The delivery of cancer care is increasingly reliant on digital involvement. Large groups of people can interact and share information thanks to tools and systems based on the internet and mobile phones. Health systems and individual health professionals are adapting to this shift in patient and consumer behaviour by figuring out how to use technology's advantages to raise the standard of medical care. One illustration is the way doctors connect with one another and the general public on social media to discuss research, medicine, and cancer treatment. Additionally, consumer electronics and sensors (wearables) have created a new, developing digital engagement dimension and an additional layer of patient-generated health data to promote better patient outcomes.

Wellness practices

Good wellness practices by the patients aid prevention of the disease. Prevention refers to taking steps to reduce your risk of developing cancer in the first place. This can include things like:

- Eating a nutritious diet: A diet rich in fruits, vegetables, and whole grains may help protect against several cancers.
- Retaining a healthy weight: Being overweight increases the chance of developing malignancies such as breast, colon, and endometrial.
- Engaging in regular physical activity: Regular exercise can help reduce your risk of developing malignancies like colon, breast, and lung.
- Reducing your risk of developing oral and lung cancers by avoiding tobacco use, which is the world's biggest cause of cancer death.
- Reducing your alcohol intake: Drinking excessive amounts of alcohol increases your risk of developing malignancies like breast, liver, and colorectal.

Recent advancements in Oncology combined with breakthrough technology have remarkably improved patient outcomes. Yet a significant number of cancer patients come late to hospitals either because of poor understanding of symptoms or late screening. The need of the hour remains regular mass screening camps and awareness sessions across strata. Once we all join our hands together at every level to provide integrated cancer care, we can change the outcomes in next 3 to 5 years.

CURATIVE CARE

Curative care is a type of cancer treatment that aims to completely remove the cancer from the body. This is often possible for cancers that are diagnosed early and are

localized, meaning that they have not spread to other parts of the body.

Diagnosis

The diagnosis of cancer is a complex process that involves a variety of tests and procedures. A physical examination is typically the initial step, and the doctor will search for any indications of cancer, including a lump or growth. If the doctor suspects cancer, they may order further tests, such as:

- Blood tests: Blood tests can be used to identify cancerous cells or other cancer-related signs.
- Imaging testing: To check for tumors inside the body, imaging tests including X-rays, CT scans, and MRI scans can be utilized.
- Biopsy: A biopsy is a technique that involves removing a small sample of tissue from the body and examining it under a microscope for cancer cells.

Once a diagnosis of cancer has been made, the doctor will discuss the treatment options with the patient. The type of treatment that is recommended will depend on the type of cancer, the stage of the cancer, and the patient's overall health.

Treatment

Once the patient is diagnosed with Cancer, there would be a variety of treatments, including any one or a combination of:

- Surgery: The tumor and surrounding tissue are removed during surgery.
- Chemotherapy: Chemotherapy kills cancer cells by using cytotoxic chemicals.
- Radiation therapy: Radiation therapy uses high-energy beams to attack cancer cells.
- Targeted therapy: The use of medications that target specific chemicals on cancer cells is known as targeted treatment.
- Immunotherapy: Immunotherapy is the use of one's own immune system to combat cancer.

In essence the goal of curative care is to completely remove the cancer from the body and prevent it from coming back. However, not all cancers are curable. In some cases, the cancer may be too advanced or the patient may not be able to tolerate treatment. In these cases, the goal of treatment may be to control the cancer and improve the patient's quality of life.

USING TECHNOLOGIES IN MAKING QUALITY CANCER CARE MORE ACCESSIBLE AND AFFORDABLE

New technologies have the potential to address some of the challenges of cancer diagnosis and prevention in India. Technology is playing a major role in increasing access to and affordability of high-quality cancer treatment. Here are a few such examples:

- Telehealth allows patients to receive cancer care from doctors and other providers remotely, using video conferencing or other online tools. Telehealth can be used to provide cancer screening and prevention services to people in remote areas or who have difficulty accessing healthcare. This can help to increase access to cancer care and improve early detection rates.
- Liquid biopsies can be used to screen for cancer in people who are at high risk, even if they do not have any symptoms. This can aid in the early detection of cancer, when it is more curable.
- Artificial intelligence (AI) is being used to develop new cancer treatments and to improve the accuracy of cancer diagnosis and in prevention. AI can be used to analyze medical images, such as mammograms and CT scans, to detect cancer more accurately than human radiologists. AI can also be used to develop new diagnostic tools and algorithms that can help to identify cancer at an earlier stage. AI can also be used to personalize cancer treatment, making it more effective and less toxic for individual patients.

- Genome editing technologies, such as CRISPR-Cas9, have the potential to radically transform the cancer treatment and prevention. Genome editing can be used to target and destroy cancer cells, or to introduce tumor-suppressing genes into cells. This could lead to new and more effective treatments for cancer, and it could also help to prevent cancer from developing in the first place.
- Robotics is another emerging technology that has the potential to improve cancer care. Robots can be used to perform minimally invasive surgeries, or to deliver targeted cancer therapies. This could lead to less pain and complications for patients, and it could also improve the effectiveness of cancer treatment.
- 3D printing is being used to create custom medical devices, such as surgical implants and prosthetics. This can help to improve the quality of cancer treatment and to make it more affordable.
- Big data is being used to analyze large datasets of cancer patient information. This can help to identify new patterns and trends in cancer, which can lead to improved prevention, diagnosis, and treatment.

These are just a few examples of how technology is being used to improve cancer care. As technology continues to evolve, we can expect to see even more innovative ways to increase access to and affordability of high-quality cancer treatment.

Here are some additional ways that technology can help to increase access to cancer treatment:

- Mobile apps can give instructional resources, support tools, and remote monitoring capabilities to patients.
- Wearable devices can measure patients' vital signs and other health data, which can be used to monitor cancer treatment effectiveness and detect early signals of recurrence.
- Virtual reality can be used to provide patients a realistic experience of cancer treatment, reducing fear and increasing compliance.
- 3D printing can be used to build patient-specific tumor models, which can aid surgeons in better planning and execution of surgery.

These are just a few instances of how technology is being used to increase the accessibility and affordability of cancer treatment. We may anticipate even more ground-breaking approaches to enhancing the quality of life for cancer patients as technology develops.

HYBRID MODELS FOR DELIVERING CANCER CARE (HUB AND SPOKE MODEL)-CHALLENGES AND OUTCOMES

Hybrid models for delivering cancer care, such as the hub-and-spoke model, are designed to improve access to cancer care by providing a network of smaller, community-based clinics that are linked to a larger, more specialized cancer center. This model can help to reduce travel time and costs for patients, and it can also improve coordination of care.

There are a few challenges associated with implementing a hub-and-spoke model for cancer care. One challenge is ensuring that the community-based clinics have the necessary expertise and resources to provide high-quality care. Another challenge is coordinating care between the community-based clinics and the cancer center. This can be especially challenging if the two entities are in different parts of the country.

Despite these challenges, there are several potential benefits to using a hub-and-spoke model for cancer care. One potential benefit is improved access to care for patients who live in rural areas or who have difficulty traveling to major cancer centres. Another potential benefit is reduced costs for patients, as they may not need to travel as far for care. Additionally, a hub-and-spoke model can help to improve coordination of care and ensure that patients receive the most appropriate treatment for their individual needs.

Here are some of the outcomes of using a hub-and-spoke model for cancer care:

- Increased access to cancer care: Patients in rural areas or those who have difficulty traveling can receive cancer care at community-based clinics that are linked to a larger cancer centre.
- Reduced costs: Patients may save money on travel and lodging costs by receiving cancer care at a community-based clinic.
- Improved coordination of care: Patients can receive care from a team of experts at the cancer center, as well as from providers at the community-based clinic.
- Improved quality of care: Patients may receive higher-quality care because they are receiving treatment from a team of experts who are familiar with their individual case.

Overall, the hub-and-spoke model for cancer care is a promising approach to improving access to and quality of care for cancer patients, however, it has many challenges. Careful planning and implementation are essential to the success of any hub-and-spoke cancer care program.

Here are some examples of hybrid business models that have evolved over the past few years for delivering cancer care in India:

- CION Cancer Clinics,[6] a Hyderabad based cancer care provider is a chain of cancer clinics that uses a hub-and-spoke model to provide cancer care in India. The company has so far created a network of hub and spokes in Telangana and Andhra Pradesh, which provides specialized cancer care services, such as Medical oncology, Surgical oncology, Radiation oncology, et al. By providing cancer care in a dispersed manner in small towns and communities, closer to the patients, and at the convenience of the family, it aims to lower the barrier to access. The CION believes that having access to care close to home will encourage patients to see a doctor at the first indication of cancer symptoms and seek assistance more quickly. CION also uniquely supports its registered patients with services like onco-nutrition, psycho-oncology, onco-pharmacy, and genetics counselling, which are part and parcel of its treatment protocols. CION also has a strong digital presence through its Teleconsultation and Digital helpline services which act as a backbone for its network of hub and spoke clinics located across the two Indian states – Andhra Pradesh and Telangana. CION strives to address the requirements of cancer screening and diagnosis and adopts the latest evolving technologies for early detection and promoting cancer prevention. CION Cancer Clinics has been able to implement evidence-based care pathways and demonstrate improved clinical outcomes while reducing the financial burden on patients.
- Karkinos Health,[7] a Mumbai based digital healthcare provider which focusses on addressing clinical needs through a digitally enabled distributed network, that will bring quality care closer to patients in the cancer care. It has built an end-to-end technology platform which coordinates cancer care continuum; medical centre for treatment of complex cancers; and research centre which leverages technologies such as genomics, synthetic biology, sensors, and AI to analyse data and leading to the development of affordable cancer interventions. The fundamental principle of Karkinos health is democratization of cancer care in a participatory fashion with existing health providers, researchers, and technologists. The company has developed a Distributed Cancer Care Network model by partnering with several healthcare providers in the private and government sector and linking such centres to its digital platform to offer its services in few districts of Kerala and West Bengal.
- ZenOnco.io,[8] is a Bengaluru based Integrative Oncology healthtech platform that provides guidance and end-to-end healthcare services to cancer

patients. It was started with a vision to improve the quality of life and increase life for cancer patients. ZenOnco assists cancer patients to get the best cancer treatment in India through our medical treatment partners and complementary therapy protocols. ZenOnco's mission is to make cancer treatment accessible to all, irrespective of their social, geographical, and economic background.

- Onco.com,[9] a Bengaluru based online platform focused on providing personalized, unbiased, expert treatment planning and care management to cancer patients through their network of oncologists in the US and India. Onco.com's mission is to create a borderless platform by leveraging their tumour board to provide expert opinions, and empower the patients with consultation, care management and services within 24 hours. With a patient-centric business model, Onco.com is bridging the gap in care and service provision for cancer patient-treatment in India and world-wide.

These are just a few examples of hybrid models for delivering cancer care in India. As the demand for cancer care continues to grow in India, we can expect to see more and more innovative models being developed.

CONCLUSION

In India, cancer is one of the main causes of mortality, but modern technologies may help with early identification and prevention. India can make great strides in the fight against cancer by investing in these technology and tactics. India ought to make investments in the study and creation of innovative cancer technologies. This will speed up the commercialization of these technologies and lower their price. India must launch programs to inform the public about the dangers of cancer and the value of early detection. Target audiences for these campaigns should include groups including women, men, and young people. India should increase its cancer screening initiatives. The earlier the cancer is detected, the easier it will be to treat. India should encourage adopting healthy lifestyle practices including maintaining a balanced diet, getting regular exercise, and quitting smoking. These modifications may lower the risk of developing cancer.

India can strengthen the infrastructure for cancer care in addition to the ideas mentioned above. This entails making investments in fresh hospitals and clinics, hiring additional medical professionals, and creating more effective cancer treatment techniques. India can make it simpler for patients to obtain the care they require by enhancing the infrastructure for cancer treatment. India can also try to increase access to cancer treatments and other medications. This include negotiating cheaper pricing for cancer medications, creating generic copies of those medications, and offering financial aid to those unable to pay for cancer treatment. India can lower the cost of providing the necessary care by expanding access to cancer treatments and medications. Cancer may be a treatable condition with early detection and prevention with better infrastructure and access to care. New technologies may aid in the development of cancer treatments with ongoing investment in research and development.

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