NAVIGATING THE FUTURE OF HEALTHCARE DELIVERY

HEALING TOUCH. TAPPED BY TECHNOLOGY.

October 2024

Foreword

The Indian healthcare delivery industry has emerged as a preferred play in India's growing healthcare sector, driven by attractive margins and huge headroom for growth. The domestic healthcare delivery industry in FY24 is ~US$ 135B and is expected to grow at a CAGR of ~18% over the next five years. This growth will be primarily driven by changing demographics, increasing urbanization and health insurance coverage, improving medical tourism, favorable government policies, and rising health awareness and accessibility.

Of the US$ 135B healthcare delivery market, private hospitals account for ~78% of the market while public hospitals account for the remaining ~22%. The healthcare delivery system is marked by significant disparities in the distribution and accessibility of facilities, particularly in rural areas, which have only ~24% of the hospital beds and ~48% of the healthcare facilities, despite accounting for ~64% of the total population. This disparity poses a challenge in terms of equitable accessibility to healthcare, but on the other hand, it provides an opportunity for expansion and newer business models to evolve.

Implementing technologies such as a) AI, b) genetic testing, c) robotic surgery, d) digital OPD, e) remote care solutions, f) smart labs, and g) 3D printing are not only enhancing patient care but also driving significant revenue generation and operational efficiencies for hospitals. These innovations are optimizing hospital operations, improving diagnostics, enabling personalized treatments, and expanding the reach of healthcare services to underserved areas without the need for extensive infrastructure investment. However, for these advancements to achieve their full potential, it is crucial to address barriers to technology adoption and resolve infrastructural gaps across the healthcare ecosystem.

The issue of healthcare financing, particularly the "missing middle" a significant population lacking adequate insurance adds to the complexity. While government schemes have expanded coverage, much of the middle-income group remains uninsured, underlining the need for innovative insurance models that can bridge this gap.

As India's healthcare ecosystem evolves, technology will play a pivotal role in addressing systemic challenges and driving inclusive growth across multiple sectors. From healthcare delivery to diagnostics, MedTech, and pharma, innovation will be key in enhancing accessibility, improving outcomes, and boosting efficiency.

At Praxis Global Alliance, we hope this report offers valuable insights into the transformative potential of technology across these domains. We look forward to continuing the conversation on how these advancements will shape the future of healthcare, diagnostics, medical technology, and pharmaceuticals in India.

Aryaman Tandon
Managing Partner
Healthcare and Lifesciences
Praxis Global Alliance

Garima Malhotra
Associate Partner
Healthcare and Lifesciences
Praxis Global Alliance

Glossary of terms

Industry related

Term / acronym	Description
ABDM	Ayushman Bharat Digital Mission
ABHA	Ayushman Bharat Health Account
AB-PMJAY	Ayushman Bharat Pradhan Mantri Jan Arogya Yojana
AI	Artificial Intelligence
ALOS	Average Length of Stay
CAR-T	Chimeric Antigen Receptor T-Cell
CGHS	Central Government Health Scheme
CHC	Community Health Center
CRO	Contract Research Organization
CTPA	CT Pulmonary Angiogram
CT scan	Computed Tomography scan
DH	District Hospital
DNA	Deoxyribonucleic Acid
ED	Emergency Department
EHR	Electronic Health Record
ESIS / ESIC	Employee's State Insurance Corporation
GDP	Gross Domestic Product
GH	Government Hospital
GoI	Government of India
GP	General Practitioner
HAQ	Healthcare Access and Quality
HbA1c	Haemoglobin A1c
HMIS	Health Management Information System
IoT	Internet of Things

Glossary of terms

Industry related

Term / acronym	Description
LPH	Large Private Hospital (>300 beds)
M&A	Mergers and Acquisitions
MI	Medical Institutions
MMU	Mobile Medical Units
MPH	Medium Private Hospital (100–300 beds)
MRI	Magnetic Resonance Imaging
NCD	Non-communicable Diseases
NGS	Next-generation Sequencing
NH	Nursing Home
OPD	Outpatient Department
PCR	Polymerase Chain Reaction
PE	Pulmonary Embolism
PHC	Primary Healthcare Center
PoC	Point of Care
PPP	Public-Private Partnership
PTSD	Post-Traumatic Stress Disorder
QC	Quality Control
RNA	Ribonucleic Acid
RFID	Radio-Frequency IDentification
SAHI	Standalone Health Insurance
STAT	Statim (latin word for immediate)
TAT	Turnaround Time
TB	Tuberculosis
TCO	Total Cost of Ownership
TKA	Total Knee Arthroplasty

Glossary of terms

Units

CAGR	Compounded Annual Growth Rate
CY	Calendar Year (From 1st January to 31st December)
FY	Fiscal Year (From 1st April to 31st March)
INR	Indian Rupee
K	Thousand
M	Million
B	Billion
US$	United States Dollar
Kg	Kilograms

Table of Contents

Table of Contents

List of exhibits

List of exhibits

1

GLOBAL HEALTHCARE TRENDS

The global healthcare landscape is rapidly transforming, driven by digital connectivity, patient-centered care, and technological advances. As healthcare becomes more interconnected, technological interventions are enabling seamless data flow and improving access. Emerging focus on preventive care aims to address health issues early, reducing long-term costs, while equity initiatives help make healthcare more inclusive and accessible.

Personalization and precision are emerging as key themes, with innovations in genetic testing, molecular diagnostics, and personalized nutrition driving more tailored treatments. Wearables and Point of Care (PoC) diagnostics offer faster, on-demand services, while AI-driven analytics leverage clinical data to improve risk modeling and patient engagement. As profit pools shift toward tech-enabled solutions and specialty drugs, providers are moving to value-based care models that prioritize outcomes and patient satisfaction, setting the stage for a more efficient, equitable healthcare future.

Exhibit 1.1

Key trends witnessed in global healthcare

1. Healthcare becoming more connected

- Electronic health records **(EHRs)**
- Digital **health exchanges**
- **Connected health eco-systems**

2. Focus on preventive care to manage increasing treatment cost

- **Mental health and wellness**
- Chronic **health management**
- Specific group wellness **such as women hygiene**

3. Efforts to advance health equity

- Equitable access to different **racial groups and genders**
- **Tech-enabled care** to patient groups in different geographies

4. Tech enablement of workforce to transform care delivery

- Tools for **clinical decision assistance**
- **Digitalized clinical workflows**

5. Efforts to make healthcare more predictive and precise

- **Genetic testing** for genetic abnormalities
- Testing for **genetic pre-disposition**
- Molecular diagnostics

6. Emergence of personalized treatments

- Microbiomes
- Personalized nutrition
- Custom interventions

7. Enabling faster care delivery – anytime, anywhere

- **Wearables** for health monitoring
- **Point of Care** diagnostic devices
- **Virtual consultations**

8. Use of large clinical data sets through advanced analytics and AI

- Long-term **patient data for risk modeling**
- Evolving **distinct care pathways**
- Sharp **patient engagement**

9. Re-alignment of profit pool across the industry

- **Re-alignment of profit pool** towards:
  - Healthcare tech
  - Non-acute site healthcare
  - Specialty drugs

10. Growing importance of value-based care

- **Cost-effective care**
- Better outcomes owing to **reduced complications**

1.1 Key factors shaping demand in healthcare

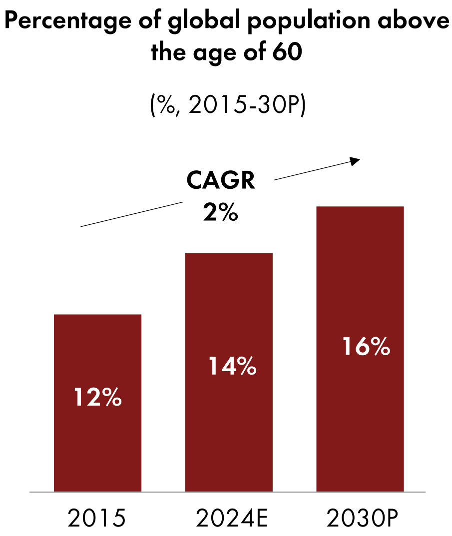
As the global healthcare landscape evolves, the factors influencing demand reflect both predictable trends and emerging challenges. Demographic shifts, particularly aging and increasing life expectancy, significantly increase the demand for healthcare services. Rising healthcare costs and expanding reach of health insurance are also reshaping access and financing. With a growing prevalence of chronic diseases and increased health awareness, healthcare systems must adapt and innovate to meet these needs.

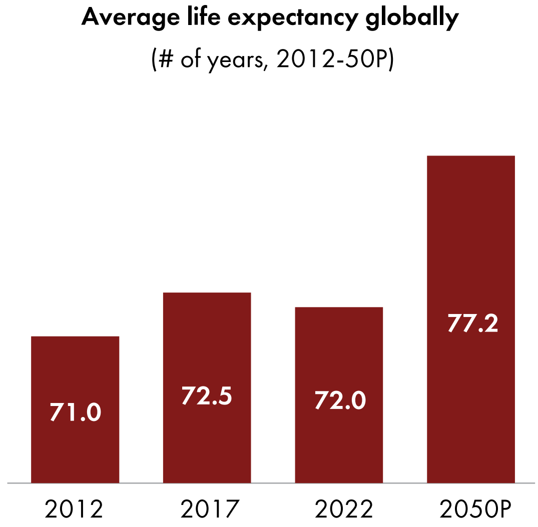
1.1.1 Aging population and increasing life expectancy

As the average age and life expectancy of the population increase, the demand for healthcare services, particularly for chronic and long-term care, intensifies. This trend leads to escalating healthcare costs and a heightened emphasis on preventive care, wellness initiatives, and proactive disease management to ensure quality of life in later years. In response, healthcare providers are strategically investing in services that promote healthier, longer lives for aging populations, with a focus on sustaining well-being over extended periods. This shift highlights the growing need for innovative care models and cost-effective solutions in managing the long-term healthcare needs of an aging demographic.

Exhibit 1.1.1

Percentage of global population over age 60 and global average life expectancy



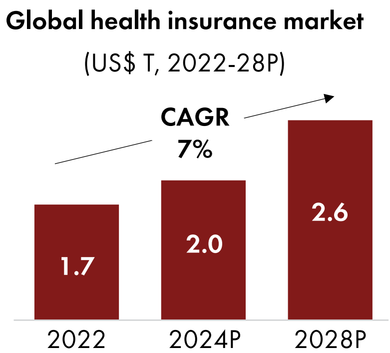


1.1.2 Growth in health insurance coverage

Expanding health insurance coverage enhances access to healthcare services, enabling early diagnosis and improved management of chronic conditions. This shift is driving a patient care model where insurance plays a critical role in facilitating access to affordable care. It emphasizes preventive services and ongoing monitoring, aiming to reduce the incidence of costly emergency interventions. This evolving landscape presents opportunities for stakeholders to innovate in care delivery models and optimize cost management strategies.

Exhibit 1.1.2

Global health insurance market



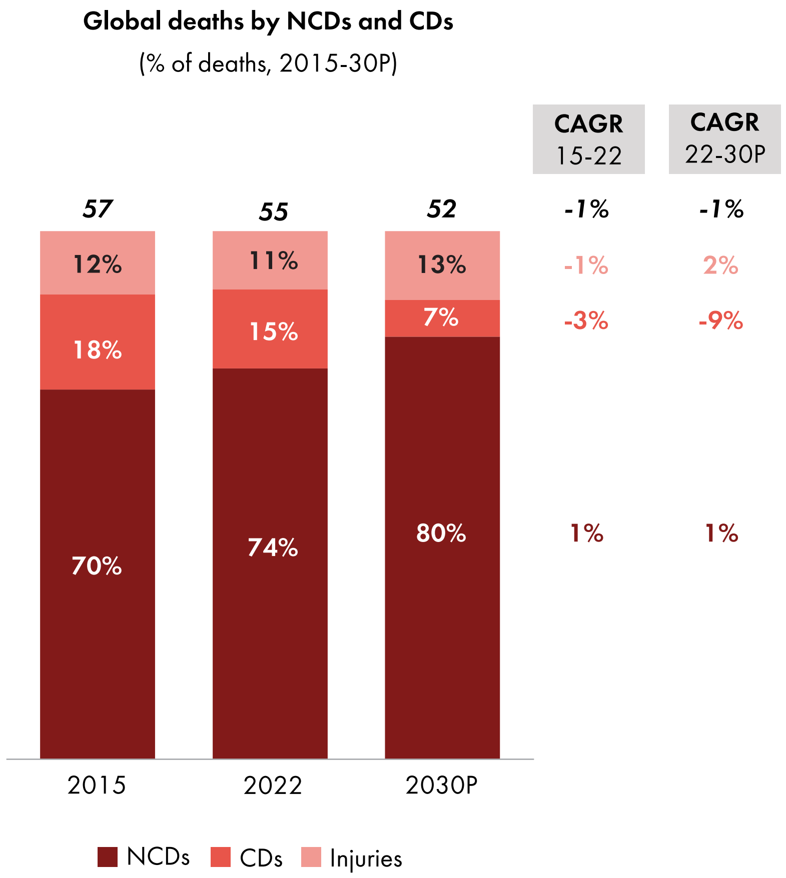
PRAXIS GLOBAL ALLIANCE

1.1.3 Shift to non-communicable diseases

There is a notable shift in global health trends from infectious diseases to NCDs such as heart disease and diabetes, which now account for the majority of global mortality. NCDs disproportionately impact lower socioeconomic populations, highlighting significant disparities in health outcomes. In response, there has been a marked rise in disease management programs and preventive health initiatives focused on addressing lifestyle-related conditions. This shift underscores the need for targeted strategies and solutions to effectively manage and reduce the burden of NCDs on both healthcare systems and vulnerable populations.

Exhibit 1.1.3

Global deaths by NCDs vs. CDs



Note(s): *This includes communicable, maternal, neonatal, and nutritional diseases

1.2 Catalysts influencing healthcare demand

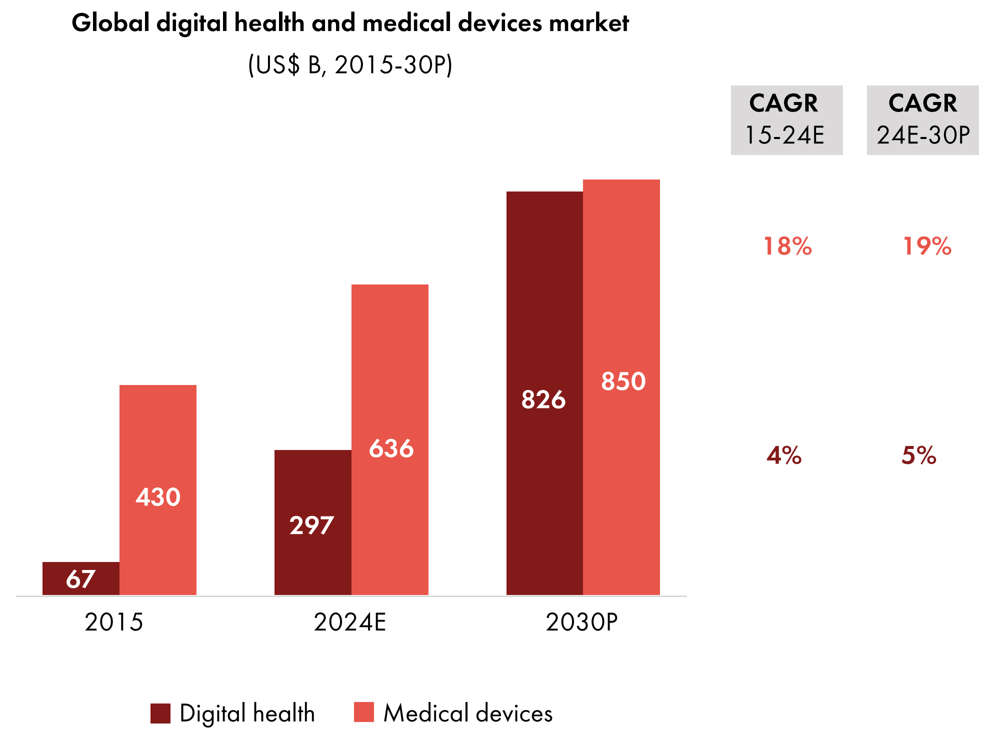
Beyond demographic and economic drivers, technological advancements and increased investments are significantly reshaping healthcare demand. Breakthroughs in medical technology and a deeper understanding of diseases are not only addressing current needs but also paving the way for future innovations.

1.2.1 Developments in medical technology

Advancements in medical technology, including digital health tools and AI-driven diagnostics, are transforming the healthcare landscape. These innovations are reducing the need for in-person visits, improving access to care in remote and underserved areas, and enabling more efficient and accurate diagnoses and treatment plans. For example, the integration of robotic surgery is minimizing complications and shortening recovery times, demonstrating the potential for technology to enhance both the quality and efficiency of care. This evolution presents opportunities for healthcare providers to leverage cutting-edge solutions to drive operational improvements and deliver better patient outcomes.

Exhibit 1.2.1

Global digital health and medical devices market

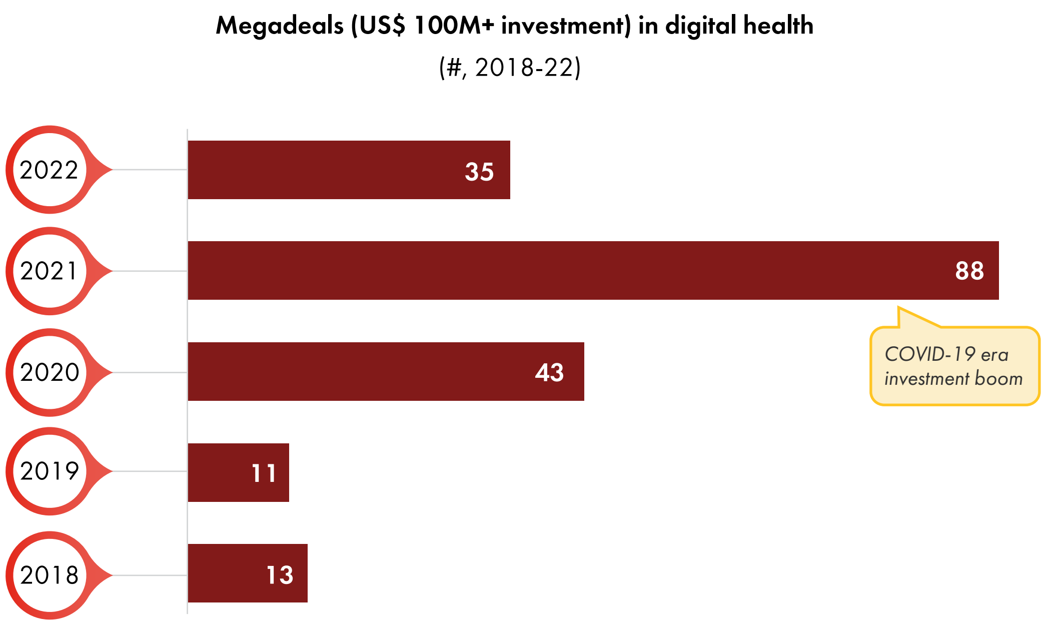


1.2.2 Investments in the healthcare sector

Significant investments in the healthcare sector, especially through large-scale mergers and acquisitions, are reshaping the industry landscape. These investments are facilitating the adoption of new technologies, improving infrastructure, and accelerating the transition towards value-based care models that prioritize patient outcomes over the volume of services provided. This strategic shift not only enhances operational efficiency but also aligns with the growing demand for high-quality, patient-centered care solutions.

Exhibit 1.2.2

Number of megadeals (US$ 100M+ investment) in digital health



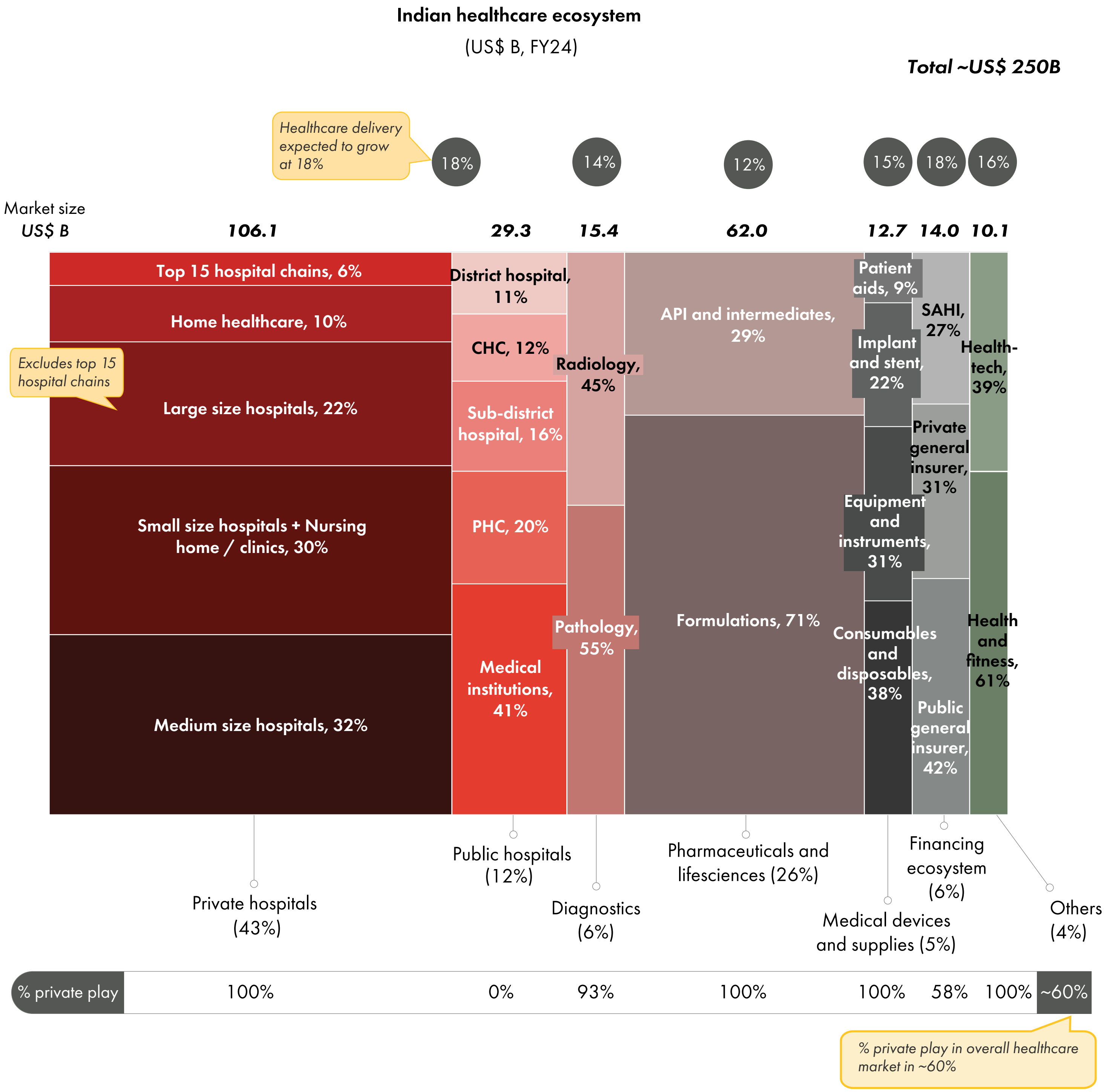
2

INDIAN HEALTHCARE ECOSYSTEM

The Indian healthcare ecosystem is on the brink of a significant transformation, driven by rapid growth and innovation. As a US$ 250B market in FY24, it encompasses a diverse range of healthcare services, including healthcare delivery, diagnostics, medical devices, pharmaceuticals, financing, and health-tech. The sector is evolving with increasing investments in digital health, telemedicine, and personalized care, aiming to meet the rising demand for accessible and high-quality healthcare across the country. This dynamic landscape is poised to reshape the healthcare ecosystem, making it more efficient, affordable, and patient-centric.

Exhibit 2.1

Indian healthcare ecosystem



Hospital type	Small + NH	Medium	Large	Large chains
Bed size	<100	100-300	>300	Top 15

xx% Growth CAGR FY24-29P

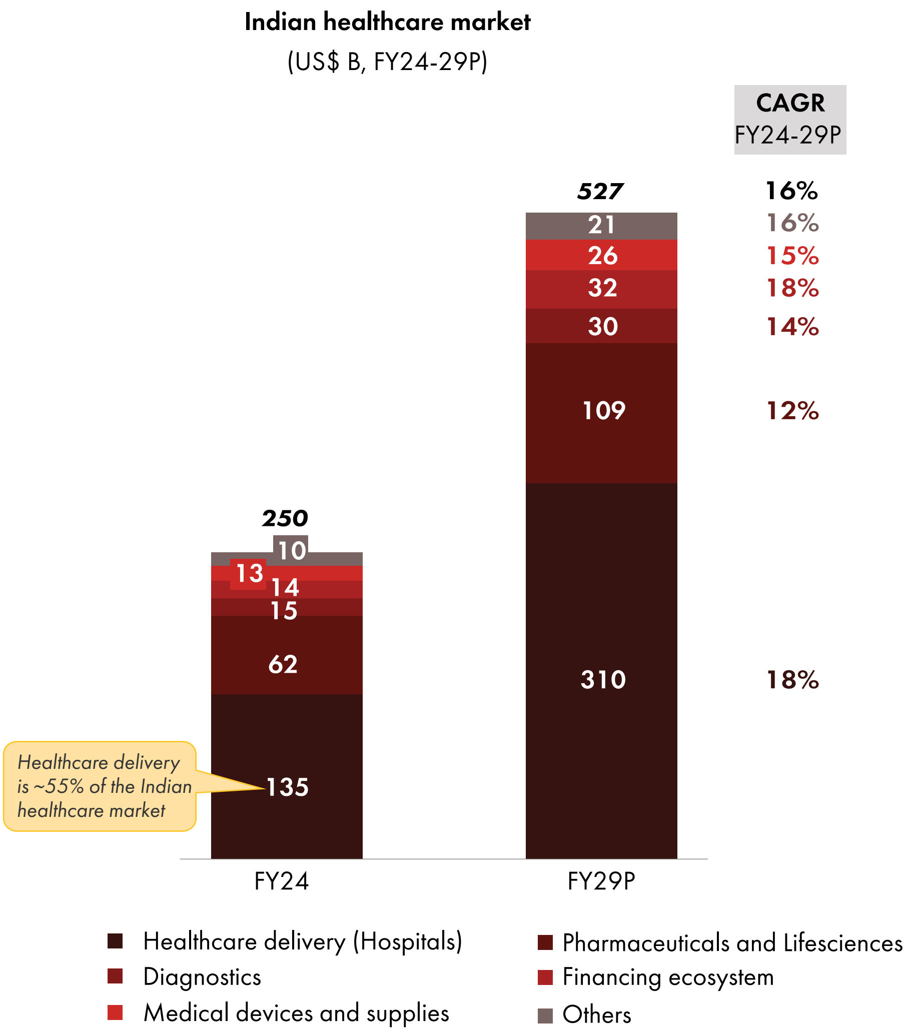
Note(s): SAHI focuses solely on health insurance products – Aditya Birla Health Insurance, Care Health Insurance, ManipalCigna Health Insurance, Niva Bupa Health Insurance, Star Health, and Allied Insurance; the market for health-tech includes telemedicine, personal health management products & services, remote diagnostic devices, and healthcare IT; the market for health & fitness includes both the fitness trackers and health & wellness coaching segments

2.1 Healthcare market dynamics and growth projections

The healthcare market is expected to grow at a CAGR of 16%, to reach US$ 527B by FY29 from US$ 250B in FY24. Healthcare delivery accounts for ~55% of the total Indian healthcare market.

Exhibit 2.1.1

Indian healthcare market dynamics and growth projections



Note(s): Others include health & fitness and health-tech

2.2 Factors driving the growth of healthcare market in India

The healthcare market in India is experiencing rapid growth, driven by improved life expectancy, an aging population, and a shift towards a higher burden of non-communicable diseases. Rising incomes and an expanding middle class are further fuelling increased demand for healthcare services. Simultaneously, private insurance coverage and government initiatives like AB-PMJAY are improving accessibility. With a projected need for 3M additional hospital beds by CY25, the sector has significant growth potential. Additionally, health-tech innovations are further enhancing coverage and accessibility across the country.

Exhibit 2.2.1

Key growth drivers for healthcare sector in India

Improved life expectancy	• Increased life expectancy of around **69.4 years** in CY14-18, which is six years more than CY99-03 • Elderly population (60+ years) is expected to be **~13%** by CY26 up from **~9%** in CY16
Increasing urbanization and income level	• India is undergoing rapid urbanization, from **~30% in FY12** to **~35%** in **FY22,** with more people moving to cities • Households with income more than **US$ 2.5K** were estimated at **~35%** in **FY22**
Increasing health insurance	• In FY22, more than **860M** people had health insurance and it is expected that coverage will increase to cover **~70%** in the next few years
Medical tourism	• India has become a **popular destination** for medical tourism, with patients from around the world coming to India for **highly complex procedures** at relatively **low cost**
Government policies	• Under Union budget FY23-24, the Ministry of Health and Family Welfare (MoHFW) has been allocated **US$ 10.8B,** an **increase of 3.4%** compared to US$ 10.5B in FY22-23
Health awareness and accessibility	• With **~65%** of India's population living in rural areas, the government is **incentivizing private investments** in these regions to create awareness about health and to find cost-effective ways to expand

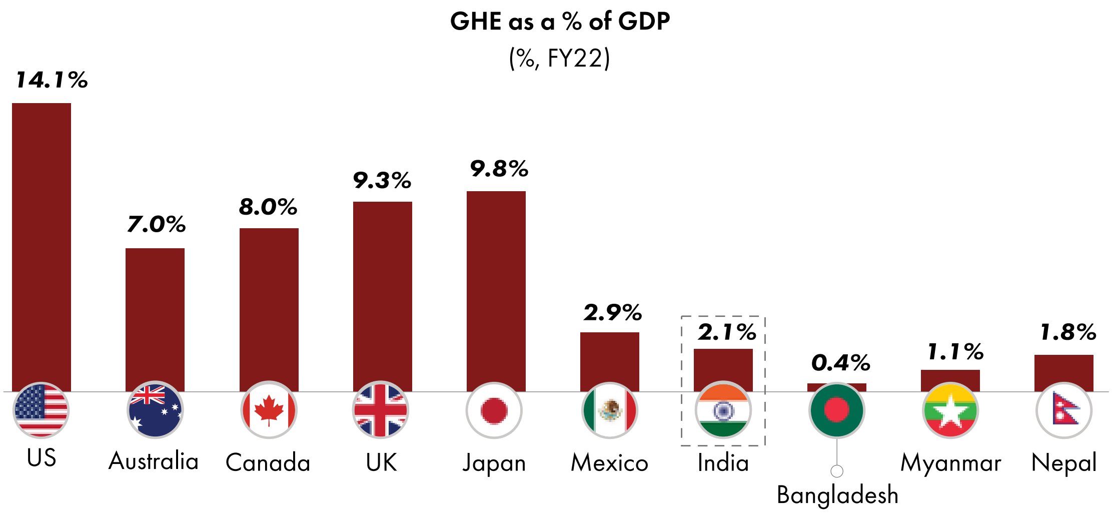
2.3 Government healthcare expenditure

Government healthcare expenditure (GHE) in India is currently underpenetrated but is expected to grow rapidly in the future, driven by increasing demand for services and the need to improve healthcare accessibility and quality across the country.

India's government healthcare expenditure is low, at just 2.1% of GDP in FY22, significantly below that of other countries. However, it is on an upward trajectory, with expectations to reach around 3.2% of GDP by FY33.

Exhibit 2.3.1

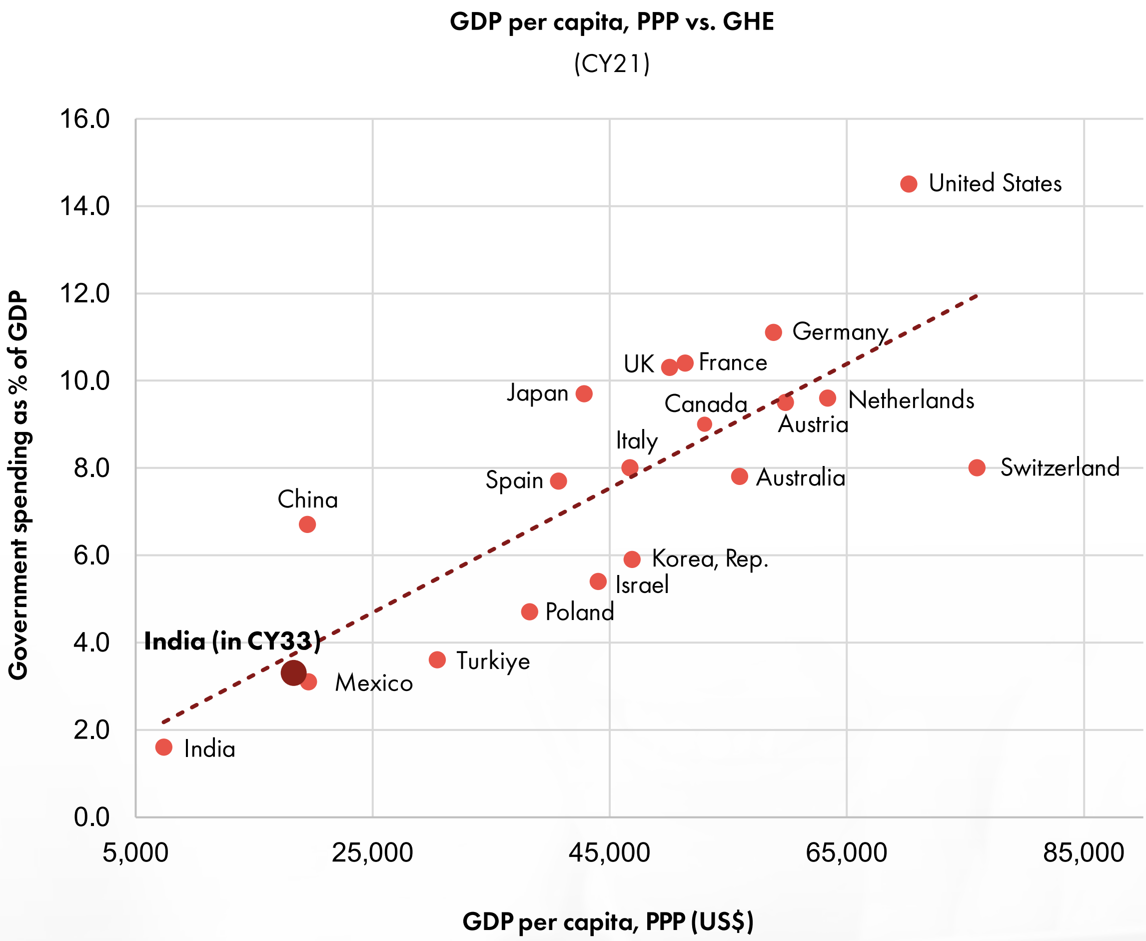
Government healthcare expenditure – country comparison



Note(s): Data on government healthcare expenditure as a % of GDP of Bangladesh and Myanmar are for FY21 and that of India is for FY23, Government health spending as a % of GDP is without PPP conversion; GPD per capita, PPP is for calendar year

Exhibit 2.3.2

GDP per capita – country comparison



3

HEALTHCARE DELIVERY LANDSCAPE IN INDIA

India's healthcare landscape is shaped by a demographic shift towards an aging population and a rising burden of chronic diseases. This shift is driving greater demand for healthcare services, particularly as the elderly and middle-class populations grow. However, uneven distribution of healthcare facilities, especially in rural and underserved regions, limits access. While technology adoption offers opportunities for enhanced care delivery, challenges in data management and integration persist. Addressing these challenges is essential for building a more equitable and efficient healthcare system.

3.1 Demographic shifts and disease burden

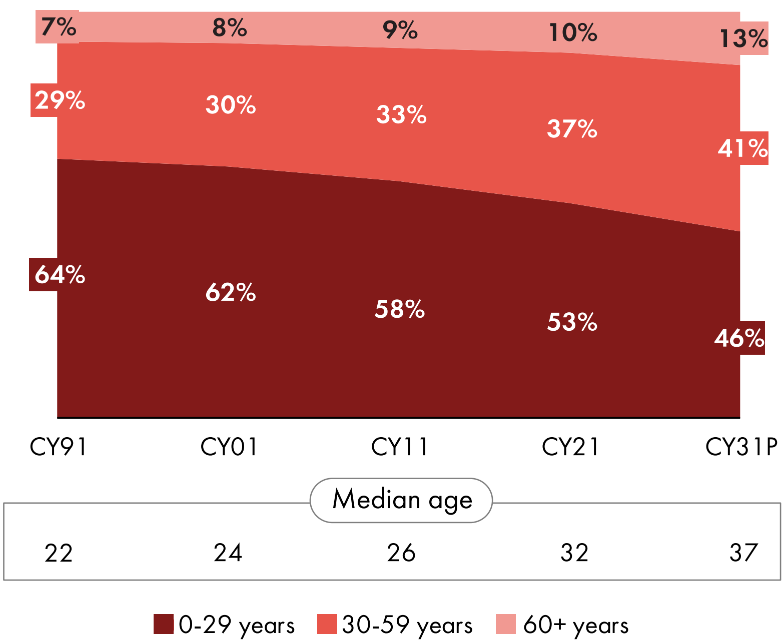
India's demographic shift towards an aging population and an increasing prevalence of non-communicable diseases is significantly rising the demand for healthcare services.

By CY31, India's median age is projected to rise from 32 to 37, with approximately 13% of the population aged 60 years or older. Non-communicable diseases are expected to account for nearly 74% of deaths by CY30, up from 66% in CY21, further increasing the demand for healthcare services. To meet these evolving needs, substantial investment in senior care and infrastructure is required to ensure the system can handle the changing demands of the population.

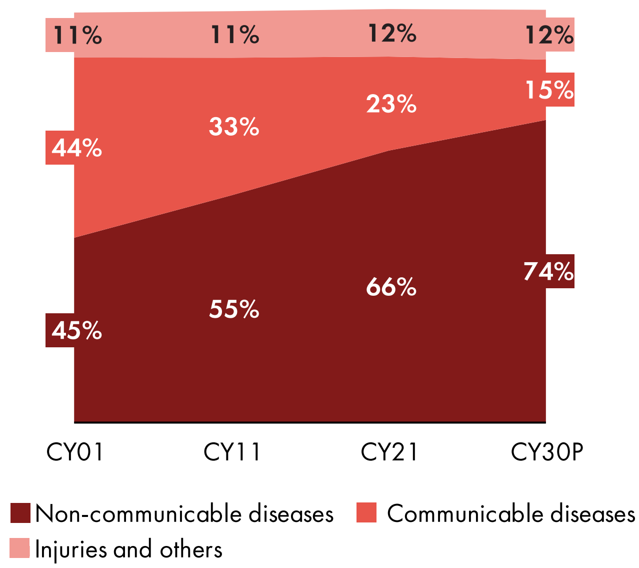
Exhibit 3.1.1

Age profile and disease burden in India

Age profile in India
(%, CY91-31P)



Cause of deaths in India
(%, CY01-30P)

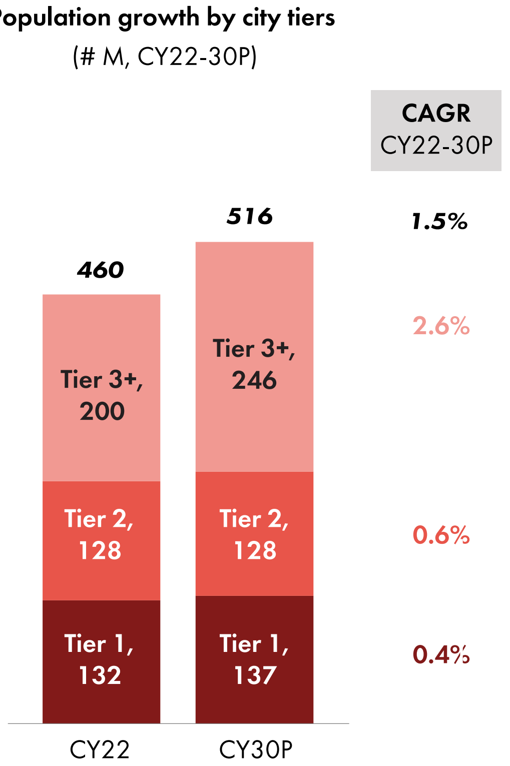


Injuries and others	Communicable diseases	Non-communicable diseases
• Damage caused to the body by external factors or accidents • E.g. fracture, ligament tear, bruise, contusions, etc.	• Caused by infectious agents and can transmit to others via direct or indirect contact • E.g. influenza, tuberculosis, COVID 19, chickenpox, etc.	• Caused by non-infectious agents and do not transmit from person to person • E.g. cardiovascular diseases, diabetes, cancer, asthma, etc.

India is home to over 540 urban cities, with nearly 90% of these classified as Tier 3+. By CY30, these cities are projected to accommodate an additional 46M residents. This anticipated population growth will require significant investments in healthcare infrastructure within these regions.

Exhibit 3.1.2

Number of urban cities and population growth across tiers



Population growth (M)

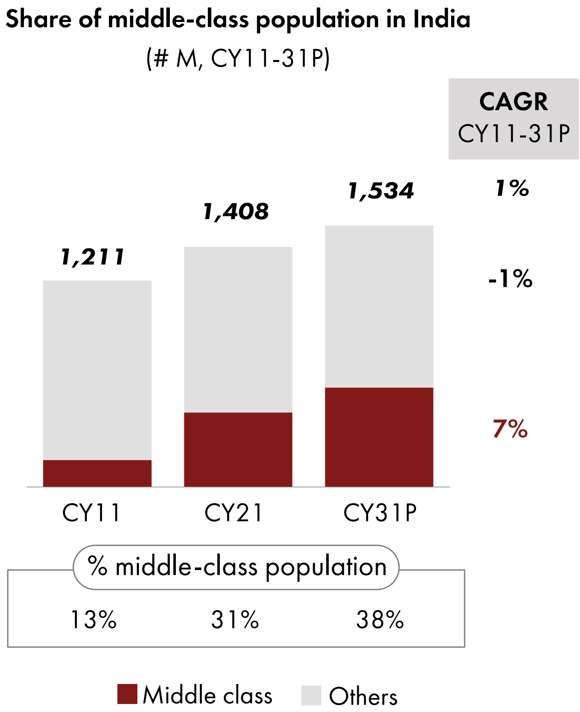
Tier 1	5
Tier 2	6
Tier 3+	46

Note(s): Tier 1 cities - cities with more than 4M population; tier 2 cities - cities with a population between 1.5-4M; tier 3+ cities - cities with a population less than 1.5M

The other significant demographic shift is the rise of the middle class, whose population is expected to rise from 31% in CY21 to 38% in CY31. As the middle class expands, there will be a heightened demand for quality healthcare services and greater healthcare spending.

Exhibit 3.1.3

Share of middle-class population in India



3.2 Uneven distribution and access to healthcare facilities

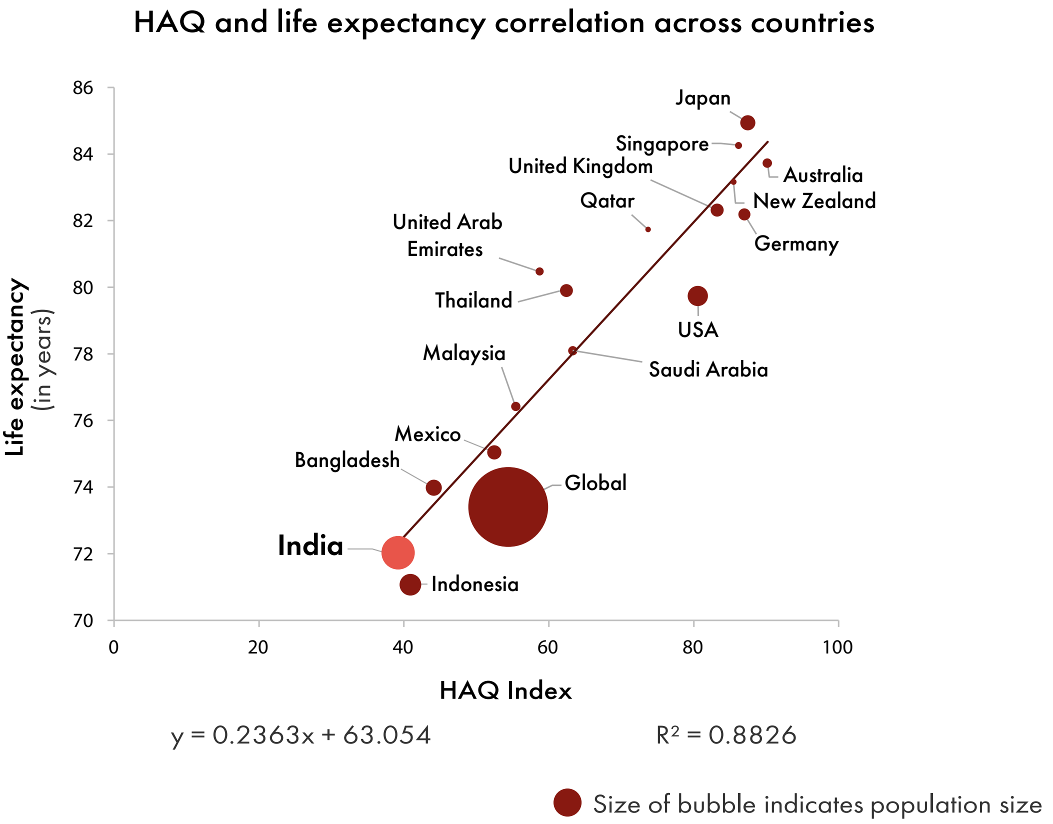
India's healthcare system is marked by significant disparities in the distribution and accessibility of facilities, particularly in rural areas. The country's healthcare access and quality index reflects considerable room for improvement, with affordability and availability of services being major concerns. Rural regions are especially disadvantaged, where poor working conditions and financial constraints hinder the retention of medical professionals, exacerbating the challenges of delivering quality healthcare.

3.2.1 Healthcare access and quality comparison

India's healthcare system faces significant challenges, as evidenced by its low ranking in the Healthcare Access and Quality (HAQ) index. This index measures the extent to which people are healthy and have access to services necessary to maintain good health including health outcomes, health systems, illness, risk factors, and mortality rates. There is a direct correlation between a country's HAQ index and its average life expectancy, with nations like Japan and Australia leading the rankings.

Exhibit 3.2.1

HAQ and life expectancy correlation across countries



3.2.2 Low accessibility to healthcare

Apart from the overall HAQ, India is struggling with multiple other issues resulting from poor access to healthcare like high mortality rate, high economic burden, public health risks, reduced quality of life, and increased healthcare costs. All these factors indicate that there is a considerable potential for enhancement across the Indian healthcare system.

Exhibit 3.2.2

Issues due to poor access to healthcare

High mortality rates	**Lack of timely medical intervention** will lead to **higher death rates** for preventable and treatable conditions
High economic burden	**High out-of-pocket expenses** for untreated illnesses **increase the financial strain** on families and reduce overall productivity
Public health risks	**Poor access to healthcare** can lead to the **spread of infectious diseases** and public health crises
Reduced quality of life	**Chronic pain** and **untreated medical** conditions **diminish** daily functioning and **overall quality of life**
Increased healthcare costs	**Delayed treatments** often lead to **more severe health issues,** resulting in **higher healthcare costs** in the long run

3.2.3 Distribution of healthcare facilities across urban and rural areas

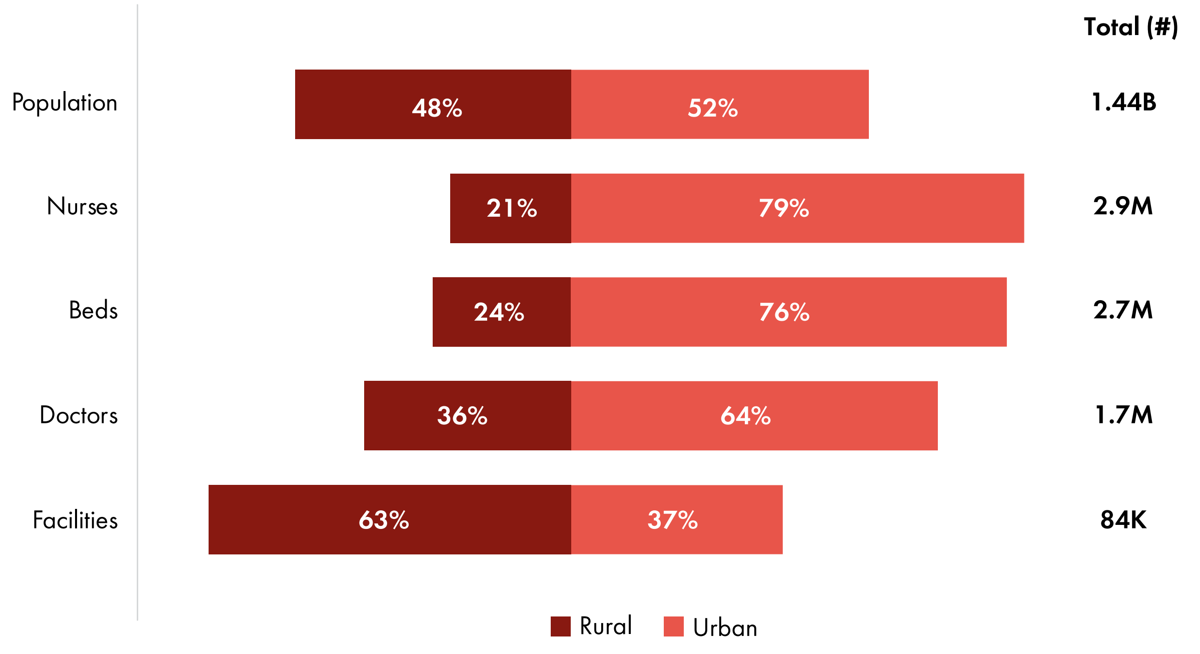
There is significant inequity in access to healthcare facilities across India. Nearly 80% of the country's doctors are concentrated in urban areas, which house less than 40% of the population. A similar disparity exists with hospital beds, as 76% are in urban regions.

Exhibit 3.2.3

Split of facilities, beds, doctors, and nurses across urban and rural India

Facilities and healthcare professionals split across urban and rural India

(%, FY24)



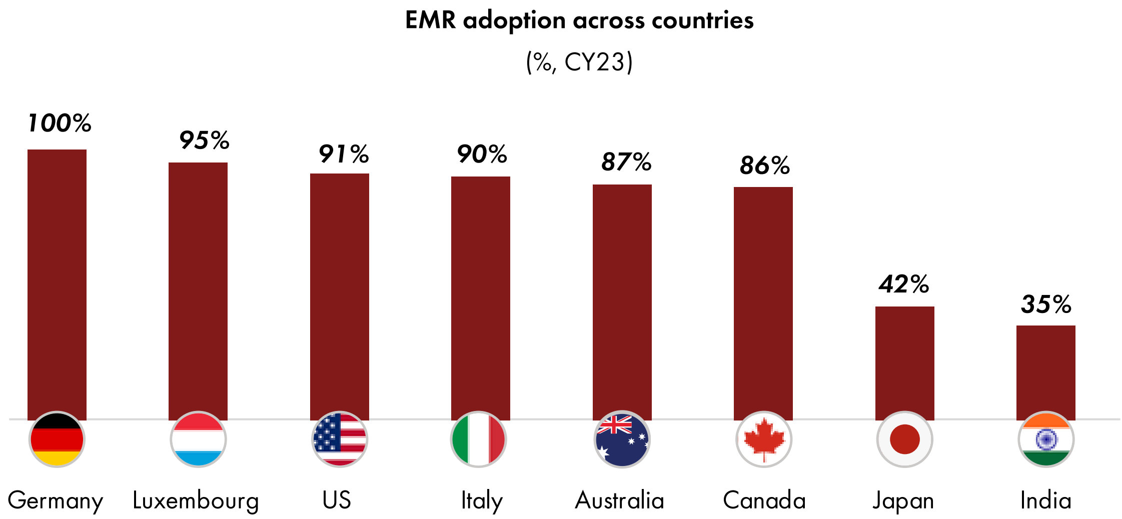
3.3 Technology adoption and data challenges

Technology adoption in healthcare is rapidly transforming the landscape, offering new opportunities to improve patient care and streamline operations. As digital tools become more integrated into healthcare, it comes with its own set of challenges, particularly around the integration of data.

The exhibit below shows EMR adoption rates across countries in CY23, with Germany leading at 100% and most developed nations above 85%. India, at ~35%, significantly trails behind, indicating a substantial gap in healthcare digitalization. This low adoption rate suggests India faces challenges in modernizing its healthcare infrastructure, potentially impacting the efficiency and quality of medical services compared to countries with more advanced digital healthcare systems.

Exhibit 3.3

EMR adoption across countries



3.3.1 Growth drivers for technology adoption

The increase in technology adoption in healthcare is being fuelled by rising internet penetration, growing awareness of digital healthcare solutions, and significant technological advancements. Increased internet penetration, with over 730M active users, is expanding access to telemedicine. Rising awareness of healthcare's importance and a focus on preventive measures are also driving change. Additionally, implementing EMR and telemedicine reduces administrative overhead and operational costs, enhancing healthcare efficiency. Government initiatives, such as India's National Health Stack and ABHA, are further supporting healthcare digitization and digital health services.

Exhibit 3.3.1

Key growth drivers for technology adoption

Increased internet penetration	• **730M+** active internet users, are expanding the accessibility of telemedicine • **Growing emphasis** on tech's ability to improve efficiency has pushed hospitals to adopt EMR
Rising awareness	• Increased **awareness** about the importance of healthcare with a growing focus on preventive healthcare measures
Rising chronic diseases	• Increasing prevalence of **chronic diseases** pushes healthcare providers towards efficient records management, making telemedicine and EMRs attractive
Cost efficiency	• Implementation of EMR and telemedicine reduces **administrative overhead, lowers operational costs,** and enhances overall efficiency in healthcare delivery
Government initiatives	• India's focus on healthcare digitization, including the **National Health Stack** and **Ayushman Bharat Digital Health** Account (ABHA) has improved the adoption of telemedicine and digital initiatives such as EMR, etc.

3.3.2 Barriers to technology adoption in healthcare

Challenges such as high fixed costs, limited digital literacy, and interoperability issues are impeding the adoption of technology in health-care. These factors underscore the urgent need for a robust digital health ecosystem that enhances efficiency, improves coordination, and supports informed decision-making.

Addressing these obstacles is essential for healthcare organizations to fully leverage technological advancements and optimize care delivery.

Exhibit 3.3.2

Barriers to technology adoption in healthcare

High upfront costs

Implementing healthcare technologies like EHR and HMIS involves **significant upfront** investment in **infrastructure, software,** and training.

Digital literacy

A considerable gap is present in digital literacy among **healthcare professionals,** particularly in **tier 2+** cities.

Interoperability issues

Lack of standardization makes it difficult to share data seamlessly across different platforms and providers.

Data privacy concerns

Patients are increasingly concerned about how their data is used, stored, and shared, and thus, ensuring **compliance with data privacy laws, is critical.**

Lack of infrastructure

Many healthcare facilities, particularly in rural areas, **lack the necessary infrastructure** to ensure secure data handling.

Resistance to change

Many healthcare professionals are accustomed to **traditional methods of record-keeping,** slowing the adoption of new technologies.

There is a need for a robust digital health ecosystem to improve efficiency, coordination, and decision-making

3.4 Financing and insurance

Government spending on healthcare plays a pivotal role in ensuring equitable access to essential medical services, reducing financial barriers for vulnerable populations, and driving better public health outcomes. By investing strategically, governments can create a more resilient healthcare system, improve overall population well-being, and alleviate the economic strain of preventable health issues

3.4.1 Out-of-pocket expenditure (OOPE) in healthcare

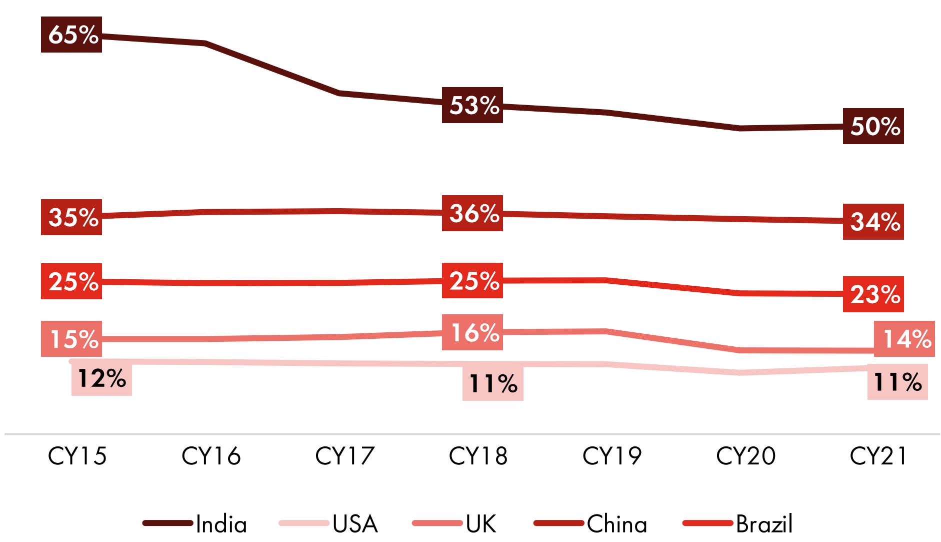
improvement compared to other nations where OOPE levels have remained stagnant. This reduction reflects the effectiveness of India's policy measures and healthcare reforms in alleviating the financial burden on individuals.

Exhibit 3.4.1

Country-wise OOPE in healthcare

Out-of-pocket expenditure (OOPE) in healthcare across different countries

(%, CY15-21)



3.4.2 Health insurance coverage by scheme type

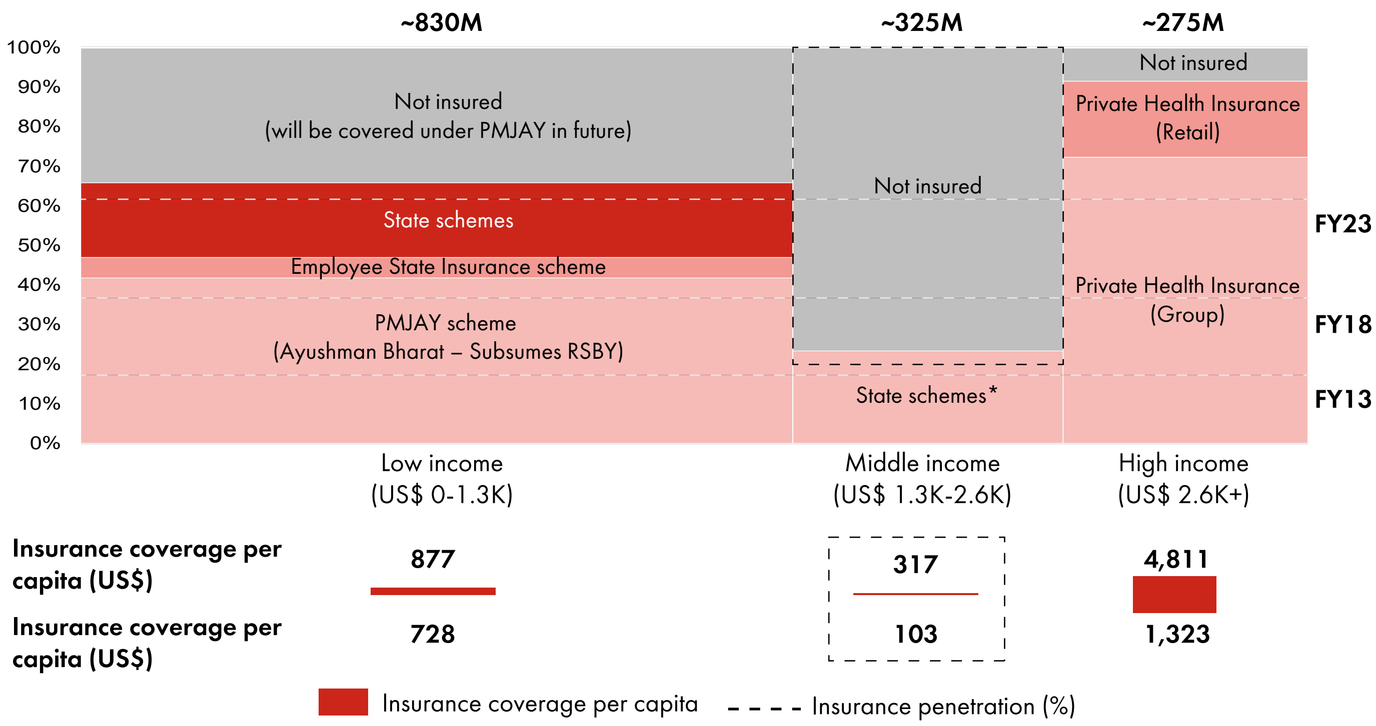
Over 75% of middle-income individuals in India lack health insurance, with this group having the lowest per capita coverage. Around 66% of the low-income population receives hospitalization coverage under Ayushman Bharat Yojana and state schemes. Additionally, 3% of the population is covered by CGHS and ESIS, while 14% have private voluntary insurance. The Government of India is working to expand AB-PMJAY and collaborate with private insurers to close the coverage gap, targeting the remaining 39% without insurance.

Exhibit 3.4.2

Health insurance coverage by scheme type

Out-of-pocket expenditure (OOPE) in healthcare across different countries

(%, CY15-21)



4

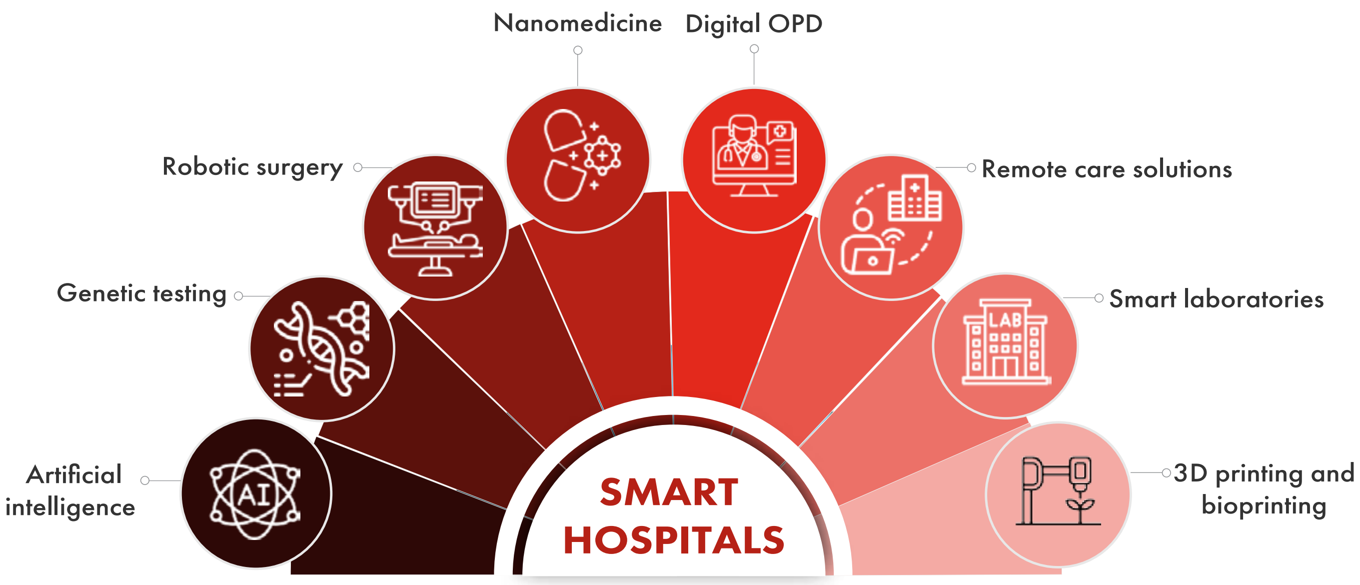
SMART HOSPITALS: NAVIGATING THE FUTURE OF HEALTHCARE DELIVERY

Smart hospitals leverage cutting-edge technologies like AI and genetic testing to enable personalized treatments, while robotic surgery enhances precision in procedures. Innovations such as nanomedicine and 3D printing, including bioprinting, drive advanced treatment solutions. Digital OPD and remote care expand healthcare accessibility, providing convenient, real-time medical support. Additionally, smart laboratories optimize operations, making healthcare delivery more efficient and patient-centric.

- **Artificial intelligence:** AI enhances diagnostics, treatment planning, and patient care. It analyzes medical data, assists in image interpretation, predicts health risks, and personalizes treatments leading to better patient outcomes and healthcare efficiency.
- **Genetic testing:** In reproductive health, it screens for genetic disorders in embryos and fetuses, aiding family planning. Pharmacogenomics, analyzes genetic markers to predict drug responses, enabling personalized medication regimens and reducing adverse effects.
- **Robotic surgery:** Enhances surgical precision, minimizes invasiveness, and improves recovery times. Provides surgeons with 3D visualization and greater dexterity, enabling complex procedures with smaller incisions and reduced complications.
- **Nanomedicine:** Utilizes nanotechnology for targeted drug delivery, precise diagnostics, and tissue repair. Nanoparticles can cross biological barriers, enhancing treatment efficacy while minimizing side effects, particularly promising in cancer treatment.
- **Digital OPD:** Enables remote doctor-patient interactions, improving healthcare access and reducing wait times. Integrates with electronic health records for comprehensive care management, benefiting remote areas and chronic condition management.
- **Remote care solutions:** Facilitate continuous patient monitoring outside clinical settings using wearables, mobile apps, and IoT devices. Enables early detection of health issues, timely interventions, and improved management of chronic diseases.
- **Smart laboratories:** Automate laboratory processes, enhance accuracy, and speed up diagnostics. Integrate IoT, AI, and robotics for efficient sample processing, analysis, and reporting, improving reliability and reducing turnaround times.
- **3D printing and bioprinting:** Creates customized prosthetics, implants, and anatomical models for surgical planning. Bioprinting shows promise in tissue engineering and organ transplantation. Also used for producing custom medications with precise dosages.

Exhibit 4.1

Transforming healthcare delivery with cutting-edge technologies



4.1 AI in hospitals

The healthcare industry is undergoing a dramatic digital transformation, powered by AI at every touchpoint of patient care. This strategic framework maps out an AI-integrated healthcare journey that streamlines the traditional medical process - beginning at patient registration and flowing through to final payment processing. Each stage showcases how AI applications are enhancing medical service delivery while simultaneously addressing three crucial dimensions: technological capabilities, patient experience, and business value. From reducing administrative burdens and enabling faster diagnostics to facilitating personalized treatments and automated claims processing, this comprehensive approach demonstrates how healthcare providers can leverage AI to create a more efficient, accurate, and patient-centered healthcare ecosystem, ultimately leading to better outcomes for all stakeholders involved.

Exhibit 4.1.1

Leveraging AI for patient outcomes and business growth in smart hospitals

Patient registration
- *Automated check-in and flow management*

Diagnostics and imaging
- *Medical imaging analysis*
- *Predictive diagnostics*
- *Automated pathology*

Treatment
- *AI-assisted surgery*
- *Clinical decision support*
- *Personalized medicine*

Post-treatment follow up
- *Remote patient monitoring*
- *AI-driven health assistants*
- *Risk assessments for preventive care*

Claims / Payments
- *Automated claims processing*
- *Fraud detection systems*

Patient impact

Patient registration		Diagnostics and imaging		Treatment		Post-treatment follow up	Claims / Payments	
Automated check-ins	Reduced wait times	Reduced repeat tests	Faster diagnostics	Precision surgery	Faster recovery	Automated follow-ups and scheduling	Faster claims processing	Personalized payment plan
Less paperwork	Improved satisfaction	Decreased radiologist workload due to AI triaging		Lower complication	Less human error	Continuous virtual care and monitoring	Enhanced transparency	Error reduction

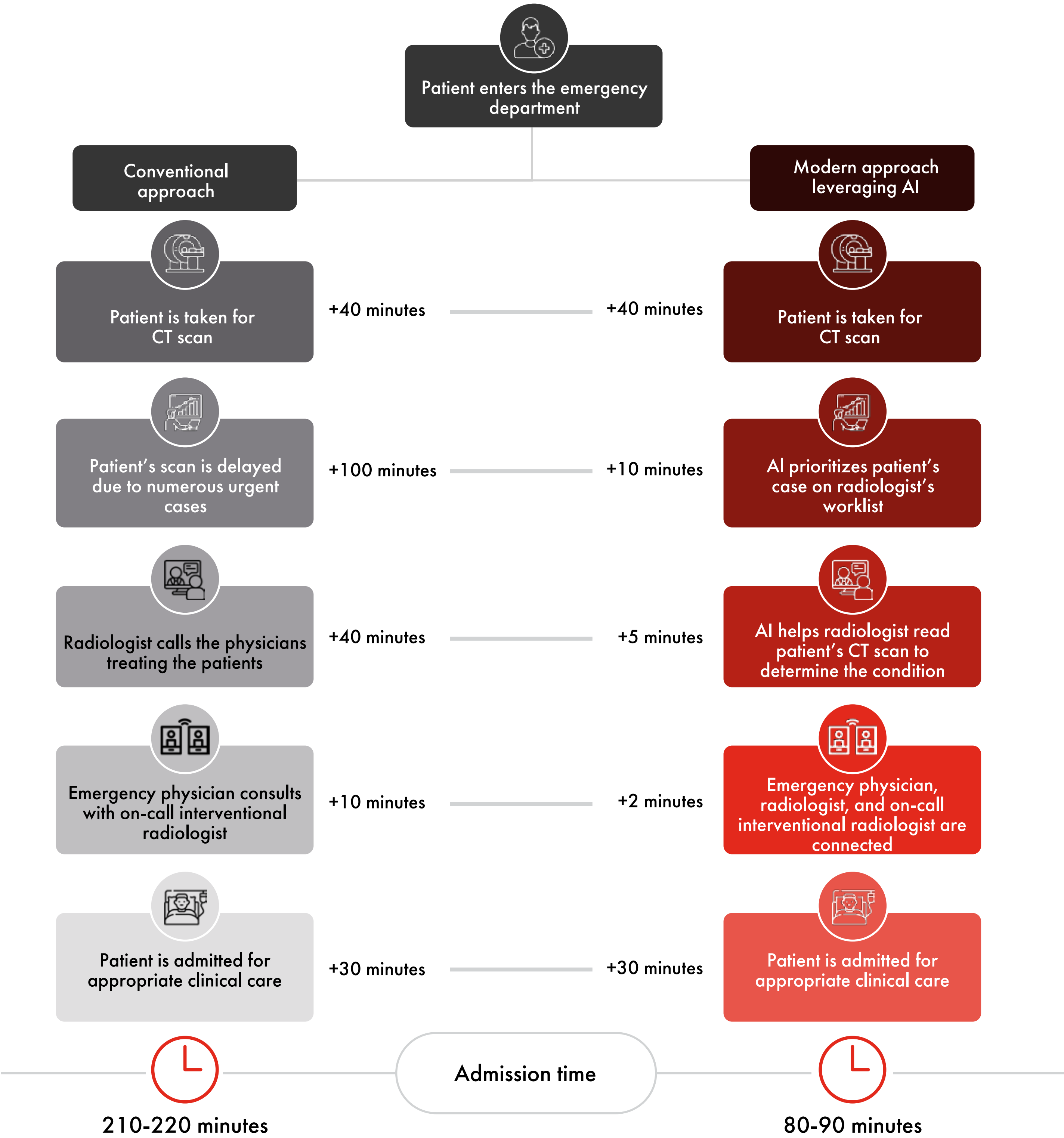
Business impact

Optimized workforce capacity allocation	Increased patient throughput	Improved patient outcomes	Remote health tracking offerings	Improved cash flow
Reduced operation costs	Lower TAT	Enhanced market positioning	Subscription-based services	Improved fraud detection

In emergency medical care, time is of the essence, and this comparative analysis demonstrates how AI is revolutionizing patient care workflows. The exhibit below contrasts a conventional medical imaging approach with a modern AI-leveraging system, specifically in the context of CT scan processing and subsequent patient care decisions. While the traditional method requires approximately 4 hours to move a patient through five critical stages, from initial CT scan to final admission, the AI-enhanced approach dramatically reduces this time to 90 minutes. This remarkable efficiency gain is achieved through intelligent case prioritization, streamlined communication between healthcare providers, and automated workflow optimization, ultimately enabling faster diagnosis and treatment initiation for critical patients.

Exhibit 4.1.2

Patient admission time: Conventional vs. AI-driven



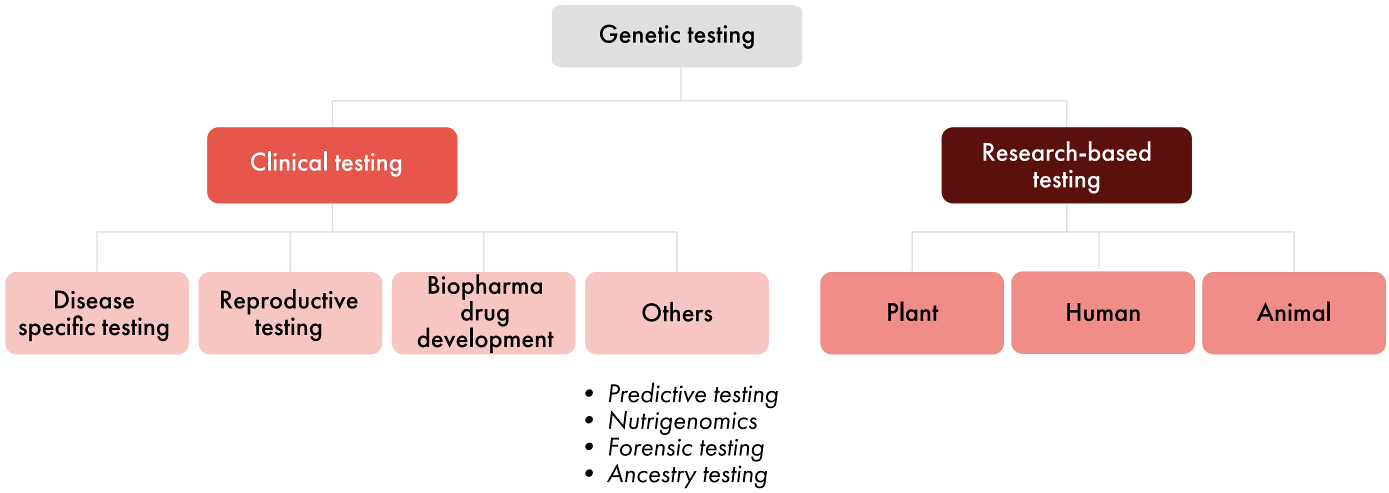
AI is revolutionizing healthcare by streamlining processes and improving outcomes. From administrative tasks to clinical workflows, AI is driving efficiency gains and enhancing patient experiences. This transformation positions healthcare institutions for success in the digital age.

4.2 Genetic testing

Genetic testing across the world is rapidly gaining popularity, offering a wealth of information about an individual's genetic makeup, and empowering individuals to make informed decisions about their health and well-being. Genetic testing in India is experiencing robust growth across both segments of clinical testing and research testing.

Exhibit 4.2.1

Overview of genetic testing



Genetic testing has evolved into a powerful tool with diverse applications across both clinical and research fields, offering significant advancements in healthcare, biotechnology, and scientific understanding. This evolution in the clinical domain plays a critical role in reproductive health, disease-specific diagnostics, and biopharma drug development.

Exhibit 4.2.2

Diverse range of tests offered in genetic clinical testing

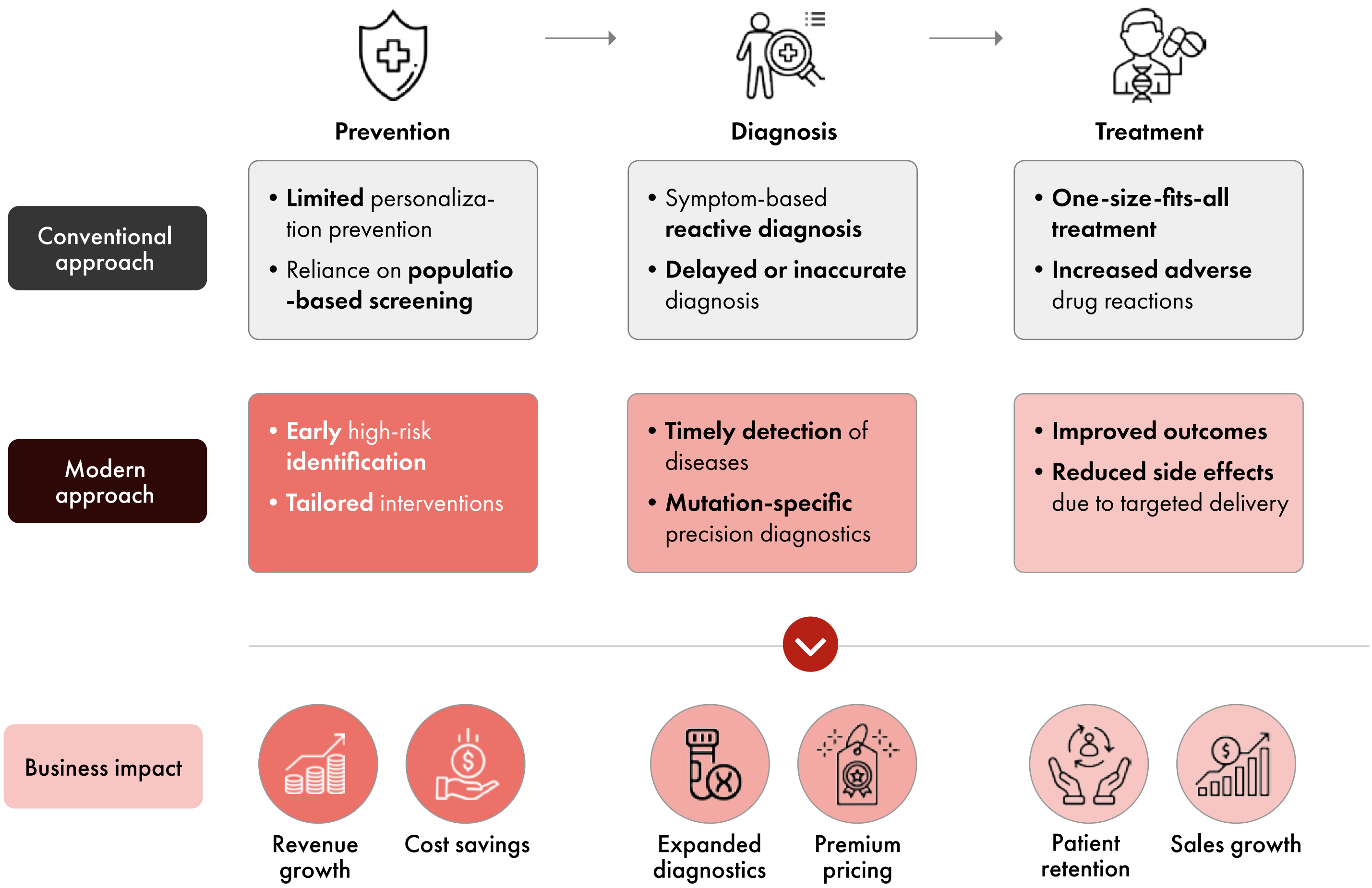
	Genetic clinical testing			
	Disease-specific testing	**Reproductive testing**	**Biopharma drug development**	**Predictive / Presymptomatic testing**
Objective	• Identify individuals with increased risk due to family history or other risk factors • Confirm a **suspected genetic diagnosis / disease** • Guide treatment and **management of chronic illnesses**	• Identify carrier status for genetic disorders from parents • Diagnose potential conditions in fetuses / new-born babies	• Includes biomarker discovery, clinical, and preclinical testing • Discovering and developing **therapeutic products** such as vaccines, biologics, and biosimilars • **Quality control of raw materials** and drugs during manufacturing • Incorporation of **personalized medicine for tailored treatments based on individual genetic profiles**	• Enable **informed decision-making** for future healthcare management • Assess the risk of developing a **specific genetic disorder** • Allow for **early intervention** and **develop prevention strategies**
Key sub-types / examples	• Infectious and symptomatic, like **COVID-19, TB** • **Oncology testing** • Rare disorders / geneticdisease testing • Disease management / routine checks	• New-born screening • Carrier testing • Prenatal (invasive & non-invasive)	• Vaccine development • Gene-drug pair testing • **Precision medicine** • Panel testing for drug efficacy and allergens • Companion diagnostics • **Gene therapy, cell therapy, and CAR-T cell therapy**	• Monogenic testing • Multigene panel testing • Cancer screening • **Targeted screenings** and treatments • **Immunizations (vaccination)** • Other chronic disease screening
Typical target segments	• Symptomatic individuals • Individuals with illness (disease management)	• Married couples • Embryo / fetus • New-born babies	• **Pharma / biopharma companies / CROs** • Drug trial candidates • Patients undergoing **experimental or personalized therapy**	• General population • Individuals at risk of hereditary diseases

Genetic testing is poised to transform healthcare across prevention, diagnosis, and treatment while highlighting significant business implications. The transition from current generic strategies to genetic testing-based approaches promises personalized medicine with improved outcomes.

Key business opportunities emerge, including new revenue streams from tailored wellness programs, cost savings through early interventions, premium pricing for advanced diagnostics, and increased pharmaceutical sales in precision drug markets. Healthcare providers stand to benefit from reduced readmissions, enhanced patient satisfaction and strengthened market positions in personalized care. This transformation represents a paradigm shift in healthcare delivery, promising both improved clinical outcomes and compelling economic advantages for stakeholders across the healthcare ecosystem.

Exhibit 4.2.3

Leveraging genetic testing for patient outcomes and business growth in smart hospitals



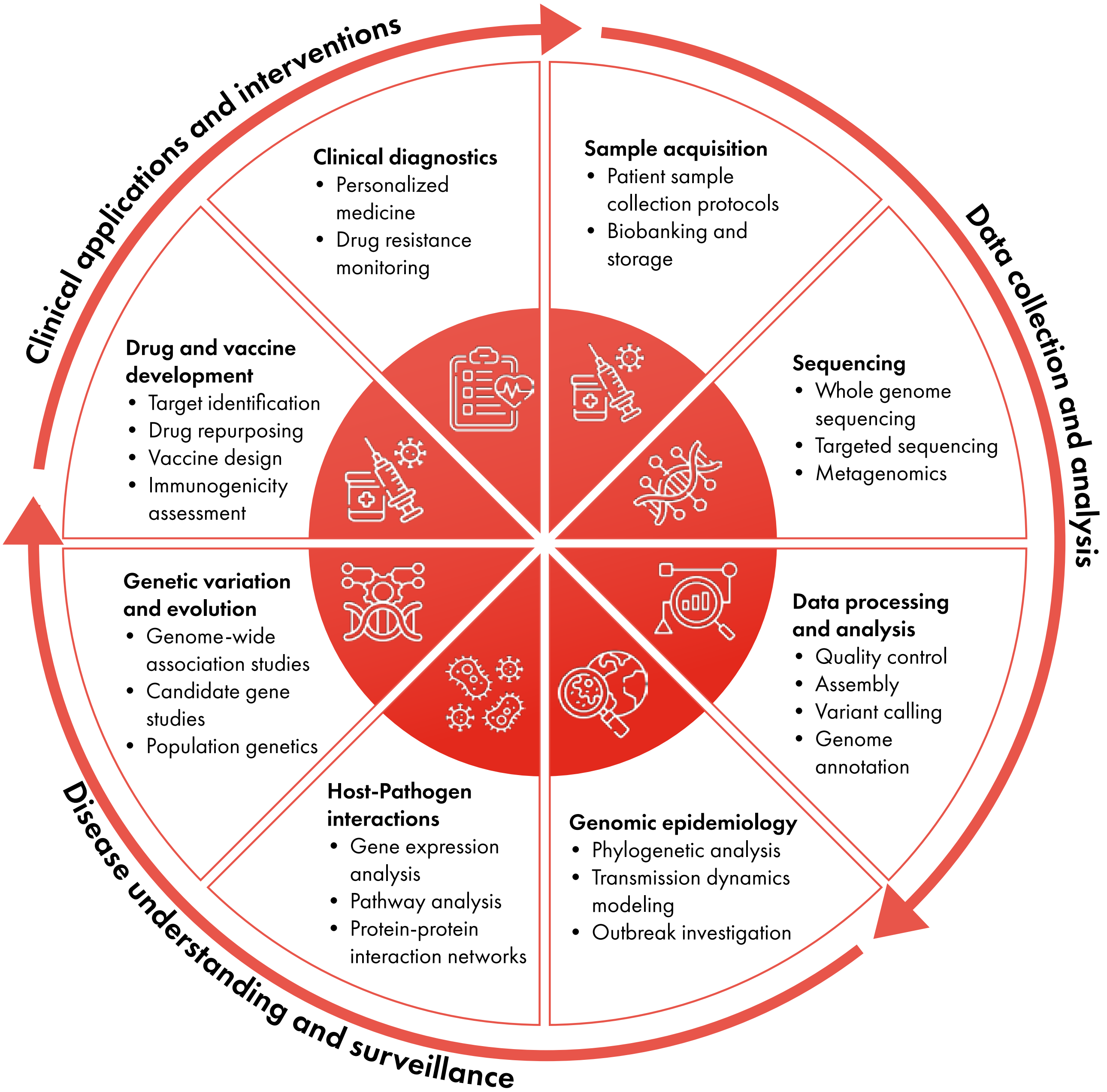
Genetic testing offers a transformative approach to tackling infectious diseases. By analyzing genomic data, researchers can unlock valuable insights into disease transmission, evolution, and pathogenesis, which are essential for creating targeted diagnostic tests, vaccines, and therapies.

The framework in the exhibit outlines eight critical steps, divided into three key segments, that guide the effective use of genetic testing in infectious disease research. From sample collection and sequencing to clinical diagnostics and interventions, this framework provides a holistic strategy to leverage genomic data in combating infectious threats.

PRAXIS GLOBAL ALLIANCE

Exhibit 4.2.4

Utilizing genetic testing in combating infectious diseases



4.3 Robotic surgery

Robotic surgery represents a cutting-edge advancement in medical technology, revolutionizing the field of surgical procedures. This innovative approach combines high-precision robotics with the expertise of skilled surgeons, offering a range of benefits that significantly improve patient outcomes. By leveraging state-of-the-art robotic systems, healthcare providers can perform complex surgeries with enhanced accuracy, control, and minimally invasive techniques, marking a paradigm shift in surgical care delivery.

The adoption of robotic surgery presents significant advantages in healthcare, mainly minimally invasive procedures, resulting in reduced trauma and faster recovery times. Patients experience shorter hospital stays and face lower risks of adverse side effects due to the precision of robotic systems. The technology's accuracy contributes to minimized blood loss during operations, often eliminating the need for pre-surgery blood donations. Additionally, patients report less postoperative pain owing to smaller incisions and reduced tissue damage. These factors collectively contribute to expedited patient recovery, positioning robotic surgery as a transformative approach in modern surgical practices compared to traditional open surgery methods.

Exhibit 4.3.1

Benefits of robotic surgery

Fast patient recovery

Combination of smaller incisions, less pain, and **faster healing** allows for a quicker recovery time **compared to traditional open surgery**

Minimally invasive

Robotic surgery often involves **smaller incisions,** leading to **less trauma** to the body

Less blood loss

Robotic surgery's precision and control help **minimize bleeding during the procedure**

Lower ALOS

Due to the reduced invasiveness, patients often **require shorter hospital stays** following robotic surgery

Less pain

Smaller incisions and **less tissue damage translate to less postoperative pain** for patients

Lower risk for adverse side effects

Smaller incisions and better precision **can reduce the risk of complications and side effects compared to traditional open surgery**

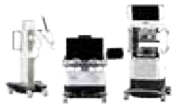
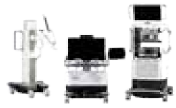
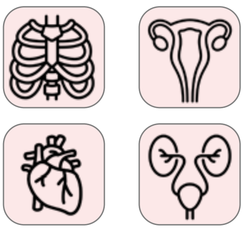
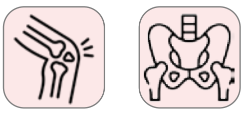
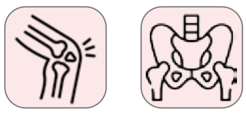
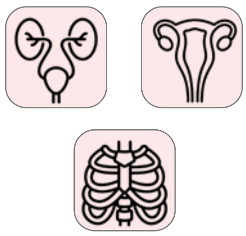
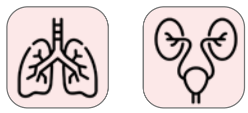
No blood donation pre-surgery

Due to minimal blood loss during surgery, **patients often don't need to receive blood before the procedure**

The robotic surgery market showcases diverse technological advancements from industry leaders. These systems offer versatile multi-specialty capabilities. modular flexibility, and yet another focus on minimally invasive thoracic procedures. These technologies exemplify the push towards enhanced surgical accuracy, improved patient outcomes, and increased operational efficiency across various medical disciplines.

Exhibit 4.3.2

Popular surgical robotics system types

DAVINCI	MAKO	CORI	HUGO	MONARCH
				
Description				
Versatile surgical robot used for various procedures, offering enhanced precision and dexterity through its **4 robotic arms** controlled by a surgeon	**An orthopedic robot** that plans and guides surgeons during **knee and hip replacements,** ensuring precise bone cuts and implant placement	An **orthopedic robot** that provides real-time bone alignment and cutting guidance for **knee replacements,** using a handheld robotic arm	**Modular surgical robot** that can be **customized for various procedures,** offering flexibility and adaptability	A **thoracic surgery robot** that navigates through the airways to reach tumors, **enabling minimally invasive procedures**
Key highlights				
• Performed **14M+ procedures** • Peer-reviewed in **38K+ articles** • **System uptime of >99%** through real-time data and proactive monitoring	• Performed **1M+ procedures** • Published and **peer-reviewed 425+ studies** • Established **1.5K+ patents and patent applications** globally • Database of **1M+ patient records** and **105M actionable data points**	• Enhanced knee surgery robotics workflow that saves time in the OR • Portable robotics designed to **offer the smallest footprint** in orthopedics • Offers highly accurate maneuvering with **surface accuracies within 0.5mm and 0.5° in all 3 planes for TKA**	• Offers **flexible configurations** to fit in various configurations of OR spaces • Tailored to perform various procedures, and cater to **unique patient needs** • Enhanced visualization and instrumentation • Designed to **reduce TCO** and optimize system utilization	• **Real-time adaptation** to changes for safe navigation • **Clear visualization** for better decision-making • Offers **comprehensive analysis** by utilizing **advanced imaging systems** • **Develops simplified plan for efficient procedures**
OEM				
INTUITIVE	stryker	Smith+Nephew	Medtronic	Johnson&Johnson MedTech
Therapy areas				
				

Robotic surgery enhances patient experience by offering minimally invasive procedures with greater precision, reduced pain, and faster recovery times. This advanced technology not only leads to better clinical outcomes but also positions the hospital as a leader in cutting-edge healthcare, strengthening its brand reputation. Patients associate such innovation with quality care and trust the provider for complex treatments.

From a business perspective, healthcare providers are leveraging these advantages to attract a broader patient base from wider geographic areas and age groups, and also optimize operational efficiency thus allowing providers to treat more patients through faster procedural turnover, ultimately creating improved revenue opportunities for healthcare facilities.

Exhibit 4.3.3

Patient and business impact of robotic surgeries across various therapeutic areas

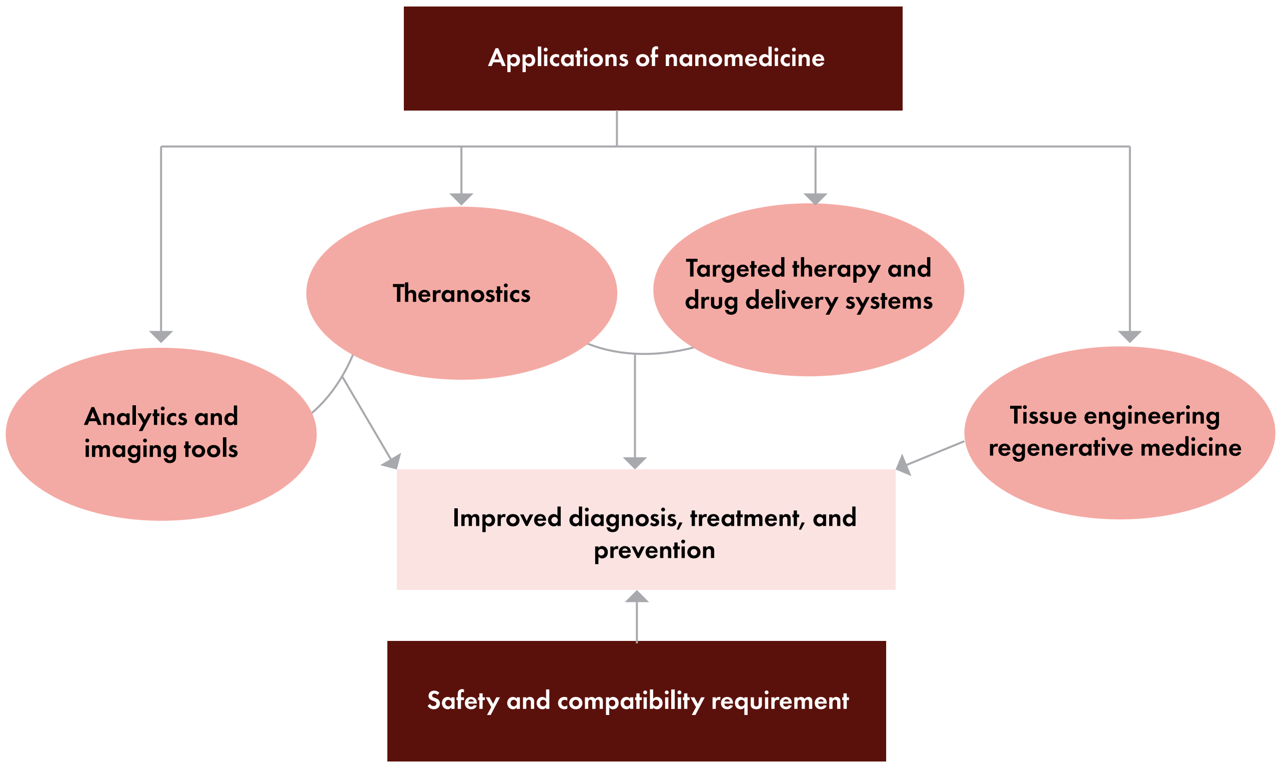
Therapeutic area	Description	Patient impact			Business impact	
Cardiothoracic	*Variety of heart and lung surgeries, including coronary artery bypass grafting, etc.*	Reduced surgical trauma	Accelerated recovery time	Shorter hospital stay	Center of excellence	High-value cases attracted
Gynecology	*Procedures such as hysterectomy, myomectomy, etc.*	Minimized scarring	Reduced pain	Shorter hospital stay	Insured younger patients targeted	Reduced operative time
Urology	*Prostate surgery, kidney surgery, and bladder surgery*	Less blood loss	Reduced complications	Improved patient outcomes	Expanded patient reach	Decreased open surgery time
Colorectal	*Colectomy, rectal resection, and low anterior resection*	Reduced infection risk	Accelerated recovery time	Precise resection	Reduced doctor fatigue	Lower wound infection rate
Orthopaedic	*Joint replacement surgery, such as knee and hip replacement*	Improved accuracy	Reduced complications	Precise alignment	Elderly hesitant patient attracted	Improved patient confidence
Neurological	*Procedures such as brain tumor removal and spinal surgery*	Enhanced precision	Reduced surgical trauma	Minimal invasiveness	Optimized OR time	Complex cases attracted
Ophthalmic surgery	*Cataract surgery, glaucoma surgery, and retinal surgery*	Improved accuracy	Minimized human error	Quicker healing	Faster surgeries increasing intake	Lower readmission rates

4.4 Nanomedicine

Nanomedicine leverages nanotechnology to develop precise, targeted treatments and diagnostics, enhancing drug delivery, disease detection, and tissue regeneration. It enables real-time monitoring, reduces side effects, and improves patient outcomes. This approach is driving personalized medicine and advancing minimally invasive procedures, offering more efficient, cost-effective healthcare solutions. Nanomaterials and devices are transforming healthcare through advances in theranostics, targeted drug delivery, and tissue engineering. These technologies, supported by analytics and imaging tools, enhance diagnosis, treatment, and prevention. With a strong focus on safety and compatibility, they promise to improve patient outcomes while driving innovation in regenerative medicine.

Exhibit 4.4.1

Application and goals of nanomedicine



Nanomedicine introduces a paradigm shift from conventional approaches to more precise, personalized, and efficient healthcare delivery. Key business advantages include improved patient throughput, enhanced predictive analytics, and higher patient satisfaction in screening; lower diagnostic costs and increased capacity for providers in diagnosis and staging; increased treatment success rates and reduced operational costs in treatment and monitoring; and lower follow-up costs with improved long-term patient outcomes.

The transition to nanomedicine-based approaches promises not only superior clinical outcomes but also significant economic benefits, including reduced chronic disease complications, increased patient engagement, and greater demand for advanced MedTech products. The comprehensive nature of these advancements suggests a future where healthcare providers can offer more effective, efficient, and patient-centric care while simultaneously improving their operational and financial performance.

Nanotechnology improves precision, reduces side effects, and enables real-time monitoring. Leading companies like Merck, AstraZeneca, and Intuitive are driving these solutions, offering enhanced patient outcomes and cost-effective treatments through earlier detection and personalized medicine.

Exhibit 4.4.2

Business impact of nanomedicine along patient journey

	Screening	Diagnosis and staging	Treatment and monitoring	Follow-up
Conventional approach	• **Limited accuracy** • **Narrow** screening scope • **Macroscale** site imaging	• **Surface-level** detection • **Invasive procedures** • **Low-sensitivity** testing	• **Longer recovery** time • **Significant** side effects • **Systemic** drug distribution	• **Non-specific markers** • Post-treatment delays
Modern approach	• Highly **accurate testing** • **Comprehensive screening** • Integrated imaging	• **Holistic** health assessment • **Reduces** patient discomfort	• **Less** recovery time • **Targeted** drug delivery **Personalized treatment**	• **Non-invasive** imaging • **Targeted** molecular markers

Business impact

- Improved throughput
- Increased patient satisfaction
- Lower costs
- Quicker TAT
- Increased success rate
- Greater demand
- Lower follow-up costs
- Improved patient outcomes

Exhibit 4.4.3

Use cases and applications of nanomedicine

Targeted drug delivery	Nanodiagnostics	Nanorobots for surgery	Tissue engineering	Nanotheranostics
• Uses nanoparticles to **encapsulate and deliver drugs to specific cells or tissues** • Enables **precise dosing and controlled** release of medications	• Utilizes nanoparticles or nanodevices for **early and accurate disease detection** • Enables **real-time monitoring of biological processes**	• Develops microscopic robots for **minimally invasive procedures** • Enables **precise targeting of diseased** cells or tissues	• Uses nanomaterials to **create scaffolds for tissue regeneration** • Enhances **biocompatibility of implants**	• **Combines diagnostic and therapeutic capabilities** in a single nanoplatform • Enables real-time **monitoring of treatment efficacy**

Impact

Targeted drug delivery	Nanodiagnostics	Nanorobots for surgery	Tissue engineering	Nanotheranostics
• Increased **treatment efficacy** • Reduced **side effects** • Improved **patient outcomes** • Treatment of previously **inaccessible areas**	• **Early disease detection** • Improved **diagnostic accuracy** • **Reduced healthcare costs** • **Personalized treatment**	• Reduced **surgical trauma** • Shorter **recovery time** • Improved **surgical outcomes** • Enables previously **impossible procedures**	• Accelerated **wound healing** • Improved **integration** of medical implants • Enables **complex tissue** and **organ regeneration**	• **Personalized and adaptive treatment** • Reduced **diagnosis time** • Improved **patient care efficiency**

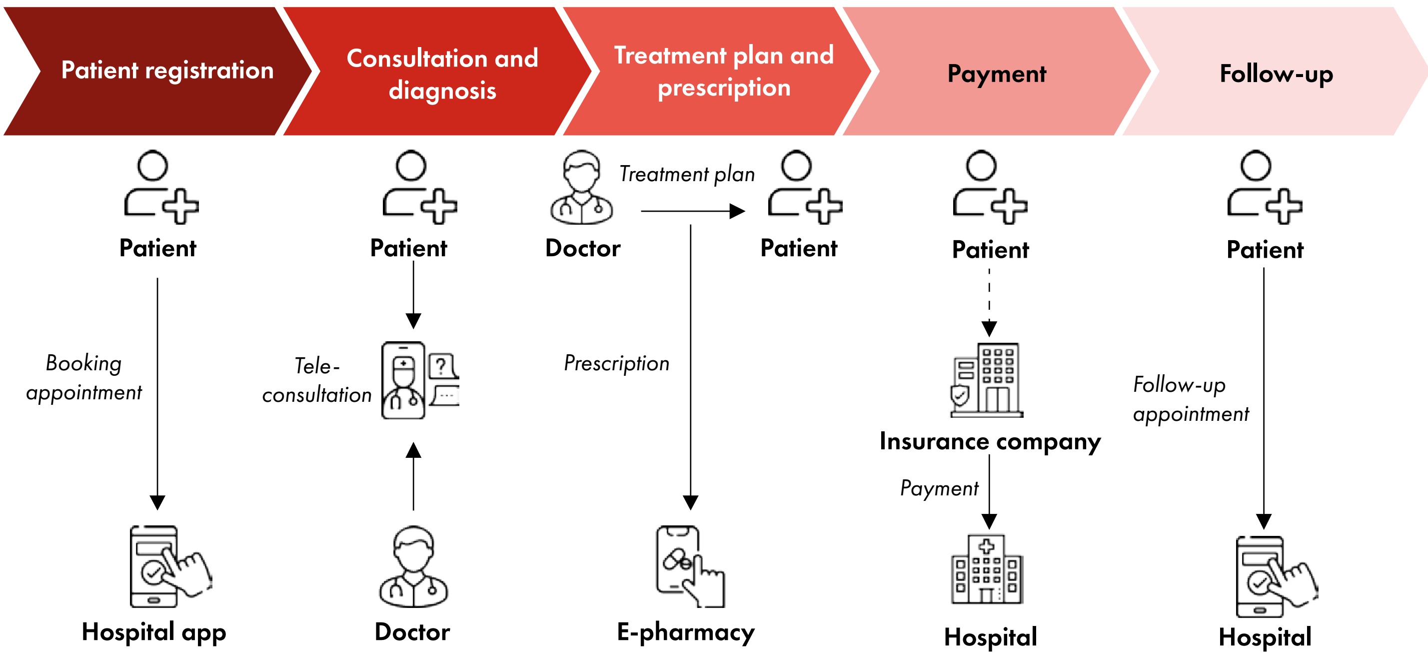
4.5 Digital OPD

Digital OPD is transforming traditional healthcare by enabling remote access to medical consultations, treatments, and follow-up services. It integrates various technologies to streamline the patient journey—from registration to diagnosis, treatment, payment, and follow-up. Digital tools such as hospital apps for booking appointments, teleconsultation platforms for remote doctor interactions, and e-pharmacies for prescription fulfillment greatly enhance patient convenience. This system reduces physical wait times, improves operational efficiency, and ensures continuous care with fewer touchpoints.

Successful implementation of digital OPD requires integrating diverse technologies into the hospital's infrastructure. Hospitals employ chatbots for initial patient interactions, AI-driven symptom checkers for preliminary assessments, and digital kiosks for e-diagnostics. Secure payment gateways, insurance claim management apps, and follow-up scheduling tools further streamline the end-to-end process. A patient-facing app consolidating medical history, appointments, and other data ensures a seamless, transparent healthcare journey.

Exhibit 4.5.1

Digital OPD tools across each stage of the patient journey



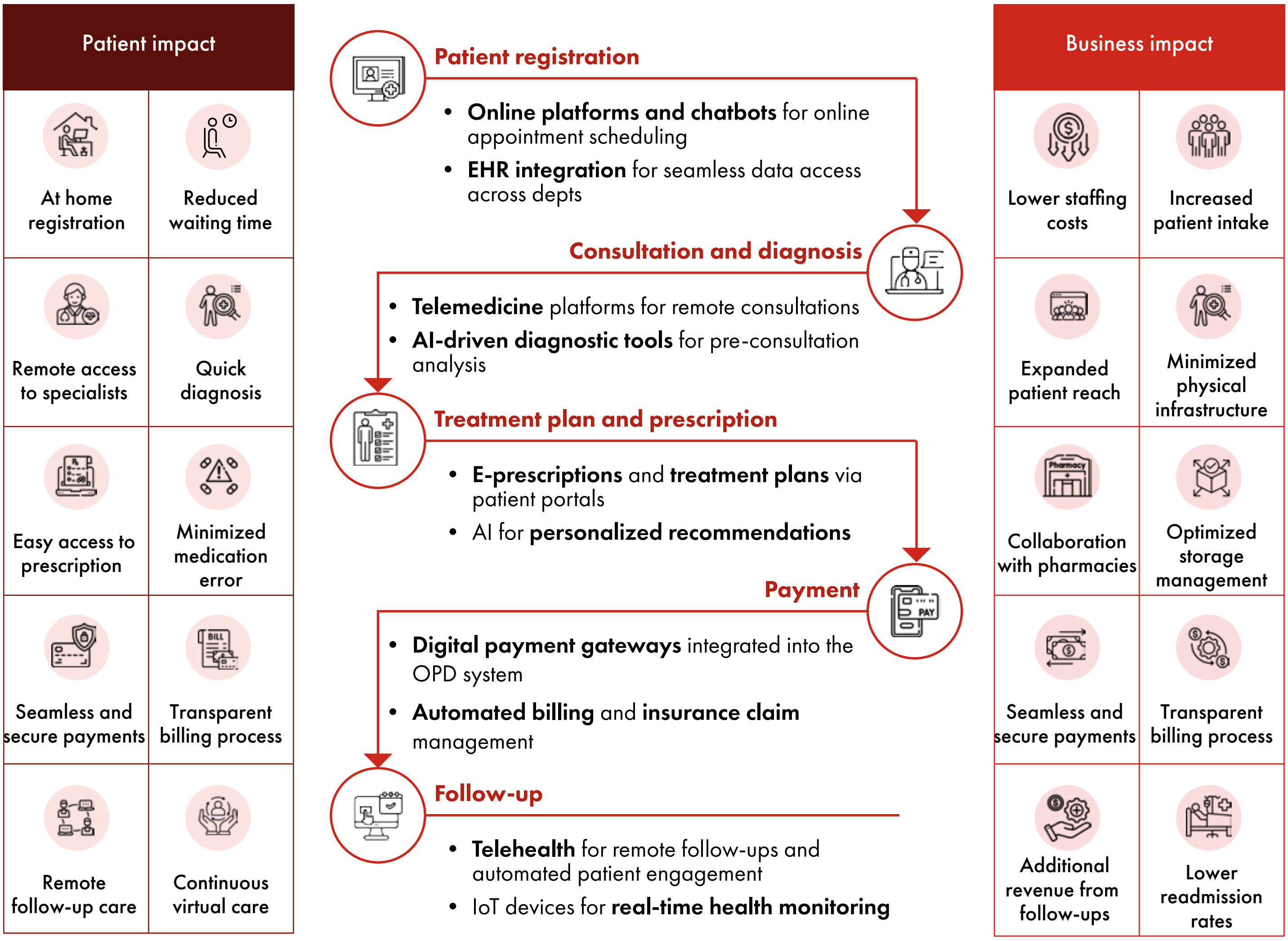
Digital tools available across patient journey

Chatbot				
Appointment scheduler app	E-diagnostics	E-pharmacies	Online payment methods in app	
AI symptom checker app	Digital kiosks		Insurance claim management in app	
AI symptom checker app				
Patient facing hospital app (integrated patient data)				

For hospitals, digital OPD offers significant advantages, including reduced staffing costs, improved patient intake, and an expanded reach through virtual consultations. It optimizes processes like registration, diagnostics, treatment, and payment, reducing physical infrastructure needs while improving service delivery. Hospitals can create new revenue streams through digital services and follow-up consultations, while faster payment processing improves cash flow. Additionally, automation of billing and lower readmission rates lead to reduced operational costs.

Exhibit 4.5.2

Leveraging digital OPD for patient outcomes and business growth in smart hospitals

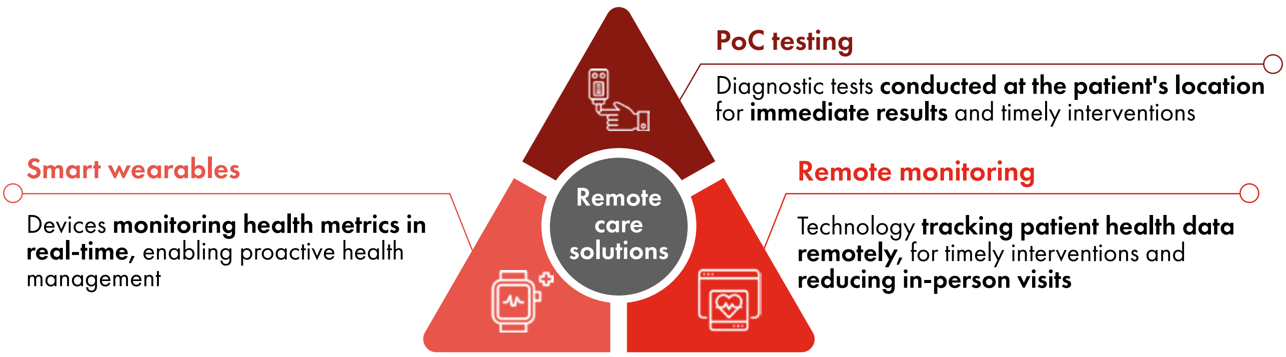


4.6 Remote care solutions

Remote care solutions leverage innovative technologies to enhance patient care outside traditional settings. This includes Point of Care Testing (PoCT) for immediate diagnostic results, smart wearables that monitor health metrics in real time, and remote monitoring that tracks patient data for timely interventions. Together, these solutions improve patient engagement and streamline care delivery.

Exhibit 4.6.1

Overview of remote care solutions



Remote care solutions drive significant business impact for hospitals across key areas. In chronic care management, continuous monitoring and PoC diagnostics reduce readmissions and generate recurring revenue. For rural care, remote monitoring enhances patient access and lowers infrastructure costs. Preventive programs create new revenue streams through subscription services while decreasing advanced treatment costs. Telemedicine, supported by real-time data, improves premium services and reduces in-person consultation expenses. In clinical trials, remote data collection accelerates time-to-market, lowers costs, and boosts participant retention.

Exhibit 4.6.2

Leveraging remote care solutions for patient outcomes in smart hospitals

Remote care solutions	Conventional approach	Modern approach leveraging AI	Business impact	
Chronic care management	• **Periodic** physical visits • **Manual** symptom tracking	• **Continuous health tracking** • **Real-time** PoC diagnostics	Recurring revenue	Lower operational costs
Remote care in rural areas	• **Limited access** • Reliance on **inadequate facilities**	• **At-home** health monitoring • **Instant diagnostics**	High patient acquisition	Less infrastructure cost
Preventive care programs	• **Annual in-person check-ups** • **Reactive approach** to diseases	• **Continuous wearable monitoring** • **Real-time** proactive interventions	Subscription-based revenue	Lower costs
Clinical trials and research programs	• **Repeated** physical visits • **Inconsistent** data	• **Real-time** data collection • **Enhanced accuracy**	Reduced time-to-market	Reduced trial costs

4.7 Smart laboratories

Smart labs are revolutionizing healthcare delivery by integrating advanced technologies to enhance efficiency, accuracy, and patient care. The exhibit below presents a comparative analysis of conventional laboratory approaches versus modern, technology-driven methods across five key stages: sample acquisition, preparation and processing, analysis and interpretation, reporting, and quality control. While conventional methods rely heavily on manual processes, leading to inefficiencies, inconsistencies, and delays, smart labs leverage IoT, RFID, automation, AI, and machine learning to streamline operations and improve accuracy.

The adoption of smart lab technologies significantly enhances laboratory operations, offering increased capacity, cost efficiency, and faster turnaround times. These innovations enable efficient high-volume sample processing, quicker diagnoses, and premium rapid-reporting services. By minimizing errors and ensuring high-quality standards, smart labs improve operational efficiency, enhance patient care, and attract valuable partnerships. Ultimately, this transformation leads to faster, more accurate diagnostic results, improving healthcare delivery and patient outcomes.

Exhibit 4.7.1

Business impact of smart labs across the diagnostics value chain

	Sample acquisition	Preparation and processing	Analysis and interpretation	Reporting	Quality control
Conventional approach	• **Manual collection** prone to errors • Physical transport without live tracking	• **Inconsistent manual processes** • Limited automation and integration	• **Variability in interpretation** • **Slow analysis with minimal AI**	• **Delays from manual review** • Slow reporting with **unlinked systems**	• Manual audits with late **error detection** • Processes **limiting scaling up**
Modern approach	• **IoT / RFID** tracking **reducing errors** • **Faster handling** and sample flow	• **Automation** improving efficiency • **AI workflows** reducing delays	• **Lower TAT** and **higher accuracy** • **ML** minimizing manual reviews	• **Automated reporting** • **Digital integration** improving data flow	• Real-time AI checks ensuring quality • **Fewer errors, faster corrections**

Business impact

- Increased sample capacity
- Cost savings
- Improved throughput
- Workforce optimization
- Lower diagnostics TAT
- Minimized expert dependency
- Faster report generation
- Improved patient and clinician turnaround
- Minimized downtime
- Lower compliance costs

4.8 3D printing and bioprinting

3D printing and bioprinting are revolutionizing healthcare delivery by enabling the creation of personalized medical solutions. These technologies allow for the rapid production of patient-specific implants, prosthetics, and anatomical models, improving surgical precision and efficiency. By tailoring treatments to individual anatomical needs, healthcare providers can improve patient outcomes and satisfaction while reducing operational costs.

Exhibit 4.8.1

Overview and applications of 3D printing and bioprinting

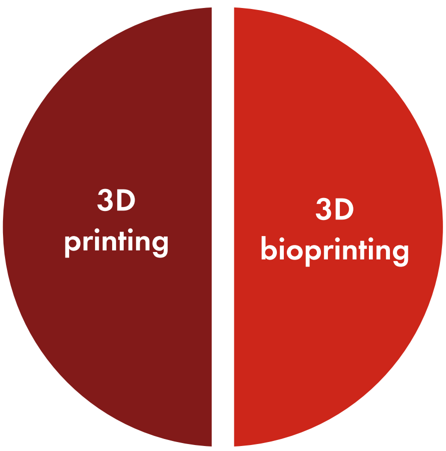
Physical anatomical model

Biologically inactive models replicating shape and structure

- **Customized implants**
- **Prosthetics**
- **Anatomical replicas**

Key applications

- Surgical planning and simulation
- Case-specific training and education
- Medical device testing on anatomical models
- Real-time guidance during surgery



Bioactive tissue model

Biologically active, capable of simulating the tissue micro-environment

- **Organ and tissue printing**
- **Cell-based therapeutics**

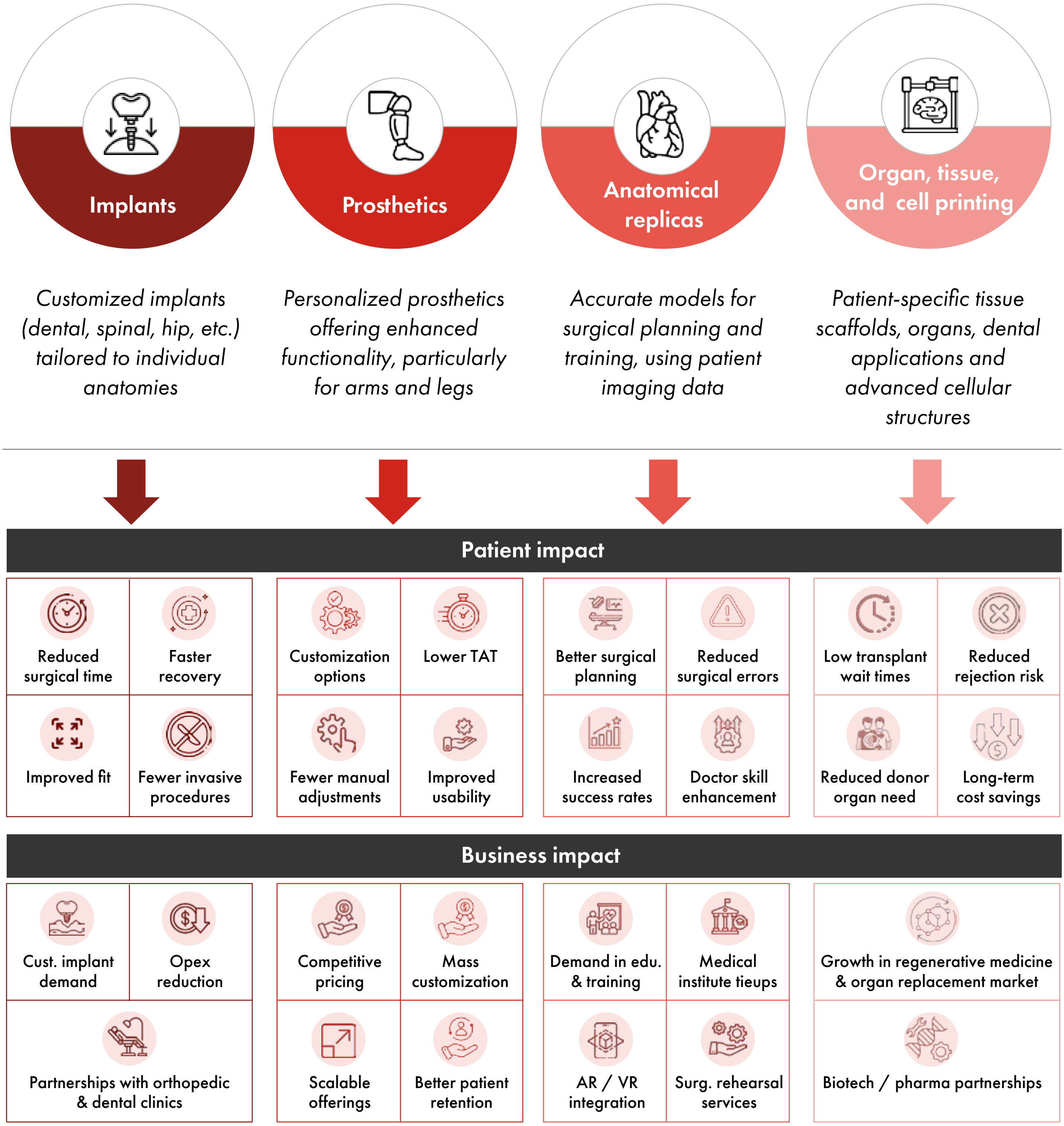
Key applications

- Regenerative medicine
  - Wound healing
  - Local tissue filling
  - Organ regeneration
- Organ transplantation
- Cell therapy
- Bioprinted dental applications
- Drug screening

The potential impact of 3D printing and bioprinting extends beyond individual patient solutions, significantly transforming healthcare delivery. These technologies allow doctors to create patient-specific implants, prosthetics, and organs that fit patients perfectly, helping improve comfort and surgical results. They also enable the making of detailed anatomical models for better planning before surgeries. By using these innovations, healthcare providers can work more efficiently and save costs, while improving patient health and satisfaction.

Exhibit 4.8.2

Leveraging 3D printing and bioprinting for patient outcomes and business growth in smart hospitals



5

VALUE ADDITION THROUGH EMERGING TECHNOLOGIES IN THE HEALTHCARE ECOSYSTEM

Emerging technologies are revolutionizing healthcare, creating value across the entire ecosystem. AI drives personalized medicine and operational efficiencies. Remote care solutions and digital platforms expand access, while genetic testing and nanomedicine enable targeted therapies. Advanced robotics enhance surgical precision and AI streamlines administration. These innovations improve patient outcomes, reduce costs, and foster a more proactive, precise healthcare system. From research to patient care and corporate strategy, technology is reshaping healthcare delivery to be more accessible, personalized, and effective, addressing current challenges while preparing for future demands.

5.1 Value addition through technologies in the healthcare delivery value chain

This technological revolution is evident across all patient care stages. Digital outpatient services and remote solutions enhance accessibility, while AI-enhanced diagnostics enable more accurate and early detection. Robotic surgery offers precision in treatment, and AI-driven tools support personalized follow-ups and remote monitoring post-treatment. These innovations streamline clinical and administrative tasks, building a more efficient, patient-focused healthcare system.

Exhibit 5.1

Value addition through emerging technologies in healthcare delivery value chain

Acquisition / Enrollment

AI
- Predictive patient outreach and enrollment
- Data-driven patient segmentation

Digital OPD
- Remote health evaluations for new patients
- Virtual enrollment consultations

Remote care solutions
- Wearable-based health data collection
- Initial health assessments using connected devices

Smart labs
- Secure patient data exchange
- Real-time verification of patient documents

Diagnosis

AI
- AI-powered diagnostic tools for early detection
- Predictive analytics for diagnostic accuracy

Genetic testing
- Personalized diagnosis based on genetic profiles
- Early detection of susceptibility to specific diseases

Remote care solutions
- Rapid testing and diagnosis in remote settings
- Portable diagnostic tools for quick results
- Wearable-driven real-time diagnostics

Treatment

AI
- AI-driven personalized treatment plans
- Auto-adjusting plans based on patient responses and real-time monitoring data

Robotics surgery
- Precision procedures via robotics for minimally invasive surgeries and micro-surgeries

Nanomedicine
- Targeted nano-therapies for precision treatment
- Drug delivery using nanotechnology

3D and bioprinting
- Custom tissue bio-printing for regenerative treatment
- Personalized 3D-printed implants and prosthetics

Post-treatment follow up

AI
- AI-driven personalized follow-up plans, and alerts for abnormal trends in recovery

Digital OPD
- Virtual consultations for post-surgery check-ins
- Remote monitoring of vital signs and symptoms

Remote care solutions
- Remote patient monitoring, providing immediate feedback to health providers
- Wearable-based reminders for medications and appointments

Claims / Payment

AI
- Automated claims processing with AI
- Fraud detection using predictive analytics
- Optimized payment processing based on data analysis

Smart labs
- Blockchain-secured claims processing
- Transparent transaction history for audits
- Automated payments using smart contracts

5.2 Value addition through emerging technologies in MedTech value chain

The MedTech industry is capitalizing on these technological advances across its entire value chain. AI and genetic testing are revolutionizing R&D, while nanomedicine is enabling ultra-precise diagnostic tools. AI-driven manufacturing and supply chain analytics are improving operational efficiency, and wearable data is driving targeted marketing. At the corporate level, AI enhances strategic decisions, positioning MedTech companies as key players in delivering more precise and effective patient care.

Exhibit 5.2

Value addition through emerging technologies in MedTech value chain

Research and development

AI
- AI-driven drug discovery and medical device innovation
- Big data analysis for clinical trial optimization

Genetic testing
- Genetic insights to drive personalized MedTech solutions
- R&D into gene-based treatments and technologies

Nanomedicine
- Nano-scale innovations in diagnostics and treatment tools

3D and bioprinting
- Rapid prototyping of MedTech devices

Operations and process management

AI
- AI for optimizing manufacturing processes
- Data-driven inventory and supply chain management

3D and bioprinting
- 3D printing for rapid production of MedTech components
- On-demand printing of customized medical devices

Marketing and sales

AI
- AI-driven customer segmentation and targeting
- Predictive analytics for sales forecasting

Remote care solutions
- Wearable data integration for customer engagement
- Health data-driven marketing campaigns

Customer service and post purchase support

AI
- AI-driven customer support chatbots and virtual assistants
- Predictive maintenance alerts for medical devices

Remote care solutions
- Continuous monitoring of device usage through wearables
- App-based device maintenance reminders for customers

Corporate roles and strategic partnerships

AI
- AI-powered corporate performance monitoring
- AI-driven decision-making for corporate strategies
- Big data analysis for partnership opportunities

5.3 Value addition through emerging technologies in diagnostics value chain

The integration of smart technologies, like AI, genetic testing, remote care solutions, and digital OPD, is reshaping the healthcare diagnostics landscape. These advances improve each stage of the diagnostic process, enabling more precise, personalized, and accessible healthcare delivery. From AI-driven sample processing to remote care and monitoring, these innovations allow for faster, more accurate diagnoses and streamlined reporting. This evolving value chain reflects a shift toward connected and efficient diagnostics, playing a crucial role in delivering precise, patient-centered healthcare.

Exhibit 5.3

Value addition through emerging technologies in diagnostics value chain

Acquisition and pre-processing

AI
- Automated image optimization
- Noise and artifact reduction
- Segmentation of key features
- Automated reagent and resource allocation

Remote care solutions
- Continuous health data transmission to labs
- On-site immediate testing
- Continuous patient monitoring
- Vital sign-driven imaging

Genetic testing
- Automated DNA / RNA extraction systems

Smart labs
- Real-time sample tracking
- Automated equipment adjustments

Analysis and interpretation

AI
- Automated anomaly detection from imaging / pathology slide analysis
- High-risk area identification
- Predictive diagnostic insights

Genetic testing
- Identifying disease markers
- Personalized treatment basis genetic profiles
- Gene expression profiling

Remote care solutions
- Bedside imaging diagnostics
- AI-enhanced rapid interpretation

Reporting

AI
- Automated report generation
- Structured report suggestions
- Predictive insights integrated reports

Digital OPD
- Instant sharing of lab results
- Virtual consultations to review and discuss reports
- Remote result explanation
- Integration with patient's EHRs

Quality control

AI
- Real-time process monitoring
- Error detection in lab processes
- Quality trend analysis
- Automated quality reviews

Smart labs
- Continuous equipment performance monitoring
- Automated calibration reminders and adjustments
- Real-time alerts for deviations

5.4 Value addition through emerging technologies in pharma value chain

The pharmaceutical sector is rapidly evolving, driven by transformative technologies across its value chain. AI emerges as a cornerstone, optimizing processes from research to manufacturing. Genetic testing and nanomedicine enhance early-stage precision, while 3D printing enables personalized medicine production. Smart laboratories automate crucial processes, improving efficiency and quality control. Remote care solutions revolutionize clinical trials by expanding participation and data collection. This technological ecosystem accelerates drug development, reduces costs, and enables more targeted therapies, steering the industry towards data-driven, personalized, and highly efficient processes. The synergy of these innovations marks a significant shift in pharmaceutical development, promising faster breakthroughs and improved patient outcomes.

Exhibit 5.4

Value addition through emerging technologies in pharma value chain

Research

AI
- Accelerates drug discovery
- Analyzes data and predicts properties

Genetic testing
- Understands genetic factors in diseases
- Targeted research

Nanomedicine
- Explores novel drug delivery methods

Smart labs
- Automate and optimize research processes
- Improves efficiency and reproducibility

Discovery

AI
- Helps in lead optimization
- Aids in drug-target interactions & potential side effects

Genetic testing
- Identifies biomarkers for drug targets and patient stratification

3D printing and bioprinting
- Enable rapid prototyping of drug delivery systems
- Creates tissue models for testing

Pre-clinical

AI
- Supports in silico testing
- Reduces animal testing

Smart labs
- Improves precision and automation

3D printing and bioprinting
- Accurate tissue and organ models for drug testing

Clinical

AI
- Optimizes clinical trial design
- Improves patient recruitment and data analysis

Remote care solutions
- Enables broader participation in clinical trials
- Improves continuous data collection

Registration

AI
- Analyzes and prepares regulatory submission data

Manufacturing

AI
- Optimizes manufacturing processes
- Predicts maintenance needs
- Ensures quality control

Smart labs
- Automates quality control processes
- Ensures compliance with regulations

3D printing and bioprinting
- Enables on-demand production of personalized medicines or drug delivery devices

Nanomedicine
- Allows for precise manufacturing of nanoparticle-based drugs

6

AYUSHMAN BHARAT DIGITAL MISSION

The Ayushman Bharat Digital Mission (ABDM) aims to digitize healthcare in India by providing every citizen with a unique Health ID. This ID enables the storage and access of medical records across healthcare providers. ABDM has established an integrated health information exchange system where linked IDs including the Ayushman Bharat Health Account (ABHA) number for patients, Healthcare Professional IDs, and Health Facility IDs serve as the backbone. These identifiers act as bridges between Health Information Providers and Health Information Users. At the heart of this system is the Health Locker, which securely manages health data, facilitating seamless and secure information flow. This foundational infrastructure has already made significant strides, with millions of health records and professionals registered, ensuring comprehensive healthcare delivery while maintaining privacy and data integrity.

Exhibit 6.1

Overview of ABDM and its core components

Health Information Providers (HIP)	Health locker	Health Information Users (HIU)
Provide health information into the exchange system	*Securely stores and manages health data, with controlled access for patients and providers*	*Utilize health data from the exchange system*

Health Information Providers (HIP)

- **Public health programs** — *Government initiatives providing public health data*
- **Doctors & hospitals** — *Adding patient data and medical history, creating a comprehensive patient profile*
- **Diagnostic centers** — *Uploading diagnostic test and imaging results*
- **Patients** — *Adding personal health data, while giving consent for data sharing and usage*

Linked IDs

- **ABHA number** — *Unique HID for patients*
- **Healthcare professional ID** — *Unique HID for healthcare professionals*
- **Health facility ID** — *Unique HID for health facilities*

Services enabled by ABDM

Health Information Users (HIU)

- **Government** — *Government initiatives providing public health data*
- **Doctors & hospitals** — *Accessing patient's medical history, diagnostics, and treatment data*
- **Diagnostic centers** — *Accessing patient's medical history for informing testing requirements or interpretations*
- **Patients** — *Accessing and manage their personal health records*

Key Unified Health Interface (UHI) services

- **Teleconsultation booking**
- **Appointment booking**
- **Lab tests & sample collection booking**
- **Ambulance services booking**
- **Discovering availability of critical beds**
- **Discovering nearby pharmacies**

ABDM transforms patient care by creating a unified healthcare network that improves data access and streamlines processes. The system enables secure and personalized care through identity verification and real-time access to medical records, accelerating decision-making and reducing administrative delays. Privacy controls empower patients to manage their health data, while healthcare providers gain timely access to essential information, leading to more accurate diagnoses and timely interventions. Continuous updates to medical records ensure better care continuity, ultimately fostering a more patient-centric, efficient, and trustworthy healthcare ecosystem. This interconnected system enhances health outcomes by improving both care delivery and patient engagement.

PRAXIS GLOBAL ALLIANCE

Exhibit 6.2

ABDM-enabled OPD journey of patient

1 Facility registration

Hospital / lab registers itself on the **Health Facility Registry** to be part of the ABDM network

2 Health ID verification

Patient shares their **Health ID** upon arrival or gets assistance to create one, enabling secure and personalized care

3 Instant patient information access

Facility retrieves patient details (name, age, gender, contact, etc.) **from the Health ID,** reducing admin delays and ensuring accuracy

4 Consent for medical history access

Facility **sends a consent request,** asking the patient to **grant access to their medical records,** ensuring privacy and compliance

5 Data sharing preferences

Patient **selects which medical data to share** with the hospital / lab and **for how long,** giving them control over their health information

6 Access to patient medical history

Consulting doctors or lab staff can **view the patient's medical history in real-time** during consultations, enabling informed decision-making

7 Report availability notification

Post consultation / investigation, patient **receives a notification** once their **medical reports are ready**

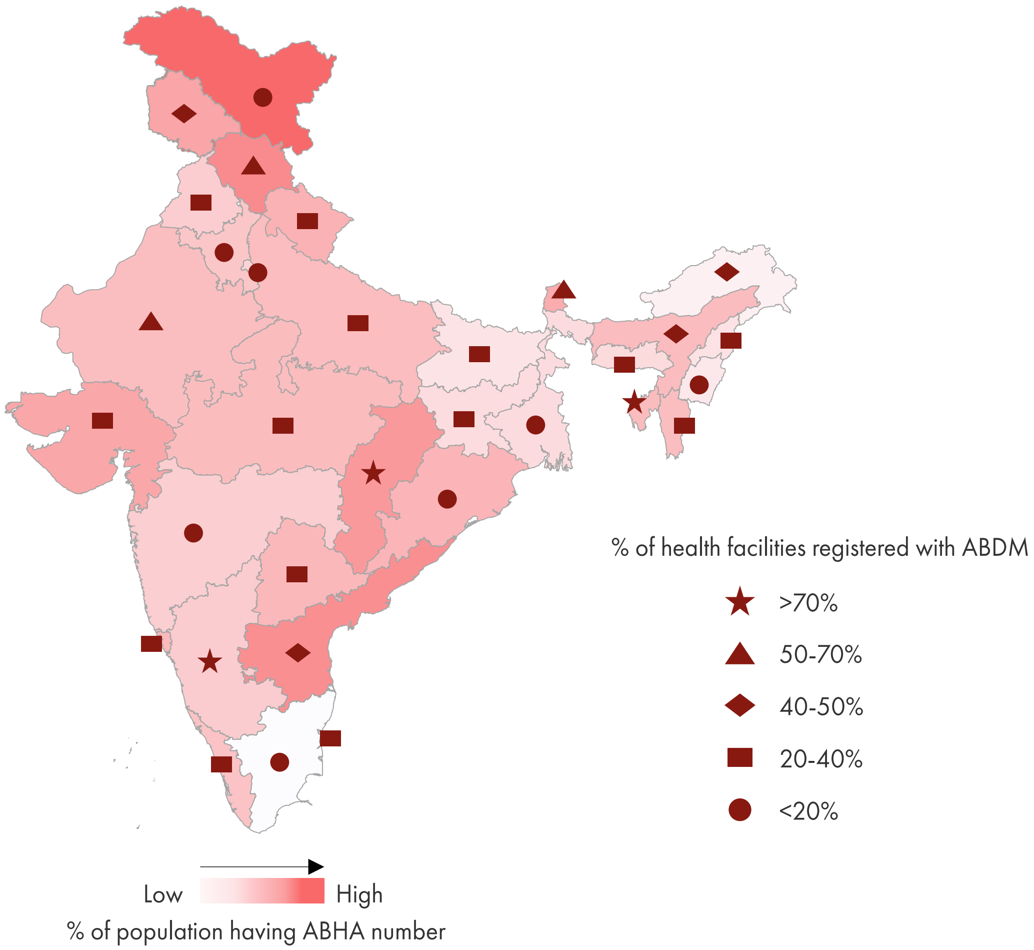
8 Digital record updates

Doctor's treatment plan, prescriptions and reports are **automatically uploaded** to the patient's **Personal Health Record** (PHR), keeping their medical history up-to-date

Exhibit 6.3 illustrates the regional progress of ABHA adoption and ABDM facility registration across India. States with higher ABHA adoption, indicated by deeper shades, do not typically align with states showing significant facility registration under ABDM, as shown by the symbols. This disparity suggests that while there is relative progress in patient ABHA registration, facility integration is inconsistent. For ABDM's objectives to be fully realized, states with high ABHA adoption but low facility registration would need to improve healthcare provider participation, bridging the gap between patient data availability and facility readiness for integrated care.

Exhibit 6.3

ABHA number adoption and ABDM health facility registration across states in India



While the ABDM promises transformative benefits, it faces several challenges. Key hurdles include high infrastructure costs, concerns around data security, and the need for interoperability between existing healthcare IT systems. Additionally, digital literacy gaps—especially in rural and economically disadvantaged areas—pose barriers to equitable access. The regulatory framework will need to evolve to address emerging issues in telemedicine, data management, and digital healthcare governance. Despite these obstacles, ABDM offers tremendous potential for driving sector-wide improvements in healthcare quality, accessibility, and cost-effectiveness. By empowering stakeholders with better tools and information access, ABDM has the potential to become a model for large-scale digital health transformation in India and beyond.

PRAXIS GLOBAL ALLIANCE

Exhibit 6.4

An outlook of ABDM across various stakeholders of the healthcare ecosystem

Potential use cases

Hospitals
- Access to medical history access using **centralized patient record management** via Health IDs improves care coordination and **reduces errors**
- Streamlined **appointment scheduling and billing** reduce administrative burden and **speed up patient flow**
- AI-driven clinical decision support **enhances diagnostics and personalizes treatment** with centralized records
- Predictive analytics for **resource allocation and patient flow management**

Diagnostics
- Integrated access to comprehensive health records **helps avoid unnecessary and repetitive tests**
- **Automated test result** sharing with physicians and patients
- Digital platforms for **scheduling home sample collection** boost convenience and **reduce missed appointments**
- **Data visualization platforms** enable trend analysis, helping **labs offer proactive and preventive care solutions**

MedTech
- **Real-time data integration** with hospital systems
- Data-driven R&D **accelerates innovation,** developing devices and solutions tailored to patient needs
- **Predictive maintenance** minimizes downtime, ensuring **optimal device performance** and reducing costs
- Equipment **utilization analytics optimize resources,** improving cost-effectiveness and device management

Pharma
- Digital prescription access improves **drug tracking,** ensuring safe and accurate **medication dispensing**
- Health data-driven personalized medicine enables **targeted therapies,** enhancing treatment effectiveness and **minimizing side effects**
- Real-time **monitoring** of **drug efficacy** and **adverse reactions**
- **Blockchain-based supply chain tracking ensures drug authenticity** and reducing counterfeit

Insurers
- Real-time **access to patient health records** for claim validation
- Integrated insurance platform for **efficient and hassle-free claim process**
- Health data-driven insurance plans offering **cover tailored** to individual needs
- Utilizing **patient data analytics** for **underwriting risk assessment**
- Preventive care programs to promote healthier lifestyle **reducing** tendency **of future claims**

Regulators
- Real-time tracking of provider and **facility registrations to** ensure compliance
- Monitoring healthcare delivery standards to ensure consistent care and enhancing **patient safety**
- Data-backed policymaking enables **evidence-based decisions,** leading to more effective healthcare policies
- AI-powered adverse event monitoring **enhances safety by identifying and addressing risks early,** preventing widespread issues

Patients
- Universal **access to personal health records** through Health ID
- **Digital consultations** and remote care access, especially for rural or mobility-challenged patients
- **Easy access to e-prescriptions and lab results**
- Emergency health profiles with critical data **enhance safety by ensuring providers** have vital information
- Automated medication and appointment reminders to boost adherence

Impact

Hospitals	Diagnostics	MedTech	Pharma	Insurers	Regulators	Patients
Enhanced operational efficiency	Lower TAT	Greater demand for connected devices	Streamlined supply chain management	Reduced fraud cases	Improved transparency	Continuous care
Improved patient history access	Increased operational transparency	Improved market insights	Improved drug adherence	Data-driven product development	Evidence backed healthcare policies	Improved patient satisfaction

Barriers

Hospitals	Diagnostics	MedTech	Pharma	Insurers	Regulators	Patients
High digital infrastructure costs	Interoperability challenges	Data standardization challenges	Limited digital literacy	Resistance from stakeholders	Data management complexities	Accessibility challenges
Staff training and adaptability issues	IT infrastructure investment	Cross stakeholders Integration	Data privacy concerns	Regulatory compliance	Digital health policies gap	Resistance to digital adoption

7

CONCLUSION AND WAY FORWARD

The Indian healthcare delivery sector is entering a transformative phase where technology is improving outcomes for both patients and healthcare providers. Innovations like AI, Genetic testing, Nanomedicine, and Digital OPD are not only revolutionizing patient care but also enhancing the operational effectiveness of hospitals. For patients, these advancements lead to better health outcomes through more accurate diagnoses, personalized treatments, and quicker access to care. For hospitals, technology is streamlining operations, improving accuracy, and reducing turnaround times, resulting in higher efficiency and the ability to deliver better services.

1. **Accelerate technology adoption:** Hospitals must focus on integrating advanced technologies like AI-powered diagnostics, telemedicine, and digital platforms to improve both patient care and operational efficiency. These tools enable faster, more precise diagnoses and treatment plans, helping hospitals to respond to patient needs more effectively.

2. **Forge strategic partnerships:** Collaborating with technology firms, research institutions, and other healthcare providers is essential to harness the full potential of innovations in healthcare delivery. Strategic partnerships can facilitate knowledge sharing, streamline operations, and optimize resource utilization, enabling hospitals to implement advanced technologies that enhance patient outcomes and operational effectiveness.

3. **Prioritize patient-centric improvements:** With advancements in diagnostics and digital health solutions, patients are receiving more personalized care, timely interventions, and quicker recovery paths. This focus on patient-centric approaches not only improves health outcomes but also builds trust and satisfaction among patients.

4. **Optimize for scalability and efficiency:** Technology allows hospitals to expand their reach and services without heavy investments in physical infrastructure. Tools like telemedicine and AI-driven analytics enable hospitals to extend care to underserved areas while maintaining high standards of service delivery and efficiency.

5. **Foster collaboration and innovation:** Collaboration between healthcare providers, technology firms, and policymakers is crucial to accelerate the adoption of these innovations. By fostering such partnerships, hospitals can stay at the forefront of healthcare advancements, ensuring that patients benefit from cutting-edge treatments and providers from more effective processes.

In conclusion, the integration of technology into healthcare delivery is shaping a future where both patients and hospitals experience significant improvements. By adopting these innovations, the Indian healthcare system can offer better, more efficient care, ensuring healthier outcomes for patients and enhanced effectiveness for healthcare providers. Now is the time for stakeholders to embrace this transformation and drive the sector towards a smarter, more connected healthcare ecosystem.

PRAXIS GLOBAL ALLIANCE

About us

Praxis Global Alliance is the next-gen management consulting firm revolutionizing how consulting projects are delivered. It delivers practical solutions to the toughest business problems by uniquely combining domain practitioner expertise, AI-led research approaches, and digital technologies. The company operates three business units, including Praxis Global Alliance Transactions, offering pre-deal support, commercial due diligence, post-acquisition value creation, Praxis Global Alliance Strategy and Transformation for practitioner-led business advisory and consulting, and PraxDigital™ delivering data engineering and analytics, AI, OpenData and visualization solutions to clients across verticals.

With a presence across 6 locations in India, UAE, and Saudi Arabia, Praxis Global Alliance has successfully served over 40 countries with a dedicated team of consultants and data scientists. Team Praxis works with C-suite to the front-line executives across business streams, helping them with end-to-end business enablement, organizational transformation, and revenue maximization support in an agile environment.

For more details, please visit:
https://www.praxisga.com/

Our offerings

GrowRevenue

- Sales acceleration
- Go-to-market
- Omni-channel distribution
- Customer experience and loyalty
- Strategy & business planning

GrowPerformance

- Metric movement
- Playbook creation
- Cost efficiency
- Supply chain optimization

GrowValue

- M&A and due diligence
- Sell side: Vendor CDD and road to IPO
- Integrity DD / Forensic DD
- Operational DD
- Future tech readiness

GrowSustainably

- ESG due diligence
- ESG value creation plan
- Impact assessment
- Sustainable supply chains
- Circular economy

Senior healthcare leadership team at Praxis Global Alliance

Aryaman Tandon

Managing Partner

Healthcare and Lifesciences,
Technology and Internet,
Mobility Energy and Transportation

Garima Malhotra

Associate Partner

Healthcare and Lifesciences

Ayush Singh

Manager

Healthcare and Lifesciences

Anjan Bose

Practice Leader and Advisor – Healthcare

Founder and Secretary General,
NATHEALTH

Prabal Chakraborty

Practice Leader and Advisor – Medical Devices & Cons.

Ex-Boston Scientific Company,
J&J Medical India

Connect with us

We will be happy to share perspectives

Aryaman Tandon
Managing Partner - Healthcare and Lifesciences
E: aryaman.tandon@praxisga.com

For media queries, please contact

Vaishnav Kumar Rai
Manager - Corporate Communications
E: communications@praxisga.com
M: +91 782 794 4925

www.praxisga.com

Build Together.
Win Together.