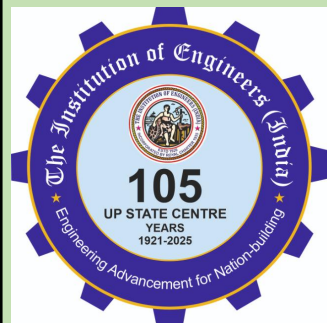
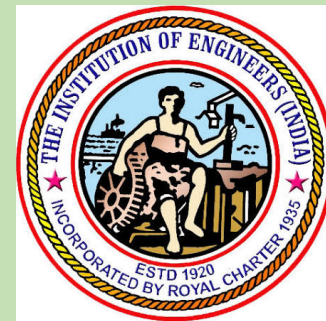




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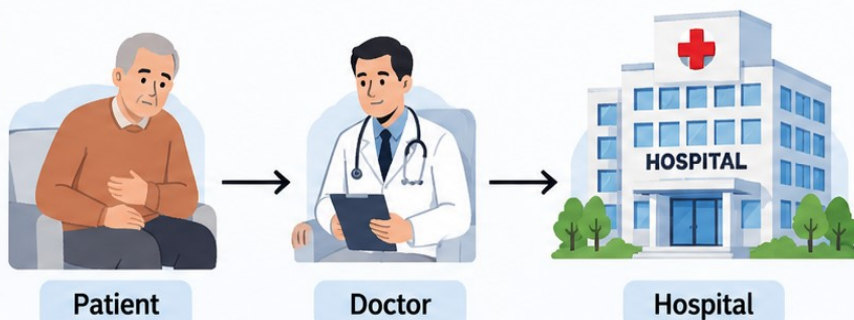
Communication-Enabled Smart Healthcare: Applications and Future Perspectives

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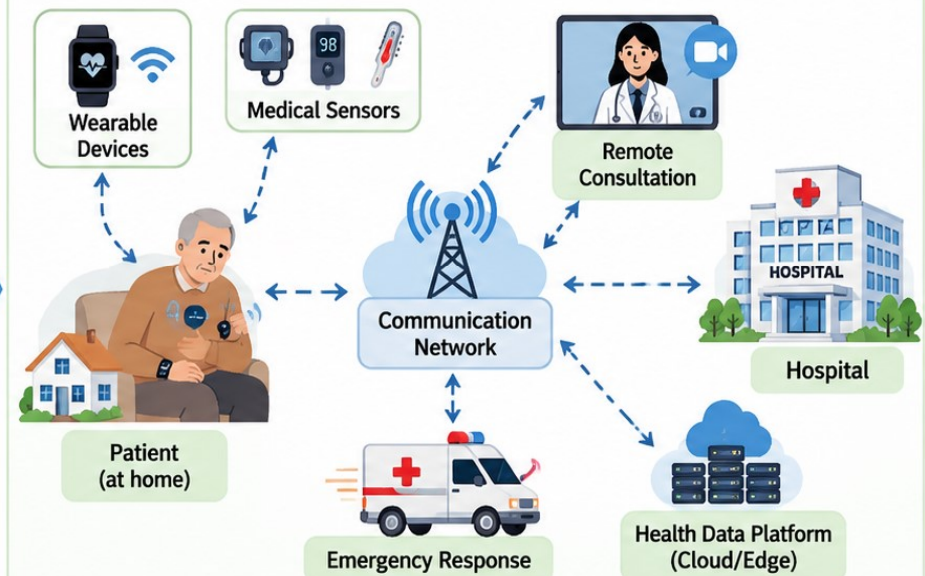
Traditional Healthcare Vs Emerging Healthcare

Traditional Healthcare



- Patient visits hospital when care is required
- Information is often collected at specific points
- Communication is mainly patient $\leftrightarrow$ doctor/hospital
- Limited continuous monitoring

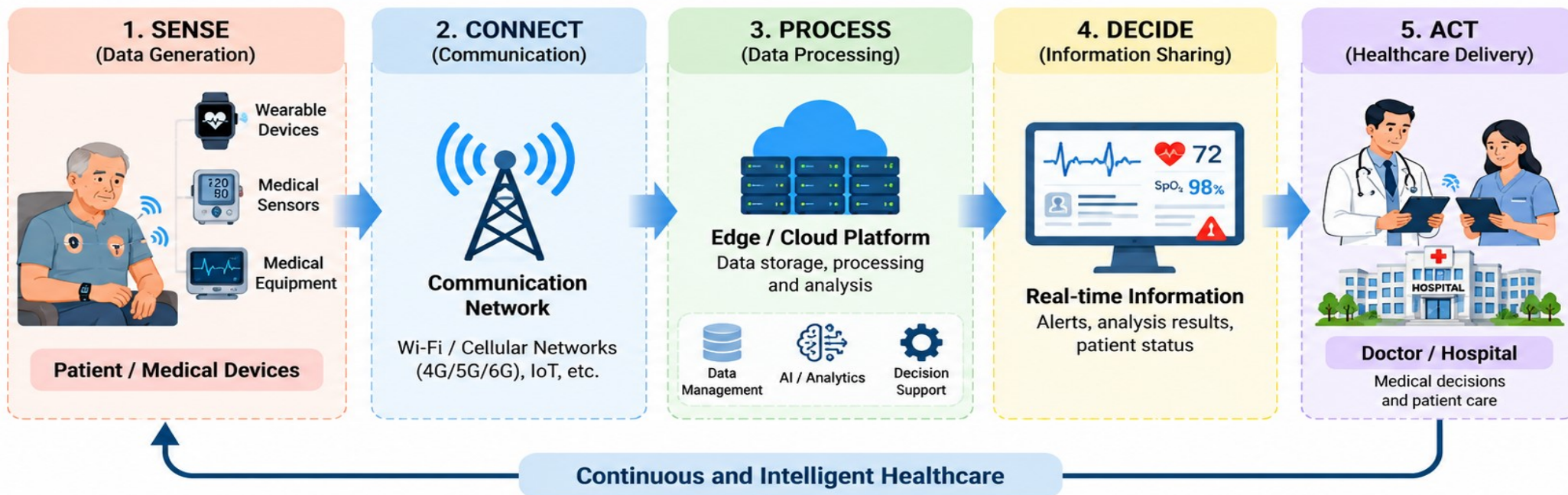
Emerging / Connected Healthcare



- Continuous patient monitoring
- Connected medical devices
- Remote consultation
- Real-time information sharing
- Faster emergency response

Smart Healthcare

- **Smart Healthcare** is an approach that integrates connected medical devices, communication networks, and intelligent data processing to enable continuous patient monitoring, timely medical decisions, and improved healthcare delivery.
- It connects patients, healthcare professionals, medical devices, and healthcare platforms to support efficient and responsive medical services.



The Role of Communication in Smart Healthcare

Communication networks link patients, medical devices, healthcare platforms and medical professionals, enabling health information to be shared beyond the patient's immediate location.

What communication enables:

- ***Information exchange:*** Patient measurements and medical data can reach healthcare professionals and platforms.
- ***Remote access:*** Doctors can access relevant patient information without always being physically present.
- ***Timely response:*** Alerts and patient updates can reach the appropriate healthcare team when needed.
- ***Connectivity during movement:*** Patient information can be exchanged while a patient is at home or travelling in an ambulance, where network coverage permits.

Evolution of Communication Technologies: 4G to 5G and Emerging 6G

4G

(2010s)

Mobile Broadband

- Supports mobile internet and online services
- Enables video calls and telemedicine consultations
- Suitable for many basic healthcare applications



Connecting People

5G

(2020s)

Enhanced Connectivity

- Higher data rates
- Low-latency potential
- Support for a large number of connected devices
- Improved reliability
- Enables advanced healthcare services



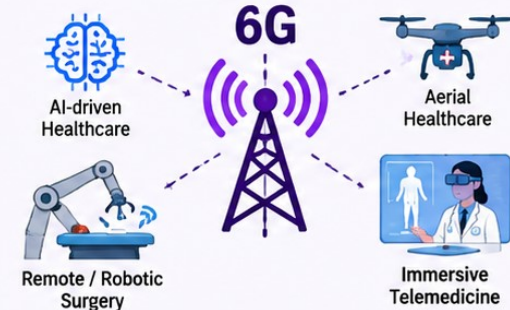
Connecting Everything

Emerging 6G

(2030s and beyond)

Future Research and Development

- More intelligent and self-organizing networks
- Closer integration of communication, sensing and AI
- Potential for ultra-low latency and high reliability
- Support for immersive and advanced healthcare applications



Intelligent and Integrated Connectivity

Why is 5G Relevant to Healthcare?

Capability	Relevance
Higher data rates	Can help transfer large medical images and support high-quality video consultations.
Low-latency communication	Can support time-sensitive information exchange, such as transmitting patient updates from a connected ambulance.
Support for dense device connectivity	Can help accommodate many connected sensors and devices in a smart hospital.
Connectivity for mobile services	It can support communication with medical teams and patients in transit, subject to coverage and network conditions.

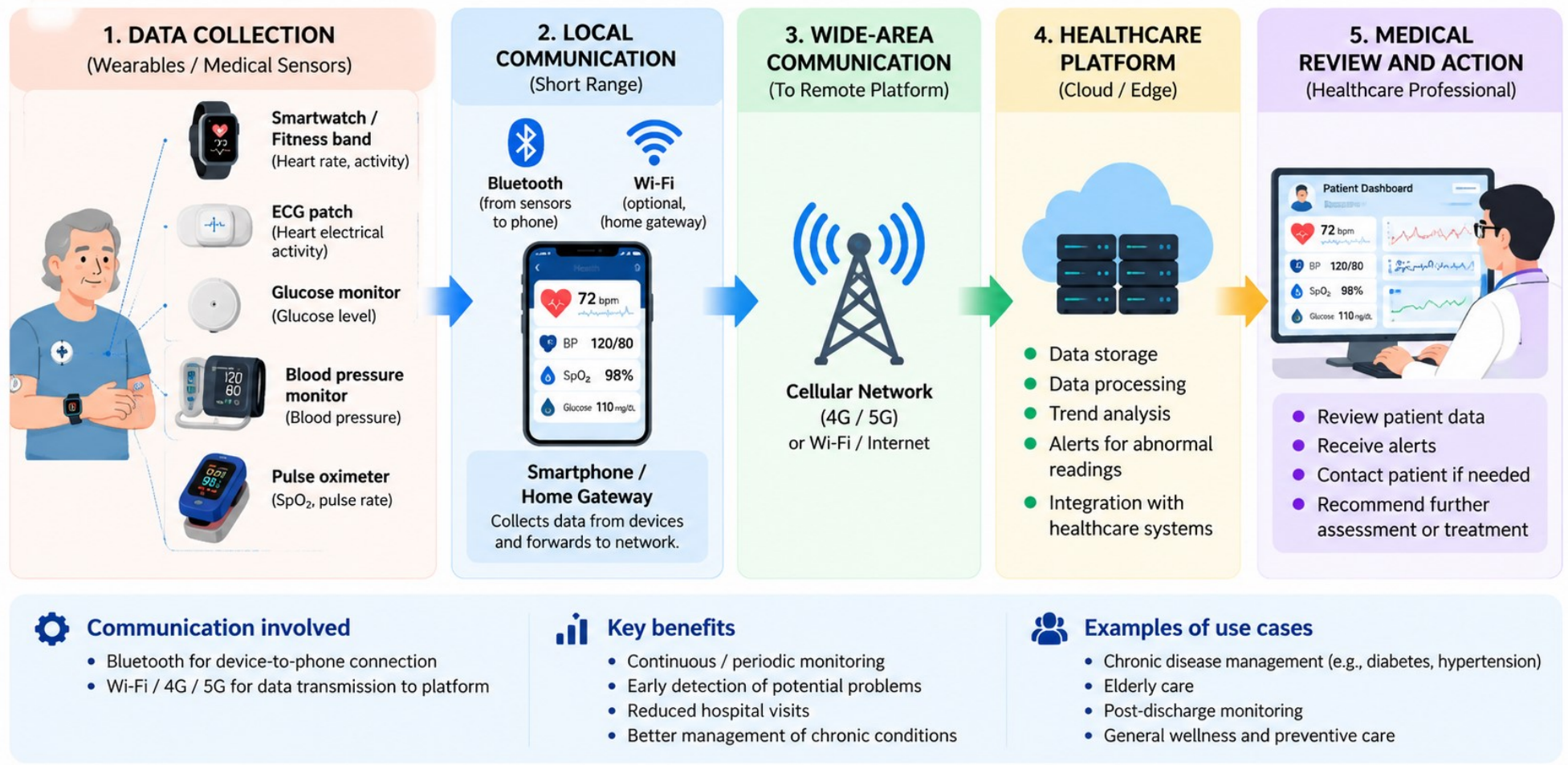
Application 1- Remote Patient Monitoring

Remote Patient Monitoring (RPM) enables healthcare professionals to monitor a patient's health remotely using wearable devices and medical sensors that collect physiological data.

Wearables and Medical Sensors

Device	Information collected
Smartwatch / fitness band	Heart rate, physical activity
ECG patch	Electrical activity of the heart
Continuous glucose monitor (CGM)	Glucose levels over time
Blood-pressure monitor	Systolic and diastolic blood pressure
Pulse oximeter	Blood oxygen saturation (SpO ₂) and pulse rate

How Remote Patient Monitoring Works

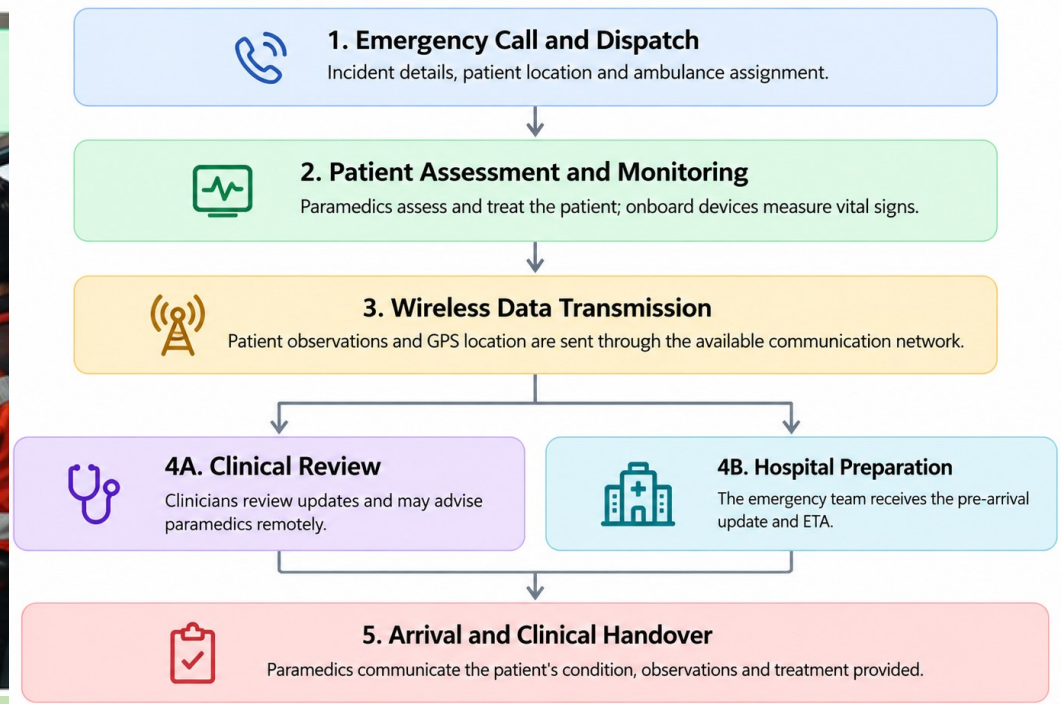
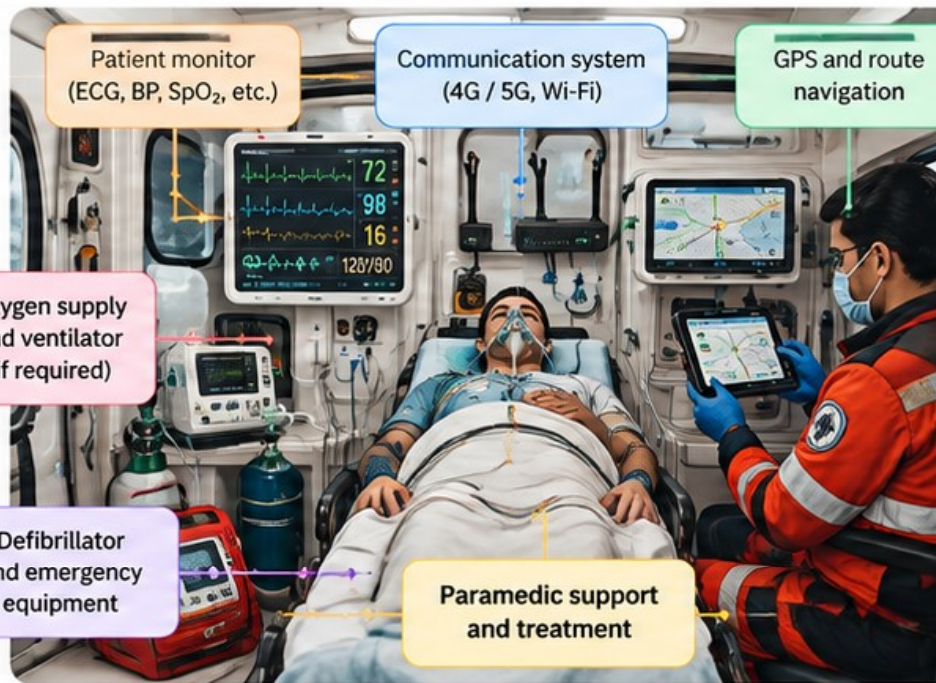


Application 2- Smart Ambulance

A smart ambulance integrates onboard medical monitoring, wireless communication, GPS and hospital connectivity to support patient care and emergency coordination during transport.

Key Functions

- **Onboard Patient Monitoring:** Monitors ECG and vital signs such as heart rate, blood pressure and oxygen saturation (SpO₂).
- **Real-Time Data Transmission:** Sends relevant patient observations and updates to the dispatch centre or receiving hospital through an available communication network.
- **Remote Medical Support:** Enables a hospital clinician to communicate with paramedics and provide guidance when telemedicine facilities are available.
- **GPS and Hospital Coordination:** Shares ambulance location and estimated arrival time, helping the emergency department prepare staff and equipment in advance.



Core Benefits

Supports Faster Emergency Coordination: Helps reduce delays in communication, emergency response and hospital preparation for critical trauma or cardiac care.

Reduces Congestion Delays: Uses GPS and available traffic information to help identify suitable routes and avoid heavy traffic.

Optimizes Resources: Helps hospitals prepare the appropriate staff, equipment and specialists before the patient arrives.

Application 3-Telemedicine and Remote Consultation

Telemedicine uses communication networks to enable patients and healthcare professionals to consult, exchange medical information and discuss treatment remotely.

Key Functions

- **Video Consultation:** Enables patients to communicate with doctors through live audio and video.
- **Medical Information Sharing:** Allows relevant reports, prescriptions and medical images to be shared electronically.
- **Remote Follow-up:** Supports follow-up consultations and ongoing care for patients who do not need an in-person visit.
- **Access to Specialists:** Helps patients in remote or underserved areas consult healthcare professionals at distant locations.



Application 4- Smart Hospital

A smart hospital integrates connected medical devices, communication networks and digital information systems to improve patient monitoring, healthcare coordination and hospital management.



Connected Patient Monitoring: Bedside monitors measure vital signs and can transmit readings and alerts to a central monitoring station when integrated.



RFID-Based Tracking: RFID tags and readers help identify tagged equipment and record where it was detected, supporting equipment location and availability management.



Digital Imaging and AI

Sharing medical images and assisting clinical review with validated software.

Smart Surveillance

Monitoring authorized areas and flagging selected safety events.



- **Electronic Health Records (EHRs):** Authorized doctors can access relevant patient history, allergies, laboratory results, prescriptions and diagnostic reports through integrated hospital information systems. This supports continuity of care between departments.
- **Connected Hospital Robots:** Automated mobile robots can transport supplies, linen or medicines along designated routes. Sensors and control systems help them navigate, while a fleet-management system coordinates tasks.
- **Smart Environment:** Sensors monitor temperature and air quality, while building-management systems control HVAC, lighting and energy use.
- **Smart Beds:** Occupancy and pressure sensors can support bed-exit alerts and pressure-injury prevention by notifying staff when attention may be needed.

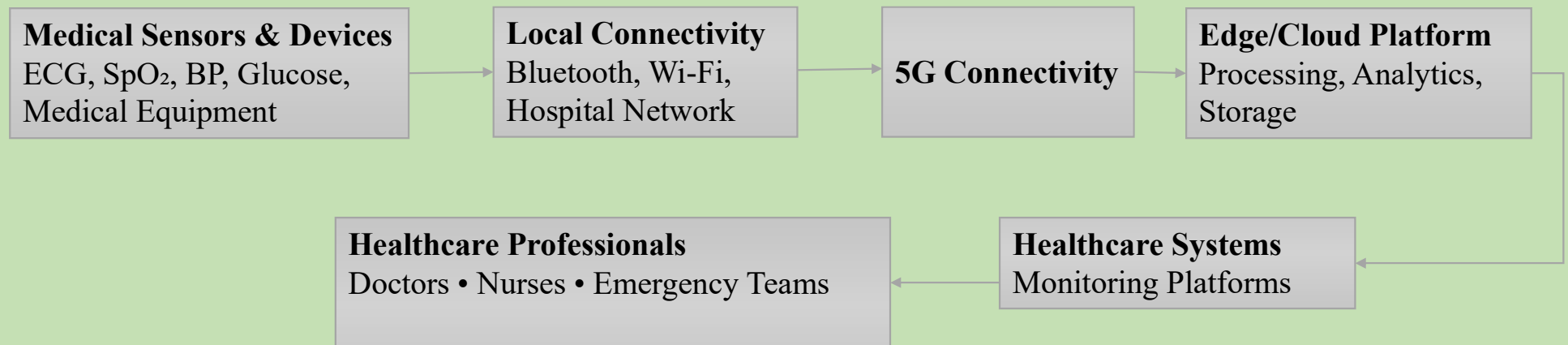
Main Benefits

- **Better Outcomes:** Predictive alerts warn doctors before a patient's condition becomes critical.
- **Higher Efficiency:** Automation handles scheduling and data entry, letting staff spend more time with patients.
- **Green Operations:** Smart lighting and climate control reduce energy waste.

How Healthcare Data Travels Through a 5G-Enabled Network

Healthcare data moves through multiple layers—from sensing and communication to processing, storage and clinical decision-making.

5G provides connectivity and data transport; processing and storage are performed by edge, cloud and healthcare IT systems.



Edge Computing, Cloud and AI in Smart Healthcare

Edge Computing

- Processes selected data close to where it is generated
- Supports faster responses for time-sensitive applications
- Can reduce the need to send every piece of data to a distant cloud

Cloud Computing

- Large-scale data storage
- Data management and access
- Long-term analytics and integration

AI / Analytics

- Identifies patterns and trends
- Supports medical-image analysis
- Can generate alerts or decision-support information when appropriately validated

Challenges in Communication-Enabled Smart Healthcare



Reliability

Dropouts can affect critical care



Privacy & security

Medical data is highly sensitive



Interoperability

Devices & systems must speak together



Coverage

Services depend on network reach



Cost

Devices & infrastructure are expensive



Scalability

Managing huge device numbers



Data management

Large, heterogeneous data volumes



Governance

Clinical trust & accountability

Future Perspectives of Smart Healthcare

- 1. 6G-Enabled Healthcare Connectivity:** Future 6G networks may provide highly intelligent, potentially low-latency and highly reliable connectivity for advanced healthcare applications.
- 2. AI-Native Healthcare Networks:** AI will increasingly be integrated into communication networks and healthcare platforms for intelligent resource management, prediction and decision support.
- 3. Integrated Sensing and Communication:** Future networks may combine communication and sensing capabilities, enabling applications such as patient/environment monitoring and localization.
- 4. Immersive & Remote Healthcare:** Higher-capacity networks may support advanced telemedicine, immersive consultation, AR/VR-assisted healthcare and remote collaboration.
- 5. Connected Robotics & Autonomous Systems:** Connected robots may assist with hospital logistics, rehabilitation, remote assistance and other healthcare tasks.
- 6. Personalized & Predictive Healthcare:** Continuous data from connected devices, combined with AI and analytics, may enable more personalized monitoring and earlier identification of potential health problems.

Future Work and Research Directions



More reliable, secure connectivity



Private medical-data communication



Interoperable medical IoT



Stronger edge computing



AI-assisted healthcare



Scalable connected systems



Affordable deployment



Better remote & rural support

Key Takeaways

- 1. Connectivity is the Foundation:** Communication networks connect patients, medical devices, healthcare systems and professionals.
- 2. 5G Enables Advanced Healthcare Services:** Higher data rates, low-latency potential, mobility and support for many connected devices can enhance applications such as remote monitoring, smart ambulances and smart hospitals.
- 3. Healthcare is Becoming Data-Driven:** Edge computing, cloud platforms and AI/analytics help transform connected healthcare data into useful information and decision support.
- 4. Technology Must Be Secure, Reliable and Interoperable:** Privacy, cybersecurity, network reliability, interoperability, scalability and clinical safety remain essential for real-world deployment.
- 5. The Future is Intelligent and Personalized:** Emerging 6G, AI, integrated sensing, robotics and connected systems could enable more proactive, personalized and accessible healthcare.

