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Quantum Sensing and Healthcare: Charting India's Next Frontier

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Quantum sensing can revolutionise healthcare by enabling early disease detection, precise diagnostics, and customised treatment plans. It detects subtle changes in fields, improving diagnoses for various diseases.

Technological advances in controlling the world of the ultra-small, made over the past few decades, have brought to fruition a field called "Quantum Sensing." While it has applicability in a wide variety of problems, medical-diagnostics and healthcare-innovation would be revolutionised. Quantum sensors are ultra-sensitive devices, capable of detecting the faintest of biological signals—be they magnetic, electric, thermal or even mechanical. They could enable game-changing applications in real-time diagnostics by detecting or measuring phenomena within single cells that were previously undetectable.

With a strategic investment in research, infrastructure, and translational pathways, India is today presented with a golden opportunity to play a leading role in this emerging domain, radically improving healthcare outcomes and building a global leadership in healthcare technologies.

National Quantum Mission: Catalysing Quantum Healthcare

India's National Quantum Mission (NQM), anchored in T-hubs like Indian Institute of Science (IISc) Bengaluru, Indian Institute of Technology (IIT) Madras, IIT Mumbai, IIT Delhi, has laid the groundwork for innovation across several domains in the field of Quantum Technology. To unlock the full potential for a revolutionary impact on healthcare, the NQM ought to give a high

priority to the utilisation of quantum sensing for the bio-medical field. A few example applications might include NV center-based subcellular imaging, optically pumped magnetometer (OPM)-driven brain scans, and quantum sensors for tissue oxygenation and metabolism etc. A clearly developed roadmap involving partnerships between the specialised academic establishment with leading clinics, regulatory integration, and funding for translational research could easily position India at the forefront of international players in this field.

Elevate Karnataka: Accelerating Deep-Tech Startups

Programmes like Elevate Karnataka demonstrate the power of state-led innovation. By providing seed funding, lab access, and mentorship, startups like Quantum Biosciences have advanced prototypes such as quantum-enhanced MRI systems for low-radiation, high-resolution diagnostics. Such collaborative models must be scaled at a national level to unlock the full role startups can play in India's quantum healthcare.

Quantum Valley, Amaravati (Andhra): Infrastructure for the Future

The Amaravati Quantum Valley initiative represents a leap toward setting up a national quantum infrastructure. Its centerpiece, the QChipIN, is a state-supported open testbed with access to IBM quantum systems, SPAD detectors, and deployable OPM platforms. With Rs1,000 crore in funding and with full backing of both the IIT Madras and of the TCS, this initiative offers healthcare startups a full and vibrant ecosystem for clinical testing, validation, and commercialisation—making Amaravati a potential hub for quantum-enabled healthcare.

Bridging Infrastructure Gaps & Launching Quantum Biology

To sustain innovation in quantum healthcare, India must address the deep structural gaps in its R&D ecosystem. Steps to be taken currently would perhaps include:

- Setting up of dedicated Quantum–Healthcare Innovation Zones – perhaps in Amaravati, Bengaluru, and in Hyderabad.
- Setting up Clinical testbeds in hospitals—for example in All India Institute of Medical Sciences (AIIMS), Narayana, Apollo.
- Setting up National standards for quantum sensor validation and calibration – Working with National Physical Laboratory team.
- Setting up an industry for scalable device manufacturing of NV sensors and OPMs

Equally important is the establishment of a world-class research facility focused on quantum biology. This centre would study quantum effects in living systems, for example ranging from enzyme tunneling to neural coherence. Its mission would include discovery-driven diagnostics, development of next-generation quantum biosensors, creating a foundation and curriculum for the absolutely required interdisciplinary training, and structuring global collaboration with internationally renowned institutions outside India.

Building Talent and Global Research Alliances

India's academic network—including from the IISc, IITs, International Centre for Theoretical Sciences (ICTS), National Centre for Biological Sciences (NCBS), Tata Institute of Fundamental Research (TIFR) and Raman Research Institute (RRI) and—must be mobilised into these interdisciplinary platforms. These should combine providing a solid educational structure for quantum sensing, data science, AI and biomedical engineering. International fellowships, jointly structured labs with US institutions like the Elevate Colorado, Quantum Chicago Hub, and the development of standards will boost India's capabilities of innovating in this upcoming field.

Translational Use Cases: Quantum Sensing in Healthcare

Quantum sensing has tangible applications in diagnostics and monitoring. Key opportunities include:

- Biophoton Detection: Label-free cancer detection.
- Brain Imaging (OPM-MEG): Non-invasive mapping for neurological conditions.
- Fetal Imaging: Safe prenatal diagnostics using wearable quantum sensors.
- Microbiome Monitoring: Real-time gut diagnostics via breath/stool sensing.
- NV-based Subcellular Sensing: Usage of fluorescent nanodiamonds to detect free radicals, these are tiny stress signals inside your cells. When hit with a laser, they glow based on oxidative stress levels. This glow is turned into real-time data with T1 curves, offering non-destructive, subcellular insights. This yields into single-cell resolution analytics, and advanced predictive toxicology.
- Quantum MRI: High-resolution imaging with reduced radiation.

Create a Startup Ecosystem and Industry Translation

India must foster its ecosystem for startups in quantum-healthcare with incubation support Biotechnology Industry Research Assistance Council (BIRAC), Centre for Cellular And Molecular Platforms (C-CAMP), I-Hub Quantum Sensing), providing targeted R&D funding, and preparing for viable commercialisation pathways. Academic–industry consortiums should be encouraged to fast-track translation from lab to clinic.

Positioning India as a Global Quantum Health Leader

With its strengths in quality science on a large population scale, India can lead the Global South in the field of quantum health. Hosting global challenges, publishing clinical validations, and shaping global standards will help build the Brand India in the field of quantum-enabled healthcare.

Conclusion

Quantum sensing is a generational opportunity to critically redefine both diagnostics as well as treatment. With a mission-driven investment, coordinated infrastructure, and a thriving innovation ecosystem, India can not only provide radically improved health care to its own citizens, but can also lead the future of healthcare at the international level.

The time to start on India’s quantum-health revolution in now!

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