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PRECISION HEALTH TECHNOLOGIES AND INNOVATIONS

Collaboration with Harvard Consulting on Business and the Environment

The Challenge

Every child has the right to survive and thrive. But millions are dying from communicable and non-communicable diseases.

Over 300 million people, many of which are children, are living with rare diseases and there are no approved therapies for over 90% of these disorders.[1] This means children suffer their whole lives or may die early from complications.

The global emergence and spread of drug-resistant infections or antimicrobial resistance threaten child survival, growth and development.[2]

Key Takeaways

- Precision health technologies are accelerating research to improve diagnosis, implement personalized treatment decisions, and develop new therapeutic targets and treatments that will benefit children around the world.
- Next-generation diagnostics technologies and novel predictive biomarkers allow for early disease diagnosis and real-time monitoring of the disease and therapeutic efficacy.
- Technologies for precision medicine can be applied to control infectious diseases such as Ebola, yellow fever, Zika virus, and E. coli.

Context

An accurate diagnosis is the first step for patients to receive effective treatment. The ability to detect subtle changes in physiological function, disease-specific biomarkers, or exposure to harmful pathogens enables prognosis and decisions on therapeutic approaches.[3] Precision medicine can be designed to target certain harmful cells, thereby allowing for optimal efficacy and minimal toxicity.

Findings

Innovations

- **In vitro diagnostics** (IVD) is a method to test samples taken from the human body to detect, diagnose, and monitor diseases. Some examples:
  - **Liquid biopsy**, which uses biomarkers in blood for prognostic and predictive purposes by non-invasive means in real-time, for diagnosing diseases through blood or urine samples.[4]
  - **Microfluids** (Lab on a chip) allow for extremely precise fluid control and manipulation, enabling rapid and high-throughput sample processing in integrated micro-scale medical systems.[5]
  - **4D sonography** creates images of tissues, glands, organs, and fluid flow within the body, offering improved diagnostic ability, precision treatment selection, and prognosis evaluation.[6]
  - **iKnife** combines an electrosurgical scalpel blade with a mass spectrometer to distinguish tissues during an operation. It can detect and diagnose cancer in seconds.[7]
- **Biomarkers** are measurable indicators used to evaluate biological processes and treatment responses. They play a vital role in diverse areas ranging from oncology to infectious diseases, aiding in distinguishing conditions like viral from bacterial pneumonia. Epigenetic biomarkers provide insights into gene expression influenced by environmental and social factors and have implications for disease prediction and progression in precision medicine.[8]
- **Next Generation Sequencing** (NGS) has revolutionized genomic research and can be applied to sequence whole genomes, and targeted regions, analyze epigenetic factors, and study microbial population studies to identify novel pathogens.[9]
- Advances in microelectronics and electrochemical sensing methods have enabled the development of **wearable and implantable biosensors**, generating signals proportional to the concentration of an analyte in a biological/chemical reaction.[10] They are used for disease detection and monitoring, drug discovery, chronic disease treatment, health management, and well-being surveillance.[11] Some examples:
  - The Commonwealth Scientific and Industry Research Organization has developed the CYBERTONGUE® protease sensors to provide early diagnoses of cancers and early detection of an infectious disease outbreak.[12]
  - **Flextronics, bioelectronics, and skin-inspired electronics** include stretchable electronics with AI chips; e-skin, elastic neurochemical sensors, and wearables for the diagnosis and monitoring of cardiovascular disease.[13]
- **Genetic therapy** is a group of techniques developed to correct defective genes and to explore the use of genes to treat certain diseases.[14]
  - **CRISPR** technology uses guided RNA to cleave the DNA at a specific location in a genome, which can potentially address diseases including cancers, genetic disorders, diabetes, inflammatory disease, cardiovascular disease, HIV/AIDS, and muscular dystrophy. During the COVID-19, it was used to develop diagnostic tests.[15]
- **Genomic surveillance**, the large-scale monitoring of virus detection, tracking, and control, is a transformative research area with significant potential for children's health.[16] This field has expanded due to recent large-scale infectious disease outbreaks, improving our ability to understand and track pathogen transmission, evolution, and interaction faster and cheaper.

Innovations (continued)

- **RNA and mRNA diagnostics and therapeutics** draw on the ability of RNA to stimulate immune responses and deliver therapeutic proteins for potentially a wide spectrum of microbial pathogens and cancers.[17] It can be used to uncover the roles that RNA has in brain development, including the root causes of neurodegenerative diseases.
- **Pharmacogenomics** studies how a patient's genes affect their response to drugs, including negative reactions, a positive response, or no effect at all.[18]
- Meanwhile, **immunogenomics** focuses on the genetics and evolution of the immune system, genetic control of immune responses, and disease susceptibility.[19]

Impact

- Many of these technologies enable faster and more accurate detection and monitoring of diseases at an early stage, allowing for timely interventions. They can be more cost-effective, allowing for more precise diagnosis and self- or point-of-care testing.
- Innovations like liquid biopsy and wearables reduce the need for invasive procedures, making disease monitoring more comfortable and accessible.
- Advances in genetics and RNA technologies are facilitating the development of targeted therapies that cater to individual genetic profiles, increasing treatment efficacy and reducing side effects, and that can often not be treated with other conventional drug groups.
- With the integration of individual biological information, environmental and behavioral characteristics, and socio-economic and cultural context, personalized prevention strategies can be developed to prevent disease onset and progression.

Individual Characteristics	Anthropometry	Behavior	Biomarkers	Genetics & multi-omics	Genes & environment interaction
Age	Weight	Diet	Cholesterol	Genetics, Epigenetics	Genes × weight/BMI
Gender	BMI	Physical activity	Hypertension	Genomics (DNA, SNPs)	Genes × diet (Nutrigenics)
Family history		Smoking	Glucose/Insulin	Transcriptomics (mRNA)	Genes × physical activitiy
Anamnesis		Alcohol	HbA!c	Metagenomics	Genes × smoking
Medication		Stress		Microbiomics (microbiome)	Genes × alcohol
Comorbidities				Metabolomics	Genes × environmental pollutants
				Proteomics (proteins)	

Figure 1: Key components of personalized prevention and data generated by diagnostics/ wearable technologies.

Source: Adapted from Jaskulski, S. et al. "Components, prospects and challenges of personalized prevention." Frontiers in public health vol. 11 1075076. 16 Feb. 2023, doi:10.3389/fpubh.2023.1075076

See Insight Report No. 3 for more information on precision health, including the potential applications of innovations and technologies for the humanitarian and development sector.

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Opportunities

- We need ethical guidelines and standards to address rising social and bioethical challenges such as the use of CRISPR technologies for human germline editing, and the modification of human sperm, eggs or early embryos, that results in heritable changes.
- The incorporation of personalized prevention into existing health practices and systems will complement and improve current preventive health strategies. However, we need to ensure health professionals have access to professional training in personalized preventive care.

Insights Briefs

Innovation Nodes Insights Briefs serve as resource for practitioners and decision makers to quickly get up-to-speed on new and unknown areas of potential innovation for children.

Publication produced by the Innovation Nodes aim to facilitate the exchange of knowledge and stimulate discussion. The findings, interpretations and conclusions expressed are those of the researchers and authors, and do not necessarily reflect UNICEF policies or approaches.

For more information on Innovation Nodes and collaboration opportunities:

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Notes

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