Released 12 January 2023

Statement of the International Council of Academies of Engineering and Technological Sciences (CAETS) on Breakthrough Technologies for Healthcare

The 2022 International Council of Academies of Engineering and Technological Sciences Annual Conference, hosted by the National Academy of Technologies of France, took place in Versailles, France from September 27–28, 2022. The conference theme, Breakthrough Technologies for Healthcare, was chosen to address the difficult transitions in healthcare needed to build from past successes while effectively addressing emerging challenges.

The conference brought together approximately 400 engineers, scientists, entrepreneurs and policymakers from all over the world, and benefitted greatly from a diverse array of international speakers who informed the discussion.

Videos from the conference may be found here: Breakthrough Technologies for Healthcare youtube.com

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The needed transition

Healthcare has changed at an unprecedented rate over past decades. Both longevity and healthy life expectancy have profited from these advances, but emerging challenges must now be addressed.

Healthcare must deal with a growing number of aging patients. Healthcare ambitions also include earlier—and lifelong—disease prevention together with an unprecedented program of rehabilitation medicine.

The tools and methods developed to date, together with healthcare organizations and industrial models, have led to the success we see today, but will not provide all of the solutions needed to go beyond. The growing ambition for better outcomes is likely to be limited by a 'glass ceiling' due to the inherent complexity of the new age of medicine.

To master the complexity, five significant challenges must be addressed:

I. An ambitious research agenda including 'change of scale' to integrate multiscale-multilevel-multidisciplinary research;

II. A growing 'personalization' to better target the diagnosis and therapeutics to individual cases;

III. An 'acceleration of healthcare adaptability' as much for designing new treatments as for designing industrial structures to cope with the rapidly changing environments. An embedded challenge is to reduce the cost of drug development, thereby promoting access to treatments for all;

IV. Assuring equity, ethics and comprehensive patient and citizen involvement, participation, and consent with the deployment of new healthcare technologies;

V. Address the growing shortage of qualified medical staff and the exploding costs of care, through innovative technologies and approaches (such as home-based care delivery) that increase productivity in health systems, empower patients, and enable clinical and nursing staff to focus on patients rather than on administrative or repetitive tasks that can be automated.

These challenges are deeply interconnected; success is dependent on a combination of fundamental advances in science and technology, including:

- The digital revolution—and its ability to gather and process big data and use intelligent algorithms.

- The biological revolution—with the ability to increase efficacity, protect against fast metabolization, and reduce toxicity by acting at the deepest part of the body from inside or outside (protein induction, nanotechnologies).
- The advent of disruptive technologies—thanks to a series of new interdisciplinary research areas at the interface of biology, physics, mathematics, signal processing, and chemistry which are accelerating understanding of dynamic functions.

Key topics from the conference

Stage-setting keynotes opened the conference by painting a picture of the new complexity and associated challenges, both technical and ethical, that await us. Individual sessions focused on:

- Penetrating the intimacy of the cell, with incredible new possibilities of local action, either by using nanotechnologies for carrying and protecting drugs, or by the new mastery of mRNA making possible the control of protein synthesis (which has been beneficial to recent covid vaccines).
- Advanced examples of the new age of Artificial Intelligence (AI) in medicine, including the (r)evolution made in modelling living systems at all scales and illustration of ways to bypass limitations of practitioners (e.g. slow analysis, limited processing capability, limited access to medical data) using AI techniques.
- Disruptive technologies in areas including image processing to support brain investigations and microelectromechanical systems (MEMS) to probe single biological cells from the viewpoint of mechanics.
- Advances in virtual brain modelling with emphasis on field applications such as epilepsy and neurosurgery. It is now possible to trace trajectories of brain health in ageing, with direct application to age-related misfunction such as dementia—suggesting the potential for early detection and prevention of pathologies.
- Body repair at all scales, from the growing control of regenerative medicine at the cell level allowing the recovery of altered neuronal motor functions, to the design of advanced neuro-prosthetic devices (e.g. for visual or auditory recovery).
- Ethics and social impacts of technological breakthroughs. Technologies influence our autonomy, privacy, justice, solidarity, and equity—for better or worse. The desire to live longer cannot be promoted solely through design and adoption of new technologies. Ethical issues must be addressed from the beginning of technology development and throughout the entire lifecycle, and must include the aspect of sustainability.

Charting a path forward

The future of innovation is increasingly taking origin from different fields. Research teams already benefit from the plurality of expertise contributed by discipline-specific scientists, technologists, and engineers. Research teams tackling the complexity described above will benefit from greater participation by systems-thinkers and social scientists. Research organizations, funding organizations, national health systems (including care providers as well as payers), regulators, and last but not least the industrial players (MedTech, Pharma, Biotech, etc.) should work together to address the most pressing unmet needs in care delivery.

An immediate priority is to implement already-available technology solutions while systematically identifying and issues that impede progress. Barriers currently limit transformation of disruptive technologies into market success (this issue is not confined to healthcare technologies). Too many disruptive technologies abort after incurring significant costs; such losses are often detrimental to real advances in the field. New industrial models are needed to improve the lifecycle and reactivity of innovative industries worldwide. International technical bodies should develop and promote approaches to mitigate the barriers that limit adoption of disruptive technologies.

A holistic approach, including global and societal issues, is needed for evaluation of emerging healthcare technologies throughout their lifecycle. International technical bodies should formulate options for use by research and funding organizations.

Finally, increasingly sophisticated (and complex) technologies require increased attention to end-user training to ensure an understanding of the why, how, and what benefits are expected with

healthcare innovations. Similarly, the broader public, as key stakeholders in healthcare technology advances, should also understand the expected benefits from emerging technologies. Such communications are a shared responsibility; but international technical bodies could add value by providing clear, unbiased communications regarding key advances to the general public.

***This statement was endorsed by the following CAETS member academies*:**

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Australian Academy of Technological Sciences and Engineering
Royal Belgian Academy Council of Applied Sciences
Canadian Academy of Engineering
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Acknowledgements: The success of this conference is attributable to the support of numerous corporations that provided funding as well as international speakers who generously devoted their time.