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Medical engineering as an essential field to tackle the future global health issues

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Medical Engineering is a relatively young field in engineering. In its most simple definition, Medical Engineering applies engineering's concepts to develop solutions in medicine and healthcare. Medical engineering has therefore an extremely wide breath as it can cover the development from large sophisticated imaging equipment such as PET scanners to nanorobot designed to perform tasks at the molecular levels. To have a more structured view of what Medical Engineering is about, we can describe it from two different but complementary perspectives: application-based and research-based. For the former, Medical Engineering is often understood as a specialty for engineers which working environment is usually a hospital. The Medical Engineer is the person responsible for the maintenance and the operation of medical sophisticated technical equipment which does make it an essential collaborator in the healthcare system. A Medical Engineer is therefore an engineer who applies its technical knowledge in a medical environment, it is a one-way traffic, from engineering to medicine.

In this article, we will be interested to elaborate on the research-based aspect of Medical Engineering and we will observe that research nourishes a both-way traffic of knowledge between engineering and medicine. Strikingly, when we look at the number of publications identified under "Medical Engineering" over the years, we can observe an exponential increase (Figure 1).

While almost no publication existed in this field in the early nineties, in 2022 pubmed referenced more than 60′000 articles. This progression reflects the incredibly high dynamism of this field of research. Not surprisingly, articles tagged with Medical Engineering have keywords which span the different facets of medicine such as diagnosis, treatment and prevention of disease or trauma. Compared to the application-based approach described above, with the research-based aspect, principles of biology are used to develop new therapeutical solutions following reverse-engineering concepts. This strategy of research can also be coined biomimetism. A two-ways knowledge traffic is then established between engineering and medicine where both disciplines are used as source of inspiration for the other. This specific approach can explain the explosion of publications in Medical Engineering and is probably also at the origin of the successful development of highly valuable engineered tools in medicine. It is indeed difficult nowadays to imagine practicing medicine without engineering.

When we look at the top 10 medical innovations for 2022 (for example, at consultqd.clevelandclinic.org), either directly or indirectly (through laboratory engineered equipment), all the innovations rely on strong engineering concepts. And already for 2022, some identified top innovations are based on artificial intelligence, a revolution to come in medicine probably sooner than we expect it. The pace of development in Medical Engineering will therefore not decrease and the exponential published

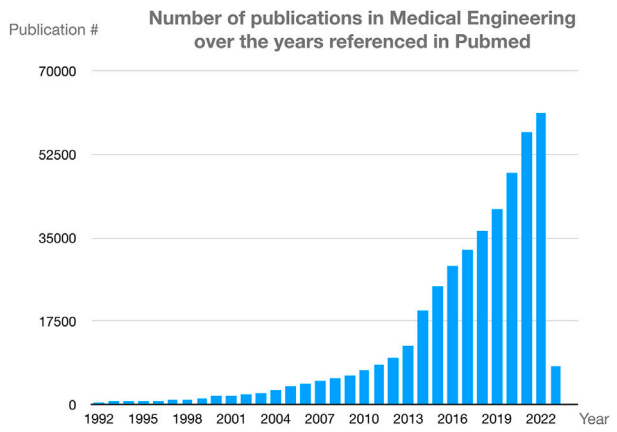

FIGURE 1
Based on a search on pubmed (https://pubmed.ncbi.nlm.nih.gov) with key word "Medical Engineering," the number of corresponding publications over the years is reported.

manuscripts over the years will certainly be reflected in an even more dependence of engineering in medicine.

While it seems obvious that developments in medicine should aim for increasing the efficiency, reliability and efficacy of patient care to ultimately increase its quality of life, the next big question is consequently, "*Will the acceleration of developments in medical engineering continue to be beneficial for the humanity*?"

To furnish elements of answers, we should have an idea of what are the health challenges for the years to come so that we may understand where developments in Medical Engineering could be most valuable. In January 2020, the World Health Organization (WHO) has published a list of the "Pressing Global Health Issues This Decade" (https://www.who.int/news-room/photo-story/photo-story-detail/urgent-health-challenges-for-the-next-decade). While the intention of this article is not to comment on all the mentioned issues, we can remark anyway that most of them will necessitate engineering developments at large (not only restricted to Medical Engineering). One of the mentioned issues is however directly related to Medical Engineering and to the requirement of understanding the ethical implications of its new advancements. Here, we can clearly understand that concerns will be more and more raised on the use of artificial intelligence in medicine as well as on the capacity in Medical Engineering to synthetize new organisms which can be potentially hazardous. It is also mentioned that "*WHO is working with countries to enable them to plan, adopt, and benefit from new tools that provide clinical and public health solutions, while supporting better regulation of their development and use*". With this remark, a point is raised on the way developments in Medical Engineering can be shared between countries having different financial capabilities to afford or not sophisticated healthcare solutions. There is clearly an important discrepancy between the majority of the global needs for humanity and the very cutting age developments done in Medical Engineering. However, this remark should not only be understood when comparing healthcare systems between countries but also inside each country. The access to high quality medicine, which by definition now involves diagnostic or therapeutical tools developed through Medical Engineering, is more and more restricted to a limited number of patients who can afford it. There is a two-tier medicine in most countries and the latest developments in Medical Engineering are partially responsible of this situation by constantly inducing an increase in the cost of healthcare.

Climate crisis will also impact the Medical Engineering field at two different levels. On one level, the healthcare system at large (including care provider and related industries) will have to adapt its practices to the concept of sustainability. A recent report published by a French citizen association has evaluated that the health sector represents till 8% of the total CO_2 production in France (https://theshiftproject.org/plan-de-transformation-de-leconomie-francaise-focus-sur-la-sante/). Although most of this production can be attributed to the transportation of personnel/patients and medical equipment/material, a more responsible approach to the life cycle of medical products is needed. This implies rethinking the way medical equipment and consumables are developed and produced with the aim of reducing energy consumption and waste. The role of Medical Engineering will therefore be essential. Climate crisis will also directly impact the health condition of a vast portion of the world population. Indeed, in the list of "Pressing Global Health Issues This Decade" published by WHO, it is mentioned that "*Climate crisis is a health crisis*" and climate change is considered as the biggest health threat facing humanity. The most affected will be people in low-income and disadvantaged countries and communities. Inequalities in access to a quality healthcare system between the haves and have-nots will be even more pronounced. In this large-scale health problem situation, innovative solutions will have to come from both the engineering and medical fields. Medical Engineering is centrally positioned to play a primordial role in this crisis to come and will have therefore to adapt its priorities. In particular this means that in the future Medical Engineering developments, we have to be careful that, as a researcher, we do not only implicate ourself in the rewarding academic research targeting so-called prestigious cutting-edge developments, but that we can balance these researches with Medical Engineering developments that could benefit to the greater numbers of persons. This would mean to develop engineering solutions that can be deployed in less favored area or in crisis situations.

Actions that combine Medical Engineering developments with a medical need in less developed countries is certainly a valuable approach as recently demonstrated with the initiative EssentialTech (https://www.essentialtech.ch/humanitarian-action) done in collaboration between academics and ICRC. A forum for scientific publications of these remarkable achievements should also be proposed in international peer-reviewed journals.

A silent danger facing healthcare systems is understaffing, a problem that will worsen considerably in the coming years. Various factors can explain this situation. In particular, it is not uncommon to hear healthcare personnel complain that their administrative workload is too heavy compared to their clinical workload, which leads to a loss of motivation and a growing disinterest to these professions. The need to master the technological aspects of medical practice can also negatively influence the choice to work in a medical environment for personnel who prefer interactions with patients rather than with a computer. Research and development in Medical Engineering must therefore also integrate an ergonomic component that favors the patient-caregiver relationship and not only aim at an efficient technical solution. In order

to relieve the ever-dwindling number of caregivers, innovative solutions will have to be deployed that could be based on artificial intelligence technology. Developments in this field are dazzling for all fields of engineering. This technology could generate a revolution in the medical field, for example, for diagnosis or treatment proposal, but could also relieve the medical staff of repetitive and uninteresting tasks related to administrative aspects. As a consequence, new technology if well-developed could make the medical professions attractive again. But as mentioned above, the ethical aspects and the trust of patients (and caregivers) in new Medical Engineering developments (especially artificial intelligence) will have to be carefully considered.

To conclude, Medical Engineering is more than ever needed for the years to come in the global healthcare system. While it has become obvious that quality medicine can no more be done without benefiting from the developments of Medical Engineering, this field has to evolve so that it can actively participate to solve the decisive health challenges that humanity is facing related to climate crisis, lack of healthcare personal, inequality in the access of quality healthcare, or new pathologies related to pollution to mention only the most important ones.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note