Review Article

BIOMEDICAL Journal of Scientific & Technical Research

ISSN: 2574 -1241

DOI: 10.26717/BJSTR.2024.56.008789

Human Augmentation in the Context of Health Equality

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ARTICLE INFO

Received: March 29, 2024

Published: April 11, 2024

Citation: Jacek Klich. Human Augmentation in the Context of Health Equality. Biomed J Sci & Tech Res 56(1)-2024. BJSTR. MS.ID.008789.

ABSTRACT

This paper presents human augmentation (HA) as one of the most far-reaching outcomes of the Fourth Industrial Revolution (4IR). HA as an emerging phenomenon is under-researched and remains unregulated by the law. It is argued here that HA may lead to increased social stratification and a stronger competitive position for high-income groups. The paper starts with the identification of the main channels the 4IR influences HA. Then cognitive augmentation, physical augmentation, mood enhancement, and moral enhancement are presented. The article ends with selected issues of HA financing and the challenges faced by health policies in this area.

Keywords: Human Augmentation; Human Enhancement; Forecasting; Financing; Government Regulations

Abbreviations: HA: Human Augmentation; 4IR: Fourth Industrial Revolution; WEF: World Economic Forum; GE: Genetic Engineering; BMI: Brain-Machine Interface; BD: Big Data; IoT: Internet of Things; AI: Artificial Intelligence; ICTs: Information and Communication Technologies; HE: Human Enhancement; CA: Cognitive Enhancement; BCI: Brain-Computer Interfaces; DBS: Deep Brain Stimulation; TDCS: TDCS Works Using Electrical Stimulation; PA: Physical Augmentation; HPEs: Human Performance Enhancements; GETs: Gene Editing Technologies; AV: Atrioventricular; SEs: Sensory Enhancements; AR: Augmented Reality; RFID: Radio-Frequency Identification; LE: Longevity Enhancements

Introduction

The Fourth Industrial Revolution (4IR) is defined as an economic and social phenomenon driven by the fast development of artificial intelligence, robotics, nanotechnology, additive manufacturing, neurotechnology, biotechnology, materials engineering, energy storage, quantum computers, etc. As phrased by Karl Schwab, 4IR "…entails nothing else than a transformation of humankind" [[1], p.7] because it blurs the boundaries between physical, digital, biological, and biological spheres [2]. 4IR has an increasing impact on nearly all the dimensions and aspects of human life, including health [3]. The impact of 4IR on health is intensively researched. The World Economic Forum (WEF) research on 4IR allows us to identify specific examples of breakthroughs tightly connected to medicine and treatment like genetic engineering (GE) (especially genome editing) to cure genetic diseases, such as sickle cell disease and cystic fibrosis; regenerative biology and medicine; tissue engineering; cancer genomics and immunotherapy; precision medicine; microbiome; optogenetics and brain-machine interface (BMI) technology; big data (BD) analytics; telehealth technologies; the Internet of Things (IoT); and artificial intelligence (AI) to transform all areas of health and medicine towards clinical decision-making. IoT and other technologies will enable real-time monitoring and technologies such as applications and wearables will help promote healthy behaviours and enable sustained behaviour modification [4].

4IR can influence healthcare systems indirectly and directly. Indirectly through the development of AI in medical imaging analysis [[5], p.2] diagnosis and decision support [6]; drug discovery and development [7]. and personalization of treatment [8], and through information and communication technologies (ICTs) for example electronic health records or virtual reality, and BD [9]. The direct impact of 4IR is on the appearance of new products (for example new medicines, new medical devices, and artificial implants), new services (telemedicine and eHealth), and new technologies like GE, nanotechnology, neurotechnology and nanorobotics. Human augmentation (HA) can be named both the essence (differentia specifica) of 4IR and one of the most far-reaching outcomes of 4IR influencing individual humans

and societies and for this reason, it should be studied carefully. The paper presents HA as a potential threat to health equality and a considerable challenge to health policy. The paper has been profiled as a special article. As will be shown below HA can be considered an emerging factor with a high potential to impact considerably health equality in the future therefore should be scrupulously examined.

Human Augmentation/Human Enhancement: Concept and Main Forms

Human augmentation has been studied for decades by researchers representing mainly humanistic and social science disciplines. Human augmentation (HA) and human enhancement (HE) are used interchangeably in this paper like in some other publications [10]. Human augmentation/human enhancement does not have one commonly accepted definition [11]. HA/HE is defined in this paper as "… means raising physical, cognitive or emotional human capacities or the performance of these capacities above levels of normality by technology or supported by technology" [[12], p.10]. Human augmentation should not be associated with therapy although the line between these two terms is blurring [13]. Researching HE is a challenge due to its in statu nascendi stage of development accompanied by the lack of an agreed methodology, including its measuring, monitoring, and assessment. The research is based mainly on qualitative methods, the quantitative ones remaining rare. Although gathering information about HE remains a challenge [14], one may notice a growing number of publications on HA/HE [15]. Acknowledging various classifications of HA forms [16], let us introduce the often indicated in the literature [17]: cognitive augmentation, physical augmentation, mood enhancement and moral enhancement.

Cognitive Augmentation: Cognitive enhancement (CA) can be defined as any augmentation of core information processing systems in the brain, including the mechanisms underlying perception, attention, conceptualization, memory, reasoning, and motor performance. CA can be achieved through technologies that aim to improve human empirical abilities such as thinking, quick and effective decision-making, memory, attention, focus, understanding, learning, pain management, and enhancing sensory abilities, such as vision, hearing, or smell, using artificial sensors or implants. Several ways are leading to CA and can be achieved either through medical or non-medical methods. Medical methods can be divided into invasive groups such as brain-computer interfaces (BCI), deep brain stimulation (DBS) and optogenetics. Invasive methods require a part of the skull to be exposed to remove appropriate pieces of physical objects. These interventions are often difficult, messy, and expensive, and usually leave the patient with severe trauma. DBS involves electrodes that are permanently placed in certain brain regions. Non-invasive methods are for example transcranial direct current stimulation (TDCS) and transcranial magnetic stimulation (TMS). TDCS works using electrical stimulation, TMS by magnetic stimulation and optogenetics by light stimulation Non-medical CA methods are represented by nootropics and pharmaceuticals.

Physical Augmentation: Physical augmentation (PA) is aimed at human performance enhancements (HPEs) understood as "…any implantable, ingestible, wearable invasive or non-invasive technology that can temporarily or permanently change or promote human function" [[18], p.1]. PA varies considerably regarding its forms and technologies used. Here gene editing technologies (GETs) and gene therapy take the lead. Out of four basic GETs currently used, clustered regularly interspaced short palindromic repeats (CRISPR, including CRISPR/Cas9) seem to dominate. The second form of PA is biomechanical enhancements (BE). HE involves the integration of mechanical or electronic components (or both) with the human body to enhance physical abilities. Examples include prosthetic limbs, exoskeletons, and wearable devices that augment strength and mobility. Here one may mention devices enhancing the biomechanics of a failing heart such as atrial shunts, ventricle expanders, stimulation therapy and mechanical circulatory support, or like in the case of atrioventricular (AV) valve disease, corresponding devices that alter the geometry, mechanics or hemodynamic of annuli, chords, leaflets, and papillary muscles [19]. The next form of PA is a cosmetic enhancement (CosE) aimed at improving the appearance or traits of a human being. Unlike the first two forms of PA, CosE has a considerable and growing share in the healthcare market.

The global cosmetic surgery market size was estimated at $70 billion in 2022 and it is projected to hit around $139.64 billion by 2032. The North American region had the biggest share of the total revenue in 2022 (35.7%) [20]. Sensory enhancements (SEs) are listed as another form of PE. SE is attained by multisensory information processing for enhancement of the ability to perceive external stimuli. The most rudimentary example of visual sensory augmentation technology could be navigational aids used by people with visual impairment which can be classified as medical treatment while more advanced sensory augmentation would be the technology that alters perception, such as virtual reality (VR), augmented reality (AR) or mixed reality. The next example of PE form is biohacking. Biohacking includes do-it-yourself biology and self-experimentation to enhance physical appearance, such as implanting radio-frequency identification (RFID) chips or using subdermal implants located mainly in fingers, hand webbing, skin near the armpit, arm, and hand/forearm. Finally PE form is longevity enhancements (LE) aimed at improving durability and extending life span.

Mood Enhancement (ME): Regarding ME apart from nootropics, smart drugs and pharmaceuticals, other non-invasive methods are used including different mood induction techniques. They can be grouped into three categories: visualization of a material selected for its emotional impact (images, films, or music pieces), imagery techniques (consisting of recalling or reactivating past emotional experiences or writing emotionally charged scenarios/phrases to enter the corresponding emotional state), and pre-set interactions better known as virtual reality (which allows for the creation of a real-life environment with which the individual has to interact). There is some

evidence that mood may improve with invasive forms of neurostimulation For example, targeting the circadian system informed by mechanistic molecular advances is considered one of the three promising areas in circadian-clock-based therapeutics in mood disorders [21]. There is sufficient base to maintain that in the coming years, the development of in-brain devices that could regulate or self-regulate the emotional needs of a person will be achievable.

Moral Enhancement (MOE): MoE is defined as modulating or fostering attitudes and behaviours that are considered morally or socially acceptable [22]. Leaving apart the intuitive typology of moral enhancement distinguishing between traditional (moral education: learning, training, habituation) and non-traditional (biotechnologies) methods of MoE, we may stay with the distinction between invasive (pharmacological enhancement, brain stimulation, biotechnologies) and non-invasive (moral education, animal-assisted interventions, drama-based interventions, etc.) methods of MoE. Recently, the enhancement-purposive use of neuroscience, neuroenhancement (interventions in the central nervous system by using various pharmaceutical means, surgery, and technology) has also been a concern [23]. One should acknowledge that while brain stimulation has the potential to alter moral behaviour, such alteration is unlikely to improve moral behaviour in all situations and may even lead to less morally desirable behaviour in some instances [22]. Using brain stimulation for moral enhancement is still a topic of scientific debate, and its effectiveness remains largely unproven. Although concerning all four forms of HA/HE the literature on empirically proven positive effects of HA/HE remains scarce, this lack of empirical data refers especially to MoE. The lack of evidence for the effectiveness of MoE (at the current stage of the development of medical science and medical engineering) does not prevent some researchers from formulating a conclusion that moral bio enhancement cases ought to be compulsory [24].

Financing Human Augmentation/Human Enhancement

Since human augmentation/human enhancement is not considered a treatment to restore and/or maintain health, it cannot be financed by various health insurance schemes. Private financing (out-of-pocket - OOP) is and for long will be the main (if not exclusive) way of HA/HE is financing. Private HA/HE is financing is feasible, First, some people can afford it nowadays and there is a ground to maintain that even more individuals will be in a position to pay for HA/HE in the future. While it is difficult to identify a clear trend in OOP payments for health in OECD countries (in some countries OOP is rising, in some declining), it is possible to trace a trend in global wealth. Here the underlying assumption is that there are middle-class individuals who constitute the main group of potential HA/HE beneficiaries. Statistics covering the years 2000-2022 clearly show that the share of adults who had less than $ 10,000 in the global population diminished (from 80,7% to 52,5% respectively), and the global middle class (adults with $ 10 000 - $100 000 of wealth) has more than doubled, driven by the expansion of emerging economies reaching 34,4% share in the global population in 2022 [25]. Also, projections for 2027 indicated that the share of the middle class in the global population would be rising [25]. This comes in line with OECD long-term baseline projections revealing that GDP in OECD countries will grow from the level of $62,558,332 million in 2023 to $97, 905,070 million in 2050 (in Purchasing Power Parity - PPP, $ at 2015) [26].

Also, the disposable income projection for 2050 is positive among others for the U.S., Canada, Mexico, Brazil, European Union, Russia, Japan, South Korea, Australia and New Zealand, China, and India [27] It is worth acknowledging that the highest average annual percentage change in disposable income from 2022 to 2050 is estimated for India and China (respectively 4.4% and 4.0%). This suggests that the HA/HE market could speed up not only in highly developed Western but also in Asian countries. Private financing of HA/HE will certainly contribute to rising inequalities in the access to HA/HE procedures. These inequalities will be then multiplicated by the competitive advantages of augmented/enhanced individuals over normal human beings especially in the labour market but also in social life. Considering how deeply the principle of competition is inscribed in every human being, one should look with concern at HA/HE. Not only it will secure the status quo of the well-off and middle-class individuals in society but also it will strengthen their competitive advantage.

Managing Human Augmentation/Human Enhancement

As indicated above HA/HE processes are in their infancy. They are not recorded or monitored systematically. The research on international, regional (European Union, Organization of American States, and African Union), and national (Brazil, China, France, Germany, Greece, the Netherlands, Poland, South Africa, Spain, Sweden, the UK, and the USA) level showed that human augmentation/enhancement is not regulated in the law [28]. All this means that HA/HE cannot be effectively managed now.

Conclusion

To conclude, it is worth pointing out just a few things:

- HA/HE represents the essence of the Fourth Industrial Revolution and could have far-reaching consequences for humans and healthcare systems.
- HA/HE does not have a commonly accepted definition and is not regulated by any current laws.
- HA/HE is in its infancy (in statu nascendi). Even though it has been intensively explored by social scientists using primarily qualitative methods it remains under researched.
- Cognitive augmentation, physical augmentation, mood enhancement, and moral enhancement are the most cited examples of various HA/HE forms.
- HA/HE procedures cannot be financed by standard health insurance schemes. Private HA/HE is financing may lead to

the deepening and further increase in social disparities and inequalities so it creates a serious challenge for health policy

- HA/HE procedures should be treated as inevitable thus appropriate regulations must be elaborated on and implemented without unnecessary delay.

Disclosure

The author reports no conflict of interest.

This paper is based on materials used in: J.Klich: Human Enhancement Technologies and Health Care Policy. Routledge 2024 (In press).

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ISSN: 2574-1241

DOI: 10.26717/BJSTR.2024.56.008789

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