Review Article

Future of Health Services: The Role of Physicians in the Disruptive Era

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Abstract

This article aimed to address the role of physicians in future health in the disruptive era. Physicians in this disruptive era must increase their capability and knowledge to compensate for this development. Advances in technology increase the impact on health care and the significance of disruption. Disruptive innovation encompasses several fields, such as physics, digital, and biology. Big data as one of the most important parts in clinical aspects encompass high-throughput cellular and protein-binding assays toward chemoinformatic-driven databases. Health status can be modified by changing epigenetic factor, such as lifestyle and environment. As a result, they affect human genetics and provide the insight of pathophysiology of disease, clinical treatment, and early preventive action. Disruptive innovations in health-care align with the development of artificial intelligence, machine learning, robotics, Internet of things, digitalization, and genomics. New paradigm shifting in physician–patient relationships is relevant to consumer health informatics.

Keywords: *Genomics, health services, innovation, physician*

Introduction

Development in the current era has significantly improved our daily lives; this fourth industrial revolution has affected many aspects of our lives, including social, economic, business, educational, and health aspects [Figure 1].[1] There has been a shift from the hunter and gatherer age to the agricultural age, industrial age, information technology age, and disruptive innovation age. Consequently, many people have transitioned to jobs that require advanced skills and knowledge.[1]

Two types of threats, from internal and external sources, have been observed with the latest industrial revolution. The main internal sources that are considered in managing innovation and technology include social behavior, knowledge, religion, health consequences, and uneven individual income distribution. The external sources are cybersecurity and natural disasters. These aspects result in ethical dilemmas in every aspect of the fourth industrial revolution.[1]

A combination of physical, digital, and biological domains comprises disruptive innovation. These domains include robotics, artificial intelligence (AI), Internet of things (IoT), augmented reality, cloud computing, three-dimensional printing, nanotechnology, biotechnology, genetic engineering, and e-learning [Figure 1].[1] The progression in information and technology with regard to health aspects allows health literate consumers to have active roles in choosing their own perspectives. Moreover, the development of health applications and telemedicine allows for easier access to the best medicines, physicians, and health-care facilities. According to the facts, physicians in this disruptive era must increase their capability and knowledge to compensate for this development. Furthermore, the development can aid in precision medicine (PM) for every patient.[1,2]

Discussion

Disruptive innovation

A disruptive innovation is an innovation that creates a new market and new value networks and eventually

Received: 27-12-2019 **Revised:** 30-01-2020
Accepted: 28-02-2020 **Published:** 28-12-2020

Access this article online

Quick Response Code:

Website: www.jhrsonline.org

DOI: 10.4103/jhrs.JHRS_172_19

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How to cite this article: Wiweko B, Zakirah SC. Future of health services: The role of physicians in the disruptive era. J Hum Reprod Sci 2020;13:250-6.

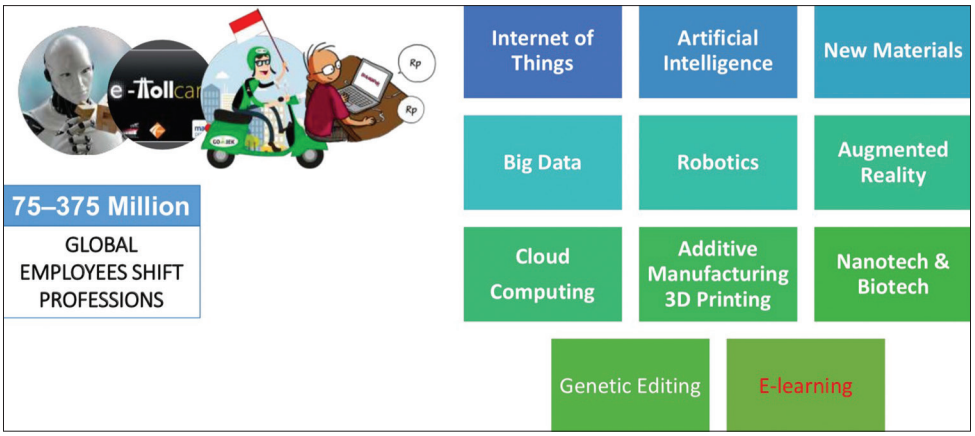

Figure 1: The fourth industrial revolution variation. Most of employment shifting their working environment into digitalization and using internet of things [IoT] bridging the gap of manual system [Reproduced from Xu M, David JM, Kim SH. The fourth industrial revolution: Opportunities and challenges. International Journal of Financial Research 2018;9:90-5; CC 4.0].[1]

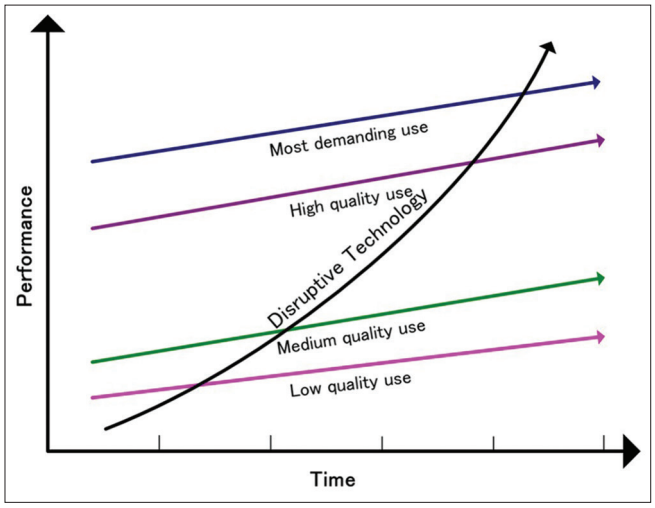

Figure 2: Disruptive innovation graphic linking the performance of market demand and time. Disruptive aided by technology might across another usual market resulted in acceleration of development [Reproduced with permission from Christensen CM, Mcdonald R, Altman EJ, Palmer JE. Disruptive innovation: An intellectual history and directions for future research. Journal of Management Studies 2018;55:1043-78.].[3]

disrupts the existing market and value networks. This displaces the established market-leading firms, products, and alliances. Advances in technology increase the impact on health care and the magnitude of the disruption. Smartphone applications, telemedicine, wearable diagnostic and remote monitoring, speech recognition and natural language processing as well as genomics are being developed to decrease the hospitalization and mortality rates. Moreover, virtual and augmented reality, automated image interpretation using AI, interventional and rehabilitative robotics, predictive analytics using AI, and writing the genome are in the developmental process [Figure 2].[2,3]

Patient empowerment through technological development marks the benefit of disruption. The virtual medical coach model with multimodal data inputs and algorithms allows individuals to access virtual individualized guidance of PM.[3,4]

Assisted reproductive innovation

Mitochondria are essential components of cellular metabolism. Cellular development and cleavage processes, such as meiotic spindle, chromosome segregation, maturation, fertilization, and preimplantation embryogenesis, require adenosine triphosphate (ATP) as a form of cellular energy. ATP is provided by the mitochondria. Other cellular processes of fertilization and development, including ion fluxes and management of the reduction–oxidation status, also need mitochondria.[5]

Women of advancing age are prone to ovarian aging. This results in a decline in the quality and quantity of oocytes, which is associated with mitochondrial dysfunction. Consequently, poor egg quality affects the fertilization rate and embryonic development and can result in a failed pregnancy. With reproductive innovation of oogonial stem cells as a source of germ line mitochondria from a patient undergoing *in vitro* fertilization (IVF), autologous egg precursor cell-derived mitochondria are injected along with intracytoplasmic sperm injection (ICSI) with the aim of providing sufficient energy for successful fertilization, embryonic development, and a healthy pregnancy.[5]

Social egg freezing

Methods of preserving female reproductive function include oocyte, embryo, and ovarian tissue cryopreservation. Oocyte cryopreservation has been widely used as a method for preserving reproductive function and remains a gold standard of fertility preservation.[5] Some medical indications of oocyte cryopreservation include cancer treatment and beta-thalassemia in a female patient who suffers from hypogonadotropic hypogonadism that is associated

with amenorrhea, anovulation, and infertility. Other indications include autoimmune disorders, endometriosis, women with a family history of early menopause, and women at risk of injury of a reproductive organ.[6,7]

The current social paradigm leads society to postpone childbearing and motherhood. Educational and career advancements are the main nonmedical reasons for preserving reproductive function. Some companies offer financial plans to support their employees with respect to freezing their oocytes. This is called social egg freezing. The live birth rate is >40% per cycle of oocyte cryopreservation in 30-year-old women, whereas it is only 6.6% with the use of fresh egg in 42-year-old women. However, ethical aspects and worldwide regulations of assisted reproductive techniques (ARTs) also need to be considered.[6,7]

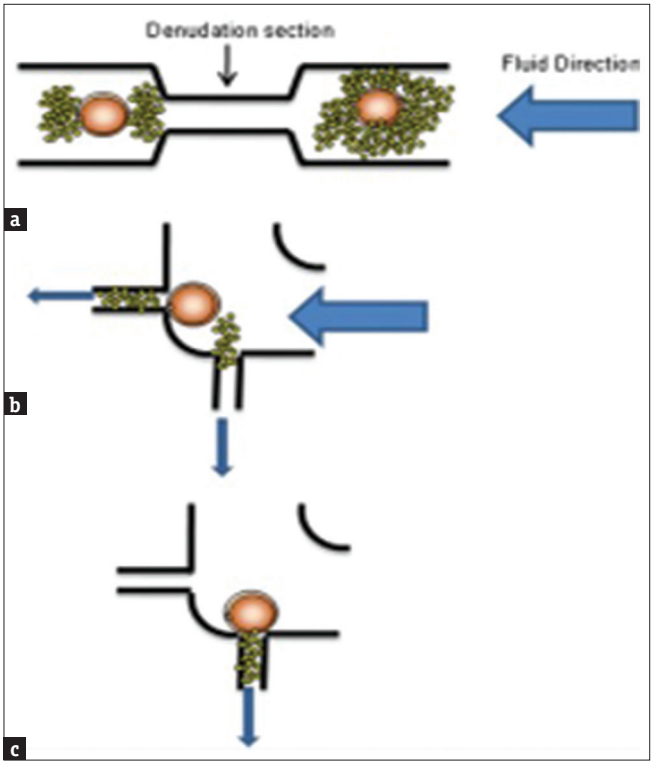

Figure 3: Proposed automatic cumulus removal device [Reproduced with permission from Meseguer M, Kruhne U, Laursen S. Full *in vitro* fertilization laboratory mechanization: Toward robotic assisted reproduction? Fertil Steril 2012;97:1277-86].[8]

Robotic assisted reproduction

IVF is an ART which uses minimal surgical procedure for human gamet to be fertilized and developed to become an embryo. IVF has been widely used with the manual procedure, such as controlled ovarian stimulation, oocyte retrieval, and embryo transfer. In future, a gynecologist aims to switch manual ART to automated ART. The mechanism is involving a robotic machine as an aid for fertilization of sperm and oocyte and embryo development and maturation. Thereafter, the best quality of embryo can be obtained with a simple procedure to be transferred into the uterus.[8]

Cumulus cells removal from oocyte is done by dropping a medium containing hyaluronidase or a small drop of oil into a container [Figure 3].[8] However, a breakthrough device is currently used to remove cumulus cells from oocyte only by passing the oocyte into a narrow pipe. Then, the machine will process the oocyte to become a partial removed cumulus cells. Furthermore, the oocyte is exposed to fluid and suction force in the second pipe to completely denude oocyte from cumulus cells. Those mechanisms explain oocyte denudation using chemical and mechanical procedures which is time consuming and requiring repetition to completely obtain full removal of cumulus cells. Unfortunately, this machine has not been validated and approved for its usefulness.[8]

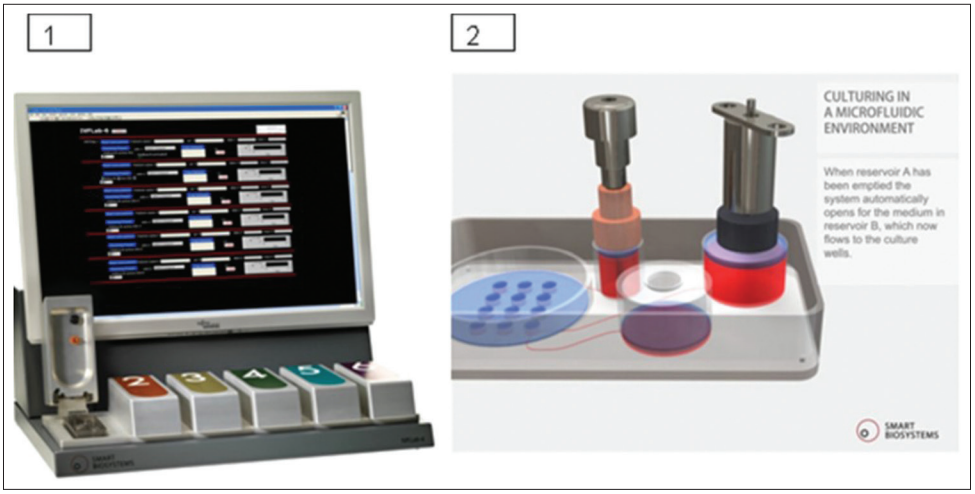

Figure 4: An example of a microfluidic system (Smart Biosystem): An automated cell culture device for *in vitro* fertilization [Reproduced with permission from Meseguer M, Kruhne U, Laursen S. Full *in vitro* fertilization laboratory mechanization: Toward robotic assisted reproduction? Fertil Steril 2012;97:1277-86].[8]

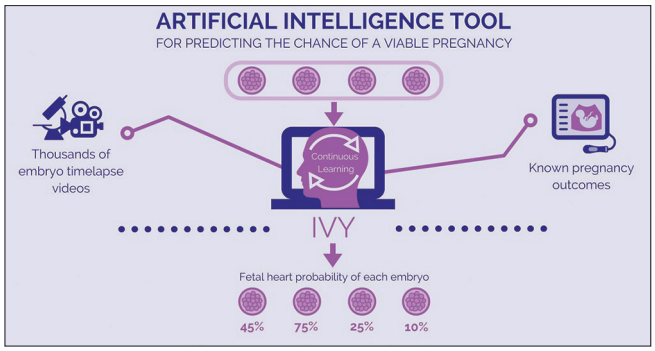

Figure 5: Artificial intelligence for boosting *in vitro* fertilization success [Reprinted with permission and first published in https://thenewdaily.com.au/life/science/2019/02/24/ivf-invention-ivy/attachment/1550817571-ivy-ai-infographic-ivf-australia/].[11]

IVF laboratory is the other device for cell culture using an automatic machine of microfluidic [Figure 4].[8] Each container of the machine can be filled by fresh medium and processed with hydrodynamic flow difference up to 20 ml/h and diffusion. Containers are safe to protect the medium from the risk of high shear stress, while autocrine substance as a waste product is washed out.[8]

Artificial intelligence in reproductive medicine

Morphological assessment of the embryo is commonly used to determine the quality of oocytes. Selecting the best quality embryo to be transferred into the uterus is important in IVF. A high-quality embryo will increase the success rate of IVF. One study conducted by Muna *et al*. showed that preimplantation genetic screening (PGS) can be used as a method of assessing the quality of the embryo by chromosomal status examination. PGS has a success rate of >90%. PGS assesses the embryo's ploidy, which is often related to embryo fragmentation.[9]

Embryo selection has been a challenge to get the best quality IVF. Subjectivity of embryo selection, such as selection bias, is still needed some improvement. A recent study discovered that AI is more accurate than an embryologist at precisely identifying which embryos have the potential to result in a healthy birth. Digital image processing machine, artificial intelligence, and time-lapse morphokinetic machine are collectively aiding embryologist to select the best quality embryo in a higher precision, which may reduce human subjectivity [Figure 5].[10,11]

The important endpoints include improving the take-home baby, implantation, pregnancy, and live birth rates. PGS combined with time-lapse morphokinetics may improve conventional embryo selection and predict blastocyst development potential. Time-lapse morphokinetics can help the embryologist in selecting embryos during direct cleavage and predict embryo viability based on early morphokinetic variables. The predictive markers of embryo viability are the time interval between the first and second mitotic division and the time interval between the second set of cleavage division.[9,10]

Genetic engineering

Germ line gene correction by genome editing of oocytes, zygote, embryo, and sperm is a breakthrough technology for preventing genetic diseases.[12] Genome editing is more likely to be performed before ART, such as IVF and ICSI. Genome editing technology, such as the clustered regularly interspaced short palindromic repeat (CRISPR)/Cas9 system as an engineered nuclease, can correct intestinal stem cell mutation in patients with cystic fibrosis. One study showed that CRISPR/Cas9 may inactivate the DNA sequence responsible for infertility or miscarriage of the human embryo. However, social and ethical aspects should be considered in each region.[13]

Internet of things and telemedicine

Advanced technology and innovation in the fourth industrial revolution as well as the development of ambulatory and home monitoring devices have modified health-care provider focus of treatment. Health-based platforms have been created to fulfill the need for consumer health informatics. There are some requirements for online helper platforms. These include a rules engine, extensible user profile, a health spreadsheet for each online helper, communication interaction capabilities (i.e., virtual interactive communication), community, co-operation competition, compensation, an on-demand platform, and authoring environment.[14] These aspects make the physician–patient relationship easier and more convenient. The patient may access reliable information related to their health condition, while the health-care provider may track the progress of the patient's health.

A study conducted by Wiweko *et al*. about the evaluation of multimedia and online support group (OSG) content for respondents who sought treatment in an IVF clinic showed that there was an insignificant relationship between the level of knowledge and use of website-based information. However, a qualitative study showed that multimedia and OSG related to information on fertility services were used when deciding to use fertility services [Figures 6 and 7].[15-17]

A health-based application, named as Jakarta Reproduksi Sehat (JAKPROS), was created by an obstetrician–gynecologist. It comprises features, such as education, question and answer (Q and A), and health service pages. Due to the wide availability of invalid information on the Internet, JAKPROS aimed to provide reliable information regarding reproductive health to consumer health informatics. Another application that was created to determine the biological age is the Indonesian

Figure 6: (a) Jakarta Reproduksi Sehat home page; (b) log-in page; and (c) article page [Reproduced with permission from Wiweko B, Riyanti A, Olivia S, Priangga M, Silvana V, Lewis A, et al. " Jakarta Reproduksi Sehat " (JAKPROS) Mobile Application for Healthy Jakarta; AIP Conference Proceedings 2019;2092;040006 and Wiweko B, Riyanti A, Olivia S, Priangga M, Silvana V, Pertiwi IP, *et al*. Jakpros: Reproductive Health Education Application for Pregnant Women. Int Conf Adv Comput Sci Inf Syst ICACSIS; 2018 2019. p. 225-9].[15,16]

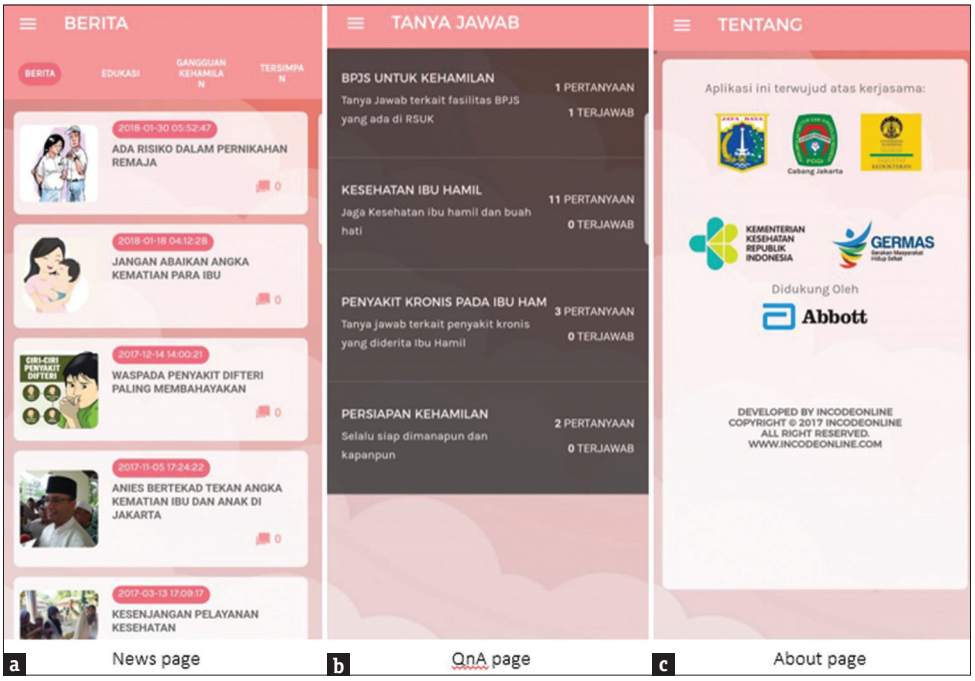

Figure 7: (a) Jakarta Reproduksi Sehat news page; (b) question and answer page; and (c) about page [Reproduced with permission from Wiweko B, Riyanti A, Olivia S, Priangga M, Silvana V, Lewis A, et al. " Jakarta Reproduksi Sehat " (JAKPROS) Mobile Application for Healthy Jakarta; AIP Conference Proceedings 2019;2092;040006 and Wiweko B, Riyanti A, Olivia S, Priangga M, Silvana V, Pertiwi IP, *et al*. Jakpros: Reproductive Health Education Application for Pregnant Women. Int Conf Adv Comput Sci Inf Syst ICACSIS; 2018 2019. p. 225-9].[15,16]

Kalkulator of Oocytes [Figure 8].[18] This application uses the anti-Müllerian hormone (AMH) level as a biological marker for predicting biological age. Conversely, if the user wants to determine their AMH levels, they can enter their biological age. A study conducted by Wiweko *et al*. proved that the AMH level can be used as an early predictor of the biological age of women than follicle-stimulating hormone and antral follicle count.[15-18]

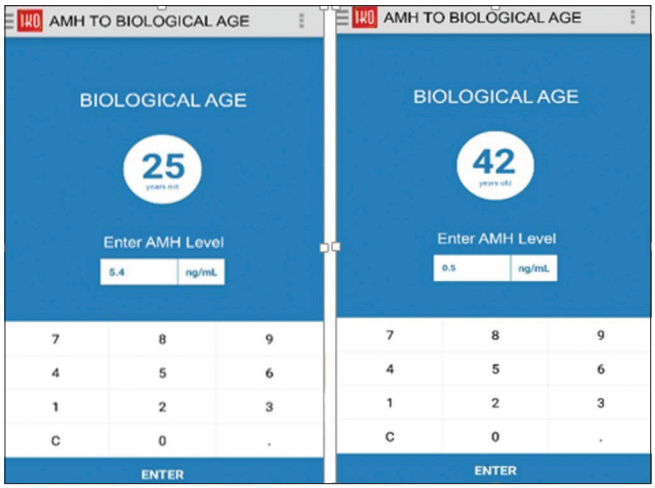

Figure 8: Indonesian Kalkulator of Oocytes platform [Reproduce with permission from Wiweko B, Narasati S, Agung PG, Wibawa YS, Maidarti M. Indonesian Kalkulator of Oocytes (IKO): A Smart Application to Determine our Biological age; AIP Conference Proceedings; 2018;1933;040016].[18]

The other aspects which have to be fulfilled from telemedicine as a breakthrough communication are teleconsultation, teleexpertise, telemonitoring, and teleassistance. Patients, physicians, nurses, and online medical records have important roles in maintaining the conformity of telemedicine. Starting from the problem to control patients from the remote area, telemedicine highlights two important things, such as increasing diagnostic complexity which requires peer-to-peer consultation among health-care provider and having access to control patients in remote rural areas, especially elderly and patients in chronic diseases.[19]

Big data

Clinical phenotypes are being described more quantitatively and biochemically using genomics, transcriptomics, proteomics, and metabolomics. These aspects refer to personalized medicine that tends to focus on promotive and preventive strategies. Big data in clinical aspects encompass high-throughput cellular and protein binding assays toward chemoinformatic-driven databases. Some processes related to the output of big data, such as record linkage, storage, data analysis, visualization, and reporting. Each aspect of healthcare can be the important source of big data describing our patients. Therefore, healthcare providers should not leave any information of patients written in the health record to support further resource of information.[20,21]

Further investigation of clinical decision of healthcare management is using computational bioinformatic information, such as proteomics, genomics, pharmacogenomics, chemoinformatic, medical informatics, computational biology, pharmacogenetics, and immunoinformatics to obtain precise information about specific patients. Bioinformatics is a basic concept of human approach using molecular and cellular information in making clinical diagnosis and clinical intervention.[22] Moreover, it enhances our knowledge related to each pathophysiology of disease. Big data, such as electronic medical records, help discover new therapeutic targets when combined with "omics" data. A health-care provider can undertake a holistic approach by involving genotypic–phenotypic biomedical information and social aspects for patient management.[20]

Precision medicine: Genomics and bioinformatics

PM can be defined as a predictive, preventive, personalized, and participatory health-care service delivery model. PM refers to medical treatment that is adapted to individual characteristics and shifts away from contemporary medical practice toward a more effective management strategy for each patient. Further clinical decisions will focus on PM, which enables the application of rules, algorithms, and reference databases. The main strategy of PM includes classifying each individual into subpopulations that differ in susceptibility to a particular disease, individual biological characteristic, and/or prognosis.[23]

Health status can be modified by changing the epigenetic factor, such as lifestyle and environment. On the other hand, genetic including transcriptomic, hold a role as unmodifiable factor affecting body metabolism of a human being. All of these components contribute the source of big data that will be processed to maintain the management of disease and healthcare.[24] As a result, they affect the approach of each human precision medicine and provide the insight into pathophysiology of a disease, clinical treatment, and early preventive action.

The current concept of bioinformatics toward molecular biology and its impact on personal or public health is related to the ethical consequences and policy consideration that affect daily life. Genomics and bioinformatics are integral parts of health-care services.[25] Health-care providers should recognize the importance of genomic and bioinformatic analyses for making clinical and data-driven medical decisions. As it becomes an effective part of medical care, strengthening public scientific literacy, particularly with respect to genomics and bioinformatics, is important.[26]

Conclusion

1. Disruptive innovations in health-care align with the development of AI, machine learning, robotics, IoT, digitalization, and genomics

2. New paradigm shifting in physician–patient relationships is relevant to consumer health informatics
3. The development and knowledge of bioinformatics are very crucial for supporting the establishment of PM
4. Electronic health records of personal data – including genetics, proteomics, and metabolomics – play an important role in PM
5. PM looks very promising regarding increasing the accuracy, safety, and efficacy of promotive, preventive, diagnostic, and treatment approaches.

Acknowledgment

The authors would like thank to Universitas Indonesia which gave the facilities and permission.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Xu M, David JM, Kim SH. The fourth industrial revolution: Opportunities and challenges. International Journal of Financial Research 2018;9:90-5.
2. Wiweko B. Fertility & reproduction cutting edge of reproductive medicine. Fertility & Reproduction 2019;1:78-87.
3. Christensen CM, Mcdonald R, Altman EJ, Palmer JE. Disruptive innovation: An intellectual history and directions for future research. Journal of Management Studies 2018;55:1043-78.
4. The NHS Constitution. Preparing the Healthcare Workforce to Deliver the Digital Future; 2019.
5. Woods DC, Tilly JL. Autologous Germline Mitochondrial Energy Transfer (AUGMENT) in Human Assisted Reproduction. Semin Reprod Med 2015;33:410-21.
6. Martinelli L, Busatta L, Galvagni L, Piciocchi C. Social egg freezing: A reproductive chance or smoke and mirrors? Croat Med J 2015;56:387-91.
7. Wiweko B, Maidarti M, Mansyur E, Yuningsih T, Ahmad A, Boediono A, *et al*. Ovarian tissue vitrification as a method for fertility preservation: A study of follicle number and morphology after vitrification. IVF Lite 2014;1:148-52.
8. Meseguer M, Kruhne U, Laursen S. Full *in vitro* fertilization laboratory mechanization: Toward robotic assisted reproduction? Fertil Steril 2012;97:1277-86.
9. Iffanolida PA, *et al*. Late embryo cleavage as an indicator of chromosome aneuploidy by pre-implantation genetic screening. Journal of Physics: IOP Conf Series 2018;1073;042049.
10. Findikli N, Oral E. Time-lapse embryo imaging technology: Does it improve the clinical results? Curr Opin Obstet Gynecol 2014;26:138-44.
11. Fratantoni M. Artificial Intelligence Tool for Predicting the Chance of a Viable Pregnancy; 2019. Available from: https://thenewdaily.com.au/life/science/2019/02/24/ivf-invention-ivy/. [Last accessed on 2020 Mar 12].
12. Reuters. DNA Editing Images; 2015. Available from: https://www.iflscience.com/health-and-medicine/why-treat-gene-editing-differently-two-types-human-cells/. [Last accessed on 2020 Mar 12].
13. Araki M, Ishii T. International regulatory landscape and integration of corrective genome editing into *in vitro* fertilization. Reprod Biol Endocrinol 2014;12:108.
14. Bosworth A, York C, Kotansky H, Berman MA. An inventor's perspective on consumer health informatics. Am J Prev Med 2011;40:S241-4.
15. Wiweko B, Riyanti A, Olivia S, Priangga M, Silvana V, Lewis A, *et al*. " Jakarta Reproduksi Sehat " (JAKPROS) Mobile Application for Healthy Jakarta; AIP Conference Proceedings 2019;2092;040006.
16. Wiweko B, Riyanti A, Olivia S, Priangga M, Silvana V, Pertiwi IP, *et al*. Jakpros: Reproductive Health Education Application for Pregnant Women. Int Conf Adv Comput Sci Inf Syst ICACSIS; 2018 2019. p. 225-9.
17. Wiweko B, Narasati S, Agung PG, Zesario A. An Evaluation of Multimedia and Online Support Groups (OSG) Contents and Application of Information by Infertile Patients: Mixed method study; AIP Conference Proceedings 2018;1933;040015.
18. Wiweko B, Narasati S, Agung PG, Wibawa YS, Maidarti M. Indonesian Kalkulator of Oocytes (IKO): A Smart Application to Determine our Biological age Indonesian Kalkulator of Oocytes (IKO): A Smart Application to Determine Our Biological Age; AIP Conference Proceedings; 2018;1933;040016.
19. Kamsu-Foguem B, Tiako P, Fotso L, Foguem C. Modeling for effective collaboration in telemedicine. Telematics and Informatics, Elsevier; 2015; 32; p. 776-86.
20. Issa NT, Byers SW, and Dakshanamurthy S. Big data: the next frontier for innovation in therapeutics and healthcare. Expert Rev Clin Pharmacol 2014;7:293-8.
21. Trifirò G, Sultana J, Bate A. From big data to smart data for pharmacovigilance: The role of healthcare databases and other emerging sources. Drug Saf 2018;41:143-9.
22. Ristevski B, Chen M. Big data analytics in medicine and healthcare. J Integr Bioinform 2018;15. pii:/j/jib. 2018.
23. Bertier G, Carrot-Zhang J, Ragoussis V, Joly Y. Integrating precision cancer medicine into healthcare-policy, practice, and research challenges. Genome Med 2016;8:108.
24. Lin Y, Chen J, Shen B. Interactions between Genetics, Lifestyle, and Environmental Factors for Healthcare. Adv Exp Med Biol 2017;1005:167-91.
25. Chen J, Lin Y, Shen B. Informatics for precision medicine and healthcare. Adv Exp Med Biol 2017;1005:1-20.
26. Brazas MD, Lewitter F, Schneider MV, van Gelder CW, Palagi PM. A quick guide to genomics and bioinformatics training for clinical and public audiences. PLoS Comput Biol 2014;10:e1003510.