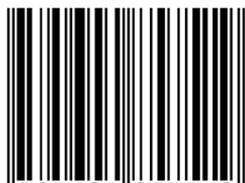# Digital Science

DSIC 2023

Editor
Tatiana Antipova

Throughout science, digitization is occurring in shorter waves than ever before. Digital transformation can reduce operational costs and inefficiencies, and puts the technology of scientific studies/research at the center of scientific strategy. Highly complex interactions between many technologies, activities, and people make up modern scientific work.

This book reflects a science-based vision of using composite materials and high-tech devices in Engineering, Biomechanics, and Medicine/Health Care.

Scholars, professionals and experts whose work is related to the digital transformation of modern socio-economic and engineering systems in the digital age are the target audience of this book.

CONTENT

High-Tech Equipment for Health Research

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Abstract. High-tech medical equipment for telemedicine, nuclear medicine, etc. is needed for patients' treatment in modern medical institutions. In order to provide medical institutions with such equipment, it is necessary to determine the adequacy of the medical equipment already available in hospitals and/or the need for the purchase of more modern and efficient medical equipment. We should also remember that the medical institutions are responsible for providing medical services that meet the standards of economy and efficiency, free of fraud, misuse, and so on. The concept of value-based healthcare institutions demonstrates improved quality of care through rigorous quality assurance measures. But in some cases, the management of these institutions falls short of their remarkable potential because of the lack of information, the lack of incentives, and the fragmented nature of the organization between management and practitioners. This chapter provides scientific view for determining appropriateness and necessity of high-tech medical equipment by integrating service data, and a logical scheme for evaluating High-tech medical equipment alternatives.

Keywords: High-tech medical equipment, cost reduction, health research.

1. Introduction

High-tech medical equipment (HME) is equipment specifically designed to provide high-tech medical care. High-tech equipment is one of the key factors for creating value in progressive medical organizations that are open to innovation and consider the ecosystem approach as a way for all stakeholders to interact, ready to implement the latest technologies together. HME is one of the key focuses of the innovative activities of progressive medical organizations as it enables the application of new treatment technologies and promotes the industry to a new level of service quality [1].

The main paradigm of this approach is that the primary goal of medicine is value from the patient's perspective, not just access to care, cost-containment policies, convenience, or service. Since value is defined as outcomes relative to costs, it encompasses efficiency. Cost reduction without regard to the outcomes achieved is dangerous and self-

defeating, leading to false "savings" and potentially limiting effective care. Outcomes, the numerator of the value equation, are inherently condition-specific and multidimensional. For any medical condition, no single outcome captures the results of care. Cost, the equation's denominator, refers to the total costs of the full cycle of care for the patient's medical condition, not the cost of individual services [2].

Countries and communities need to prioritize the protection of new and existing hospitals and other health facilities from identified hazards and should ensure the physical integrity of buildings, equipment and critical hospital systems. More and more attention has been paid to creating comfortable and functional hospital environments, where the patients can feel good and at ease maintaining the same efficiency of medical activities. In addition, flexibility has been particularly considered because hospital facilities must adapt to the continuous needs of change [3, 4].

To make these change implementing of HME requires special skills in design, manufacture, maintenance and operation and requires effective approaches to managing its life cycle, including funding models for its development, manufacture, acquisition, use and maintenance. Coordination of all these steps of the equipment life cycle, performed by different actors, seems hardly possible without an open innovative society. Such a society (formal or informal) needs a specific management mechanism for effective management of the HME life cycle [1] because the most HME devices, e.g. telecommunication devices, electronic instruments, microprocessors, are characterized by rapid technological innovation and a shorter product life cycle [5]. But despite of this hospitals can also be seen as a small "factory" that contains a variety of services that need to find a balance between medical resources and patients. Yet, hospitals are currently facing changing medical needs. This requires hospitals to constantly add new services as they demand, and to make those services more efficient [6]. To make Health Care services more efficient it must have adequacy facilities with possibility to produce clear visual imagines.

In medicine, the visual imagination of the physician has always been crucial for diagnosis and therapy, as medicine become an image-guided discipline. Due to technological improvements, medicine is now moving towards a video-guided discipline, where the physician has no direct view on the area of interest, but is using a video camera. The integration of these modern visualisation technologies, communication systems and remote-control facilities in a medical workplace of the future

allows the customized display of all relevant information for the physician at the right time and place. [Graschew G. et al. New Medical Technologies of the Future. I978-1-4799-0924-7/13/, pp 84-89. IEEE]

That is, scientific medicine is converging with such sciences as physics, engineering, economics, public administration, computer sciences, and many others and requires new technical equipment.

This research aims to answer the following research question: how can we develop medical investigations to provide efficient, patient-centric healthcare in part of needed high-tech medical equipment use? To answer this question, author propose the logical scheme to evaluate possibility of effective use of high-tech medical equipment.

2. Data and Methodology

In 2005 - 2022, the data were obtained from financial and statistical reports of health care institutions with once-a-year frequency of data observation and calculation. From the organizational point of view, the authors have organized and participated in multidisciplinary and thematic meetings (management, engineering, technical, logistic, health, artificial intelligence). Experts and stakeholders were involved in working groups with different purposes according to the development phase of the methodology, following the Delphi method. All the key points of these actions as part of the future methodology (strategic objectives, reference standards, algorithms and results) were discussed in periodic meetings during ten international conferences 2017-2023.

Within the framework of this section, the methodology of a study conducted in accordance with the purpose of scientific qualification research, namely, defining of Need for High-Tech Medical Equipment in medical investigation, are presented.

According to World Health Organization (WHO) recommendations [A stepwise approach to identify gaps in medical devices (availability matrix and survey methodology). https://apps.who.int/iris/bitstream/handle/10665/70451/WHO_HSS_E HT_DIM_10.1_eng.pdf?sequence=1&isAllowed=y], to determine the needed medical devices for treatment it is necessary to be guided by the Global Burden of Disease and Risk Factors [7] for mapping of diseases/disabilities, then selecting the relevant clinical guidelines developed to describe the treatment of these diseases/disabilities. Clinical procedures and medical devices are then extracted to complete the Availability Matrix. This method identifies the medical devices

recommended by WHO for the treatment of a specific disease in clinical practice mentioned in the clinical guideline.

In the following section presents the logical scheme to define needed medical devices in medical diagnostics/investigations.

3. Results

High-tech equipment for telemedicine, nuclear medicine, etc. is needed in modern medical institutions. In order to provide such equipment, it is necessary to determine the adequacy of the equipment already available in the health care facility and the need for financial support for the purchase of more modern and efficient equipment [8].

At the same time, it is necessary to take into account that health care institutions must provide medical services in accordance with the standards of economy and efficiency in the use of budgetary funds. At the same time, they are expected to improve the performance of all services provided. Health care institutions with the worst indicators must improve them within five years. The concept of better-quality forces health care facilities to demonstrate improvements in the quality of services provided under strict quality management controls. At times, the management of medical equipment does not live up to its remarkable potential due to a lack of qualified personnel for its use and application, inadequate information, inappropriate incentives, and organizational fragmentation between management personnel and practitioners. This chapter applies the basic principles of determining the appropriateness and necessity of precision devices based on value (integrated price and performance data, alignment of financial incentives, and organizational capacity to evaluate alternatives) to the medical device market.

To assess the adequacy of a medical facilities' resources, we must understand what those resources are and how and what they are used for. Some of these resources are presented in Fig. 1.
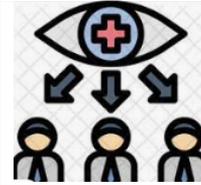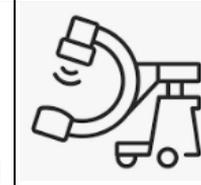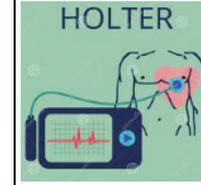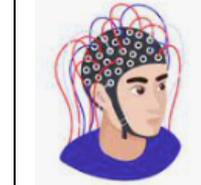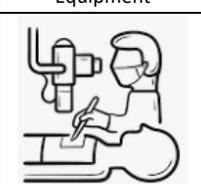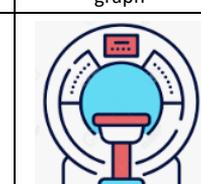
Oxygen Machine	Tonometer	Medical Surveillance Cameras	X-Ray Machine
CT Scanner	Medical Drone	Medical Mobile Sensors	Holter monitor
Telemedicine Devices	Nuclear Medicine Equipment	Ultrasonic diagnostic devices	Electroencephalo graph
Robotic Surgery Equipment	Surgical Microscope	Medical Robots	MRI Scanner

Fig. 1. Common medical equipment. Source: [9].

CT scanner

CT scanner use for Computed tomography (CT) that is a type of X-ray imaging test which allows a layer-by-layer picture of the body in slices. In this procedure, as the X-ray tube and the detector are rotating around the patient, a cross-sectional or sliced image is displayed on a computer. These images can be applied to diagnose appendicitis, kidney stones, or cerebral artery diseases [9]. Examples of CT images shown in Fig. 2.
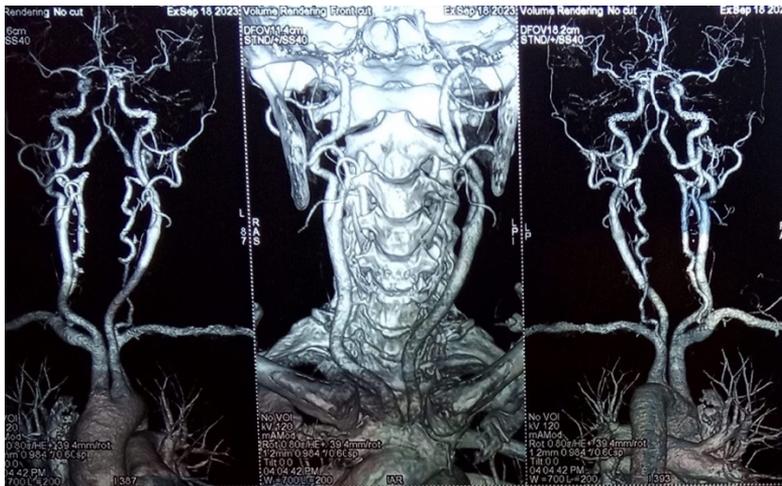
Fig. 2. CT image of the neck and head made on a computer tomograph.
To visualize blood vessels, before the patient's medical investigation, IV with
contract has been done. Source: own elaboration.

Medical Robots

Humanoid robots, autonomous vehicles, and other intelligent robots can help reduce physical interactions between health- care workers and infected persons. Robots can help in many tasks such as preparing food, providing medication to patients, and cleaning and disinfecting health facilities.

In addition, robotics is recognized as a key technology with the potential to make a significant contribution to global health care and the economy. Thanks to the tremendous progress made over the past two decades, robots can now perform direct interventions to help improve treatment outcomes.

Diagnostic robots focus on three main areas: autonomous control of medical devices (such as endoscopes, ultrasound probes, or exam tables), robotic laboratory setups (such as automatic sample processing), and telepresence robots that can measure vital signs (such as temperature, pulse, and respiration) and interact with patients. These systems can increase productivity, reduce data processing time, and allow medical professionals to observe the patient from a safe distance.

Robots can also boost moods, especially when patients are in the hospital, providing either a means of socializing with friends or entertainment.

Medical Drones

Drones can be used for different purposes, including surveillance, mass testing, announcement, diagnosis, delivery, and disinfection of areas. Diagnosis drones such as thermal-imaging drones can be used for monitoring and detecting infected cases by checking the temperature, vital signs such as heart rate, and symptoms such as sneezing or coughing remotely. China and India applied surveillance drones for crowd control. Delivery drones were deployed in Ghana, China, and Canada for delivering swab test kits. They can also be used to deliver other goods and groceries to avoid visits to supermarkets and reduce potential human physical interactions.

MRI Scanners

MRI Scanners generate MRI images. Magnetic resonance imaging (MRI) is an imaging technique used to generate images of body organs. MRI scanner includes a large tunnel inside which the patient is placed during the process of imaging and controlled by a computer. MRI scans are used to take pictures of internal parts of body, such as brain, spinal cord, bones, heart, blood vessels, and other organs [10]. Example of MRI images of human brain shown in Fig. 3.

Fig. 3. Example of MRI images of human brain.

Image-based MRI models try to facilitate medical lesion detection and abnormalities by evaluating medical images as objectively as possible, using image features and prior knowledge about the particular application domain. Such systems usually combine image segmentation methods to isolate recognizes regions of interest corresponding to

prominent objects, and automatic annotation methods, to attach labels that characterize each region [11].

Hospitals are generally budgetary entities that founded by Federal/State/Local Administrators of budgetary funds and may receive High-Tech medical Equipment (HME) through budgetary allocations. Let's consider the process of receiving high-tech medical devices by hospital. This process can be happened in condition of VBH medicine application with personalized approach. This process shown on Fig.1. To determine the needed medical devices for treatment it is necessary to be guided by [13]. During determination the needed medical devices for treatment responsible persons may use SCORE Assessment maturity models for indicators included in scoring that developed by WHO. For purpose of this study author considered middle part of SCORE Assessment maturity models for indicators included in scoring (see Table 2).

Table 1. SCORE Assessment maturity model for indicators included in scoring

	Nascent capacity	Limited capacity	Moderate capacity	Well-developed capacity	Sustainable capacity
Assessment	**1**	**2**	**3**	**4**	**5**
Data and evidence drive policy and planning	Total score of key indicator items is **3 or less**	Total score of key indicator items is **4-6**	Total score of key indicator items is **7-8**	Total score of key indicator items is **9-11**	Total score of key indicator items is **12 or higher**
Data access and sharing	Total score of key indicator items is **8 or less**	Total score of key indicator items is **9-12**	Total score of key indicator items is **13-16**	Total score of key indicator items is **17-20**	Total score of key indicator items is **21 or higher**
Strong country-led governance of data	**No plan exists** that is linked to the current national health sector strategic plan	Total score of key indicator items is **9 or less**	Total score of key indicator items is **10-14**	Total score of key indicator items is **15-17**	Total score of key indicator items is **18 or higher**
Strong country-led governance of data – eHealth strategy	An eHealth strategy is **non-existent** or is no longer current	Total score of key indicator items is **8 or less**	Total score of key indicator items is **9-12**	Total score of key indicator items is between **13-15**	Total score of key indicator items is **16 or higher**

Sources: Author interpretation a part of SCORE Assessment maturity models for indicators included in scoring [8, 13, 14].
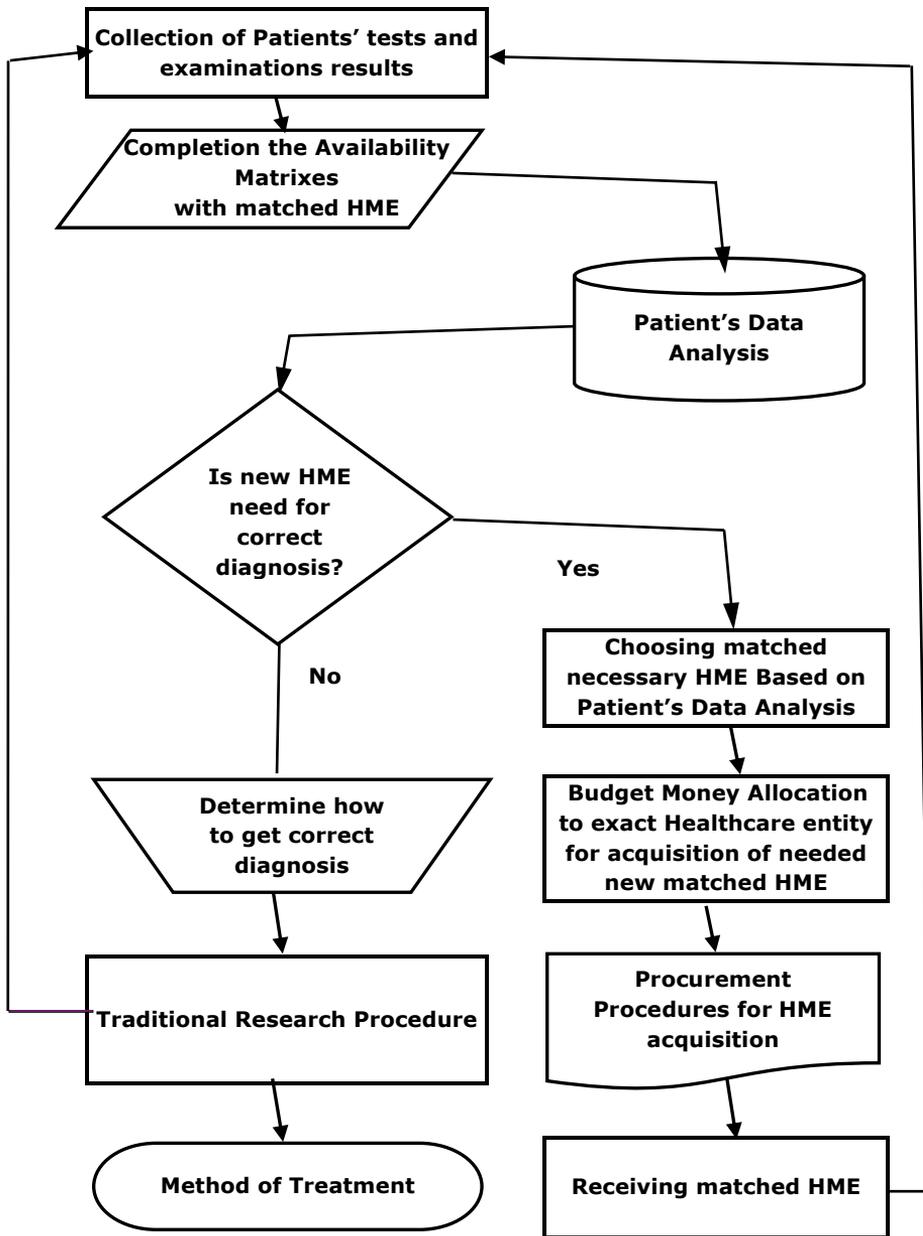
Fig.4. Logical scheme to determine the correct high-tech medical equipment
needed to medical research. Source: own elaboration.

Considering the scheme shown in Fig.4, it is necessary to note that none of the high-tech medical equipment can guarantee correct diagnosis or method of treatment for patients. In the author's opinion, one of the reasons for this is the division of medicine as a science into many narrow specializations that do not allow the patient to be seen as a holistic organism that cannot function without the interrelationship of organs/elements. But these are topics for much future research.

5. Conclusion

The aspects to assess have been identified to provide decision-makers with an overview of the situation of health care facilities. The purpose of this study is to provide an overview of modernization and how the physical environment can contribute to the resilience of the overall health care system.

Implementation of modernization strategies of health care facilities to ensure high standard of care and effective use of given resources is one of the duties of decision makers. Using modern equipment, i.e. magnetic resonance scanners, computer scanners, etc., this process was aimed at eliciting expert reasoning. The adaptation has concerned the objectives of the assessment, the main aspects, the algorithms, the metrics, and how to present the results. The main aspects are related to specific established objectives. They are based on a hierarchy of main indicators, giving greater importance to safety and functionality of HME. In addition, the algorithms take into account the relationships between the parts of the hospital facilities. They are considered as complex systems of outcome-oriented health care. While addressing the new challenges of power system operations, the safety of utility employees, contractors, and the public is paramount. This will be accomplished through the adoption of integration with municipal/federal disaster response structures where appropriate.

References

1. Ilin, I., et al (2022). Life-cycle contract as an innovative business model for high-tech medical organizations. Journal of Open Innovation: Technology, Market, and Complexity, 8(4), 207. doi:https://doi.org/10.3390/joitmc8040207
2. Bentley Tanya G.K., et al. Validity and Reliability of Value Assessment Frameworks for New Cancer Drugs. Value in Health, **20** (2), 200-205, 2017, https://doi.org/10.1016/j.jval.2016.12.011.
3. World Health Organization (WHO), Organisation for Economic Co-operation and Development (OECD), International Bank for Reconstruction and Development, Delivering Quality Health Services: a Global Imperative for Universal Health Coverage, 2018, p. 93.
4. World Health Organization (WHO), Comprehensive Safe Hospital Framework, 2015, pp. 1–12.

5. Sharma, N. (2022). How core, technical and social components of business relationship value drive customer satisfaction and loyalty in high tech B2B market. The Journal of Business & Industrial Marketing, 37(5), 975-994. doi:https://doi.org/10.1108/JBIM-12-2020-0554.

6. Guo, J., & Lv, Z. (2022). Application of digital twins in multiple fields. *Multimedia Tools and Applications, 81*(19), 26941-26967. doi: https://doi.org/10.1007/s11042-022-12536-5.

7. Lopez AD et al, eds. Global burden of disease and risk factors. New York, World Bank and Oxford University Press, 2006

8. Antipova T., Zhelnin A., Zhelnina I. Briefs in Assessing the Adequacy of Health Care Facilities' Fixed Assets. JDS, **4**(1), 85 – 91 (2022). https://doi.org/10.33847/2686-8296.4.1_8.

9. Antipova T. Need for High-Tech Medical Devices in Value-Based Health Care. Advances in Digital Science, 50-62, 2022. https://doi.org/10.33847/978-5-6048575-0-2_4.

10. Fouladi, S., Safaei, A. A., Arshad, N. I., Ebadi, M. J., & Ahmadian, A. (2022). The use of artificial neural networks to diagnose Alzheimer's disease from brain images.*Multimedia Tools and Applications, 81*(26), 37681-37721. doi:https://doi.org/10.1007/s11042-022-13506-7.

11. Aljabri, M., AlAmir, M., AlGhamdi, M., Abdel-Mottaleb, M., & Collado-Mesa, F. (2022). Towards a better understanding of annotation tools for medical imaging: A survey. *Multimedia Tools and Applications, 81*(18), 25877-25911. doi:https://doi.org/10.1007/s11042-022-12100-1.

12. Istudor, N., et al (2023). Integration Of Circular Economy Principles In Consumer Behaviour For Electrical And Electronic Equipment. Amfiteatru Economic, 25(62), 48-62. doi:https://doi.org/10.24818/EA/2023/62/48.

13. "SCORE for health data technical package: global report on health data systems and capacity, 2020" – WHO Global report on health data systems and capacity, 2020.

14. Antipova T. Health Digital Indicators' Juxtaposition. JDS, **5**(1), 55 – 62 (2023). https://doi.org/10.33847/2686-8296.5.1_6.

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