Application of Ergonomics in Health Care

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Abstract. This paper defines the definition of human ergonomics, and introducing human ergonomics as an important subject in the medical and health services, and discusses the technical skills associated with human ergonomics and medical and health services, let us on the non-technical skills in medical and health services with the understanding of the important role. This paper analyzes the current situation of some non-technical skills in our hospital, and summarizes some effective methods and measures at home and abroad to reduce the influence of human factors in recent years.

1. Introduction
As an emerging and rapidly developing interdisciplinary subject, ergonomics involves many disciplines, such as physiology, psychology, anatomy, management, engineering, systems science, labor science, safety science, environmental science and so on [1]. In the course of its formation, scholars from different disciplines and countries all over the world have defined and named it from different perspectives, however, its name has not been fixed yet. The common name is ergonomics which is the most widely used name in the world. Other names are "human factor engineering" or "human factor science" [2].

It is most commonly used in the nuclear power industry and house goods design in the United States and some Western countries [3]. In China, ergonomics is also used more frequently. In the field of Aeronautics and Astronautics in China, the name "man-machine-environment system engineering" was first adopted. It covers a wider range of subjects. Other similar names, such as "Engineering Psychology" are the early names of it. Like the naming of this discipline, the definition of this discipline is not uniform, and with the development of the discipline, its definition undergoes constant change. The definition given by the International Society of Human Ergonomics is the most authoritative and comprehensive one. Human Ergonomics studies various factors of human anatomy, physiology and psychology in a certain working environment as well as the interaction between human, machine and environment, and how to consider work efficiency, human health and safety in work, family life and vacation in a unified way. For the sake of unity, this paper uses "ergonomics" as the name of the subject, and talks about the application of ergonomics in medical and health work in recent years [4-5].

In health care field, ergonomics refers to adoption of a variety of scientific measures to enhance the compatibility between the workplace and employees. These measures are the potential and limitations of the working environment, which are formulated by taking into account the actual situation of workers. Therefore, safety and worker-related conditions (the level of comfort, job satisfaction,
efficiency, etc.) can be significantly improved. In addition, ergonomics allows the design of appropriate workplaces to promote a healthy work culture, that is, by solving workload management problems, to make up for human errors of medical health workers. Human factors often lead to human errors. From the perspective of human factors, human errors can be understood from two aspects: human reliability analysis and cognitive errors [6]. In order to ensure the safety of high-risk industries, the study of human factors derives human reliability analysis. Human intelligence, health status, positive attitude and training experience will affect work efficiency. Moreover, human errors can be also caused by cognitive factors. Cognitive factors also affect the judgment of human errors. Because the evaluation data of human errors in complex systems are very limited, the main research is how to evaluate and predict errors [7].

2. Medical errors caused by human factors in medical and health care.

Researches show that the actual operation process of cardiopulmonary resuscitation in pediatric intensive care unit to rescue children with cardiac arrest is not completely consistent with the usual training standards [8]. What is the reason behind it? In interviews with the medical staff who performed CPR, they say that the CPR in their memories are inconsistent from the video presented. The study of human factors can help us understand and explain this change. In practice, when emergencies which requires immediate response happen, even well-trained medical personnel may take inappropriate actions to carry out rescue. Repeated, ineffective or even wrong actions continue to occur. For example, when a patient has cardiac arrest and needs CPR, many medical staff do not immediately perform cardiac compression, but repeatedly listen to the sound of the heart to determine whether cardiac arrest occurs, or immediately start sputum suction. They may think that opening the respiratory tract is the most important thing. Although these procedures are useless for patients with cardiac arrest and it also delays of best rescue time, and even lead to irreversible adverse results. This may be due to the medical staff's "human factors" as they do not realize that the operation process is wrong, nor do they realize that these actions are wrong when the patient is in a critical moment of rescue [9].

Some studies have also pointed out that, considering the cognitive limitations of health service providers, surgical experts also suffer from the limitations of work in high-risk systems during perioperative period [10]. Therefore, some cognitive aids and checklists should be taken into account in their working environment and workflow. Researchers also find that the ability of trained professionals to deal with emergencies is not enough, so that in some cases, they often deny the ongoing crisis. At present, the research of the medical and health industry focuses on optimizing the work flow, technology and tools in order to improve the work efficiency of medical staff. Although some progress has been made, compared to other high-risk industries, human factors analysis should be further carried out. Academic and practical research on human factors have made a lot of achievement in foreign countries. It is necessary for medical staff to learn and understand as well as apply human factors into clinical practices.

The reason for medical errors caused by human factors is consistency factor. It has been found out that when team members face group pressure, even the individual deems that the result is obviously wrong, he or she will follow the consensus of the majority of team members. In interviews with medical staff who have experienced acute emergencies, it was found that it was very difficult to judge the sudden emergence of a recognized recovered patient [9]. As patients expect their illness to be "better", it will be difficult for medical staff to communicate with worsening patients. When the individual medical staff find mistakes, especially when authoritative experts do not point out the mistakes, it is very difficult to "speak it out". There is a common mentality of blindly belief in experts and scholars in the medical environment. In comparison with the successful cases and experiences of experts and scholars, the findings of some individual medical staffs seem to be insignificant. Medical staff's ability to detect crisis events in time is limited in medical environment. When you are in an English-speaking country, all streets are English names. The locals can remember street names very well, but it is difficult for foreigners to distinguish. Similarly, medical staff in pediatrics should learn to listen to parents to express “how sick a child is” for it is difficult for the pediatrician to discern the minor changes in children. Parents can detect abnormal situations more quickly through daily observation of children. It
is relatively difficult for medical staff to find the patient's minor changes in time, as it requires good professional literacy, keen observation, good response ability and other "human factors". Medical environment design is also influential in human error. Health information technology is of great significance to promote the quality, safety and efficiency of medical and health services, and to detect and deal with emergencies in time. Health information service system needs to consider human factors in environmental design, otherwise, its development would be hindered. The most important feature of health information technology is its applicability. The design of computer interface should pay attention to the compatibility between human and machine. The mismatch between human and machine is one of the reasons for human errors. The operator-centered design concept should be emphasized to ensure the efficiency and safety of the work system. At the beginning of the design, the characteristics and functions of health information technology should be integrated with medical staff, such as medical staff's preferences, work flow and information needs.

3. The influence of human factors on the use of medical equipment.

It is common knowledge that medical equipment, especially medical electronic equipment, has special requirements for environmental conditions. Therefore, when installing new equipment, medical and health units should not only consider factors such as temperature, humidity, radiation, pollution, but also electromagnetic radiation, vibration and mutual interference. If not taking everything into consideration before installation and effective measures are not adopted, it will leave problems for future medical workers. Nowadays, people pay more attention to the environmental factors. However, some human factors are often ignored.

Some examples will be given on the human factors. In our new medical building, some problems emerged in the arrangement of departments and equipment rooms. For example, the ECG signal of a certain type of ECG machine was seriously disturbed in lead I, II and III sections, even the standard square wave was inverted and the amplitude was halved, while the ECG signal was disturbed beyond description. Because this kind of fault phenomenon occurs randomly, after engineers carefully checked the earth electrode, they were assured that some other interference resources exists. In the end, they found a new high-speed dental drill was installed in the next room. When the dental drill worked, its adjacent electronic equipment will be disturbed to varying degrees. In fact, when the high-speed dental drill is moved to a room 15 meters away from the centrifugal electrogram room, the interference signal of the electrocardiograph is obviously reduced. Another example was that corrugated interference signal appeared on the TV image of a certain type of gastrointestinal X-ray machine, sometimes there was water ripple interference almost in the morning, but the photographed film image was still normal. For this sudden failure phenomenon, of course, first of all, we would consider grounding and leakage of TV and video circuit. However, there were few disturbances in the afternoon. In fact, the source of the malfunction was that two new high frequency and ultra-high frequency therapeutic machines had been installed in the physiotherapy department under the X-ray machine room. When the high frequency therapeutic machine works, the X-ray image upstairs will be disturbed to varying degrees. When the high frequency therapeutic machine was removed, the malfunction was eliminated immediately.

Human factors can also lead to the increase of humidity in large equipment room, which would result in shutdown failures. During the sultry season in the south, the temperature and humidity in CT room are normal, while the outside temperature and humidity are relatively high. Because of rescue and other reasons, the door of the equipment room is not closed in time, so a large number of hot and humid air in the corridor would spill into the equipment room and they would condense into dews on the metal surface of the equipment. This may cause the equipment display the "standard signal error" fault. The improper use of air conditioning will also cause some problems. As the temperature increases at night in the equipment room, if the air conditioning is turned on in advance to cool down the room, the rapid cooling speed will also lead to the rapid condensation of humid air into droplets indoors, which will be adsorbed on the surface of the equipment metal surface, circuit board or humidity sensor. If not carefully checked, it will be possible to cause high-voltage breakdown or circuit short-circuit. For the equipment with computer or data processing device, because of the limitation of its working environment, its temperature sensor often produces wrong signal and leads to
shutdown protection. For example, the working requirement of a certain equipment is between 16~26℃. Although the indoor temperature is 24℃, as there are many fibers, the fast indoor air conditioning will cool down the surface of the equipment which is obviously attached with water droplets. The surface temperature of the sensor may drop below 16℃ and the circuit is cut off. This kind of fault occurs when the indoor temperature and humidity is normal, it is sometimes difficult to find the cause of the failure.

4. How to avoid the risk of human factors in medical and health work.

So what inspiration does the theory of human factors bring to patient safety management? Through the study of this course, I would like to talk about my own views as possible risks caused by human factors can be avoided through the following ways.

German scholar Maurer pointed out that when an error occurs, we should also investigate and deal with the source of the "incident" in time to prevent the recurrence of similar incidents. Hospital authorities should timely investigate the potential safety hazards of patients and strangle all kinds of accidents in the cradle. Small probability events can't be ignored. There is the illusion that small probability events would not happen so that the safety consciousness of medical staff is paralyzed. However, some minor mistakes may lead to serious consequences, even life safety of patients. Murphy's Law reminds medical staff to treat various potential safety hazards as "100% occurrence" [11].

Hospital should strengthen the construction of patient safety culture so as to prevent the occurrence of unsafe incidents in each link [12]. From hospital management, clinical department culture to individual medical staff, there are loopholes in each level that will lead to patient safety incidents. For example, transfusion errors may occur because of drug dosage errors, but if one medical staff carefully implement the check system in the whole process, the occurrence of errors could be avoided or reduced. Every medical staff in medical activities should be reminded to perform their duties and restrain their behavior in accordance with the standards, so as to reduce the occurrence of patients' safety accidents.

According to the theory of human factors, punishment is not necessary means and does not help solve problems [13]. In order to prevent the recurrence of errors, the real focus of the problem should be found. When patient safety incidents occur, hospital authorities often punish the related personnel, rather than find the cause of the accident in time. Even if some hospitals try to find the cause of the error after the incident, they only seek the basis for formulating punishment measures. Hospital administrators should first find out the causes of accidents and take appropriate measures to prevent the recurrence of such accidents rather than blindly implement punishment.

Furthermore, it is important to attach importance to teamwork and improve the reporting system of adverse events for any complex human production activities. Health care usually needs interdisciplinary cooperation among teams of different disciplines in order to complement each other's strengths and improve work efficiency. A perfect workflow and construction of safety culture should be perfected in order to strengthen teamwork and reduce the possibility of unsafe accidents.

With the rapid development of medical devices in China, the frequency of using medical devices in hospitals has been greatly increased. At the same time, medical treatment also benefits from the emergence of a large number of advanced medical devices, but it also involves human factors, mainly including clinical engineering technicians and clinical instrument operators, whose knowledge does not match the knowledge needed for the management and maintenance of medical devices [14-15]. We should reduce the influence of human factors from the following aspects: strengthening the education and training of medical and nursing personnel to improve their practical operation ability. Secondly, although some technical personnel of biomedical engineering specialty are engaged in the management of medical devices, their proportion with medical personnel is seriously imbalanced. A considerable part of the members of the equipment department are still electricians, bricklayers, boilers, and the overall quality of the personnel of the equipment department do not match with the technological development. Thirdly is to improve the status and salary of senior engineers and technicians and retain senior engineers and technicians. With the gradual development of medical device management, excellent device management engineers could be selected via certification.
examinations and other diversified methods, so that excellent personnel have the opportunity to be entrusted with important tasks. Fifthly, medical colleges and universities should add courses related to risk management education to cultivate the students’ ability of safety management of medical devices. Safety management knowledge should be instilled into the knowledge system of every future clinical engineering technicians. Medical education in schools increases the knowledge of science and engineering, and arranges practice to strengthen operational training. At present, the clinical medical departments of colleges and universities have not yet set up science and engineering knowledge courses, and there is no practical arrangement for the operation of medical devices. This is an important reason for the lack of understanding of the principles of medical devices by doctors in hospitals in China, which leads to the non-standard operation of medical devices and errors. Therefore, relevant knowledge of science and engineering should be added into the clinical courses in medical universities and practice of instrument operation should also be included in the compulsory courses. There are other ways to avoid the related risks caused by human factors. Some scholars have put forward the three-level prevention measures of patient safety, which refers to three different levels of defensive measures established by the individual system according to the evaluation and response to the source of stress [16-17]. Primary prevention: it refers to identifying and eliminating various sources of risk factors, strengthening the individual defense line, avoiding individual stress response, in order to prevent potential adverse reactions. In the theory of human factors, Murphy's law and Hain's law are based on the hidden dangers of accidents. Secondary prevention: symptomatic treatment measures to treat stress caused by stressors, aiming at strengthening the resistance line, reducing or eliminating stress response, and restoring stability of individual system. Third-level prevention: individuals use maintenance factors, through education and the use of internal and external resources of individuals, to promote the reconstruction of the body after rehabilitation. The theory of human factors establishes a three-level prevention system for patient safety management, which suggests that hospital safety managers should use different human factors theory to guide patients in different stages in the practice of patient safety management, and ultimately to prevent or reduce the effect of patient safety accidents.

Some scholars also put forward the idea of applying resilience engineering to reduce human errors in medical and health service system [18-20]. The concept of resilience engineering can explain and deal with human errors [21]. Jeffcott, S.A defines three different crisis situations for resilience engineering [22]. The first is common crisis, which is part of daily work. People's response to such crisis is stylized and realistic. The second is the irregular crisis, although rare, but can be predicted and imagined, people will spontaneously respond to it on the basis of the first situation. The third kind is the crisis, which cannot be expected and imagined. It requires all personnel to have innovative spirit and mobilize their initiative to solve it. Most of the crises in the medical and health service system are the second type, such as sudden cardiac arrest. The first kind of crisis is predictable, but it needs the medical staff to change the routine psychological work model to deal with the crisis and start effective rescue procedures. The second kind of crisis can be achieved by training all medical personnel, conducting continuous and effective behavioral training to rebuild a psychological work model. In this way, the medical staff could consciously recognize the impact of human factors on rescue effect in the rescue process of sudden cardiac arrest, and the concept of resilience engineering can help medical personnel reduce the occurrence of human errors in their daily work.

Medical and health service system is complex and dynamic [23]. It has a tendency to change from dynamic stability to unstable state. This change may be chronic. For example, the electronic medical records are neglected in management, and there are many errors and omissions. It may also be sudden, such as sudden cardiac arrest of patients, if medical personnel do not take appropriate and necessary preparations, there is a potential tendency for human error. If medical personnel lack the ability to anticipate and respond to emergencies artificially and cannot implement effective strategies, the harm is great. Therefore, medical personnel should fully recognize the errors caused by human factors and apply the concept of resilience engineering to adjust and adapt to the dynamic changes caused by emergencies. With the lowest cost, they should accurately judge and predict the possible dynamic changes of medical and health service system, and quickly restore it to its normal operation state and maximize its operation and reduce errors caused by human factors. The essence of resilience
engineering is that the system or organization can continue to operate smoothly under continuous pressure or in the face of emergencies, to ensure the dynamic stability of the system or organization. Some scholars have adopted the method of PDCA quality management, and they discover that it has achieved remarkable results in reducing the failure rate of medical equipment caused by human factors [24]. To sum up, the theory of human factors throws new light on patient safety management as it can explore and explain the crux of unsafe incidents, excavate safety risk factors from multi-levels and evaluate the whole process of safety risk formation, and then realize the early control and prevention of safety risk factors, so as to achieve the purpose of safety prevention. In China, the theory of human factors has not yet been used in patient safety management. Through the preliminary understanding of the theory of human factors, I think the theory of human factors can be used to guide the management of patient safety at every link and level, which can ultimately improve patient safety and build a harmonious medical ecological environment.

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