# Designing HRD Interventions for Employee-Robot Interaction

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## Abstract

The purpose of this study was to identify critical causes of work stress and job satisfaction of nurses, which can contribute to find appropriate organizational supports to help nurses effectively work with a surgical robot. Delphi method was employed to identify the critical stressors and the key causes of job satisfaction of nurses working with a surgical robot. Throughout three consecutive rounds, participants built up consensus about the critical stressors and the key causes of job satisfaction of nurses working with a surgical robot. In addition, they expressed their opinions about appropriate organizational interventions for employee-robot interaction. Based on these responses, desirable organizational supports for nurses were finally identified. During this research, nurses did not tend to mention extraordinary stress or job satisfaction. Although using a surgical robot is a new experience, the causes of work stress and job satisfaction were closely related to the chronic diseases of their organizations. For example, uncertainty concerning treatment and conflict with other nurses stems from a lack of communication or misunderstanding among nurses or between nurses and surgeons. In conclusion, except the process interventions, suggested interventions are not so new to nurses. In other words, most well-known strategies to become a better organization are still working for nurses partnering with a surgical robot. In order to effectively support nurses working with a surgical robot, the priority is to go back to basics for a better organization, not to totally depend on emergent practices.

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# Chapter 1: Introduction

## Background

Humans made robots, just as many people believe that God made humans. Certainly, robots are new creatures resulting from the human imagination. More surprisingly, not only in our imagination but also in everyday worlds, people can meet robots as co-workers or friends.

According to the survey of United Nations Economic Commission for Europe and International Foundation of Robotics (2005), robots will be more frequently used in the workplace, assisting elderly and disabled people by means of sophisticated interactive equipment, carrying out surgery, inspecting pipes and sites that are hazardous to people, fighting fire and disabling bombs.

The United Nations, in its recent robotic survey (United Nations & International Foundations of Robotics Research, 2002), robots are categorized into three groups; industrial robots, professional service robots, and personal service robots. Industrial robots usually work for welding, machining, assembly, packaging, palletizing, transportation, and material handling (Thrun, 2004). Most industrial robots are used on assembly lines, chiefly in the auto industry (U.N.E.C.E. & I.F.R., 2005). Professional service robots assist people for achieving professional goals such as milking cows, handling toxic waste, ferrying medicine within hospitals, and assisting surgeons (U.N.E.C.E. & I.F.R., 2005). Lastly, the examples of personal service robots assisting or entertaining people act as follows; vacuum cleaners, lawn mowers, receptionists,

assistants to elderly and people with disabilities, wheelchairs, and toys (Thrun, 2004).

Robotic Industries Association estimates that North America uses 192,000 industrial robots, second only to Japan and roughly one-fifth of the world's robots (IFR Statistical Department, 2010). According to its latest report, *World robotics 2010: Industrial robots*, 2009 had a decline of 47% (60,000 units) compared to 2008, considered one of the most successful years. This is the lowest level reported since 1994. The worldwide economic and financial crisis caused a significant slump in the sales of industrial robots (IFR Statistical Department, 2010). According to Brown (2010), North American manufacturers ordered 30 percent fewer robots (worth 43 percent less money) during the first nine months of 2009 than they did in the same period in 2008. Orders fell to 7, 172 robots worth $426 million compared with 10,279 robots valued at $743 million a year earlier. The downturn was distributed equally among the automotive industry (down 29 percent in units) and non-automotive customers (down 32 percents). Orders rose 14 percent in life sciences and 12 percent in food and consumer goods, which are small markets.

However, Statistical Department of the International Federation of Robotics (2010) suggested that a strong recovery of worldwide robot installations in 2010 will result in an increase of about 27% to about 76,000 units and there is a continued growth between 2011 and 2013. According to the IFR Statistical Department (2010), the stock of professional service robots is forecast to increase to some 80,000 units for the period 2010-2013. Application areas with strong growth are defense, rescue and security applications, field robots, logistic systems, inspection robots, medical robots, and mobile robot platforms for multiple uses. Besides, it is projected that sales of all types of

domestic robots (vacuum cleaning, lawn-mowing, window cleaning, and other types) in the period 2010-2013 could reach 6.7 million units (IFR statistical department, 2010). The market for entertainment and leisure robots, which includes toy robots, is forecast at about 4.6 million units (IFR statistical department, 2010).

While traditional assembly lines had come under criticism from those concerned with their effects on workers, industrial robots perform many of the repetitive tasks. For this reason, recent variations on the assembly-line process have been believed to increase productivity and employee interest. According to Burnstein (2010), robots in factories are likely to save and create more jobs than they eliminate. U.S. technology and business innovators recognize that robots help companies turn out higher-quality and lower-cost goods to compete with those made in China, Mexico, India, or other low-wage nations. They remove people from dangerous and boring jobs they shouldn't have been doing in the first place, and put them in higher-skilled, higher-paying positions (Burnstein, 2010).

Burnstein (2010) pointed out that there is also a large ecosystem of robotics-related companies in America that employ thousands of people who design, build, program, and service robots and the equipment they work with. More surprisingly, General Motors containing more than 1,100 robots is now hiring back some laid-off workers to keep up with growing demand for stylish and high-quality new cars.

Industrial robotics also creates jobs at the companies that build and service the machines. Even though most of today's industrial robots are built in Japan and Europe, major robotics companies including ABB (ABB), Fanuc, Kuka Robotics, and Yaskawa Electric have U.S. divisions (Burnstein, 2010). Adept Technology (ADEP) is based in

Pleasanton, California. Of course, if the robots working outside factories such as medicine, defense, and home maintenance are included, there are more than 8 million of the machines worldwide (Burnstein, 2010). Many leaders in those areas, including Intuitive Surgical Systems (ISRG) and iRobot(IRBT), have headquarters in the U.S.

It was around 1960 when industrial robots were first introduced in the production process, and until the 1990s industrial robots dominated robotics research (Garcia, Jimenez, Santos, & Armada, 2007). For example, several researches written in the 1980s on the robotization's impact on the workplace have been found. At that time, researchers were questioning about the result of the automation related to the use of robots. According to Hollon and Rogol (1985), people did not think that a high level of chronic unemployment among displaced workers will result from increased usage of robots. Although the implementation of robotics will result in substantial displacement of workers from their current jobs, its introduction would be evolutionary rather than revolutionary (Hollon & Rogol, 1985). Given this slow-paced application, robotic adopters anticipate that displaced employees will have time to be retrained for robotic-related jobs or positions in an expanding service sector (Hollon & Rogol, 1985). Hollon and Rogol (1985) also pointed out that only those displaced personnel who are unwilling to undergo retraining will encounter prolonged unemployment.

Rather, in the case of Japan, Japanese management tended to conclude that the use of robot not only provides the user company with a competitive edge on the market, but also plays a major role in stabilizing its labor situation (JMA Research Institute, 1983). In other words, at that time, companies using industrial robots could open new lines of business including the development of new products and could enter into new markets.

Besides, industrial robots assured companies of stable labor power through the stabilization of production output and provided labor with improved benefits. In order to maximize the effect of robots, JMA Research Institute (1983) advised that user companies need to consider the re-education and re-training of employees in line with the introduction of robots, the carrying out of robot engineering for the purpose of installing and effectively operating industrial robots and the implementation of measures aimed at improving the work site and ensuring worker safety.

Since the introduction of industrial robots in the automotive industry, robotics research has evolved over time towards the development of robotic systems to help the human in dangerous, risky or unpleasant tasks. As the tasks given to robots are more complicated, industrial robots have been designed to be more flexible, and robotics research has turned to adaptive and intelligent systems (Garcia et al., 2007).

According to Green, Billinghurst, Chen, and Chase (2008), there is growing interest in the field of human-robot collaboration as can be shown by the recent research of the Cogniron project, MIT Media lab, and the Mitsubishi Electric Research Laboratories. However, as a result of literature review, the researcher found that existing literature has been primarily about the technical engineering aspects of robotics. Little attention has been given to the anticipation and solution of problems on the human and organizational side of the robotics. Besides, most recent research about the social aspect of human-robot interaction has focused on autonomous and mobile robots (Forlizzi, DiSalvo, & Gemperle, 2004; Green, Billinghurst, Chen, & Chase, 2008; Kanda, Hirano, Eaton, & Ishiguro, 2004; Kuno, Sadazuka, Kawashima, Yamazaki, Yamazaki, & Kuzuoka, 2007; Shibata, 2004).

According to Kiesler and Hinds (2004), autonomous robots are distinctive from computers or other machines. First, people tend to perceive autonomous robots differently than they do most other computer technologies (Kiesler & Hinds, 2004). People's mental models of autonomous robots are often more anthropomorphic than their models of other systems (Friedman, Kahn, & Hagman, 2003). The tendency for people to anthropomorphize may be fed, in part, by science fiction and, in part, by the powerful impact of autonomous movement on perception (Scholl & Tremoulet, 2000).

Secondly, autonomous robots are more likely to be fully mobile, bringing them into physical proximity with other robots, people, and objects (Kiesler & Hinds, 2004). Because mobile robots will have to negotiate their interactions in a dynamic, sometimes physically challenging environment (Kiesler & Hinds, 2004), one or more remote operators must help the robot negotiate its interactions in the remote place, creating a complex feedback system.

Lastly, autonomous robots are different from other machines because these robots make decisions to learn about themselves or their world and to exert some control over the information they process and actions they emit (Kiesler & Hinds, 2004). According to Kiesler and Hinds (2004), when compared to computer or other machines, an autonomous robotic system tend to add more complexity because it must adjust its decisions sensibly and safely to the robot's abilities and to the options available to the robot in a given environment.

This dissertation investigates the impact of surgical robots on workers and makes suggestions for workers interacting with a surgical robot. Although the surgical robots are not autonomous robots, they are still worthwhile to research. When compared to

industrial robots, medical robotic systems were slower to develop in a commercial capacity due to financial constraints (Francis & Winfield, 2006). Although laparoscopic procedures were performed in gynecology for many years, completion of the first laparoscopic cholecystectomy in 1985 was a contributing event in the development of medical robotic technology (Reynolds, 2001). This spurred the growth of minimally invasive surgery into a highly practiced surgical specialty.

According to Murphy, Hall, Tong, Goel, and Costello (2008), most of this demand is due to the proliferation of da Vinci surgical system (Intuitive Surgical), especially in the USA, where more than 500 systems have been installed. Along with the upsurge of the surgical robots, the number of surgeons using robotic technology is also increasing. For example, urologists have been quick to embrace this technology and robotic-assisted laparoscopic radical prostatectomy (RALRP) is the most commonly carried out robotic procedure worldwide (Murphy et al., 2008). From 766 procedures in 2002, more than 48,000 are projected for 2007 (Murphy et al., 2008). This accounts for almost 40% of the radical prostatectomy market in the USA.

Because the surgical robot is a master-slave system rather than a true autonomous robot, the results of most recent research on robotics do not meet the needs of operating rooms in healthcare industry. In addition, because most existing research has been based on the technical engineering perspective, it is difficult to understand human and organizational aspect of robotics in surgery. For this reason, I believe that this dissertation will be able to contribute to the enlightenment from the socio-cultural perspective about the challenges and potentials of the robotization in the healthcare industry, especially in operating rooms.

## Discussion of Related Issues from HRD Perspective

In the future, HRD professionals are expected to deal with human-robot interaction issues in the workplace more frequently than before. I think that four specific agendas can be brought up in the future workplace: defining the components of expertise in terms of human-robot interaction; coping with organizational change process; designing appropriate interventions for an organization; and establishing the work ethics in the robotic age.

### *Defining the Components of Expertise in terms of Human-Robot Interaction*

In the future workplace, interacting with robots will bring about each organization's redefinition of expertise in terms of working with robots. According to Swanson and Holton III (2001), human expertise is composed of three elements: knowledge; experience; and problem solving. Interacting with robots will change the previous landscape of expertise, which leads to modifications or additions to knowledge, experience, and problem solving.

For example, if employees are routinely working with robots, they are required to be familiar with the interaction with robots in addition to their domain-specific knowledge. In this case, people cannot help but face this inevitable question about working with robots: Are they colleagues or tools? This question will be an evolving issue for each organization using robots. Some organizations will promptly include the knowledge of human-robot interaction as more obvious kinds such as procedural or formal knowledge. On the other hand, other organizations tend to regard the knowledge

of human-robot interaction as the less obvious kinds such as informal, impressionistic, and self-regulatory knowledge. Of course, determining which the best fit for human-robot interaction is depends on the unique organizational contexts and characteristics.

Likewise, interacting with robots will influence the components of experience and problem solving. Although it is not certain that efficiency with working with robots will strongly influence employees' productivity, it seems to be plausible that familiarity with new technology will be helpful to promote their productivity. Besides, how smoothly employees interact with robots will be one of important standards for measuring their performance. In this respect, as time goes on, organizations will be likely to combine domain-specific experience or problem-solving with effectiveness of working with robots even though they tend to differentiate them at the beginning of the robots' introduction.

*Coping with Organizational Change Process*

Using robots will be a kind of experiment for both organizations and employees. At the introduction of the robots, it is hard to always guarantee the success of working with robots. However, at least, it is possible to analyze the expected outcomes of using robots. It is related to consider how organizations will cope with organizational change represented by the use of robots.

Watkins and Marsick (1993) offered a definition of change that speaks to the means by which change occurs: "Change is a cyclical process of creating knowledge (the change or innovation), disseminating it, implementing the change, and then institutionalizing what is learned by making it part of the organization's routines" (p.21).

Likewise, Beckhard and Pritchard (1992) asserted that learning and change processes are part of each other. In other words, change is a learning process and learning is a change process. These definitions remind us that change always involves learning. Besides, this fundamental relationship points out why change is one of the core constructs for the discipline of human resource development (Swanson & Holton III, 2001).

Before organizations begin to use robots, it is necessary to evaluate the readiness to change. In fact, experiencing the resistance to change is a natural phenomenon when organizations try to implement a new strategy. In order to make an effective change, recognizing the causes of resistance is a necessary step for understanding the organizational change. According to Piderit (2000), resistance to change consists of three dimensions: Cognitive beliefs about the change; Emotional (affective) feelings in response to change; Behavioral actions in response to change. Because this three-part view of resistance may not be consistent on all three dimensions, a person may experience the conflicts (Piderit, 2000). For example, a person may believe change is needed but still fear it. Or, a person may not believe in it and fear it, but act as if in support of the change. According to Piderit (2000), this kind of ambivalence may be more widespread during change than is acknowledged. In this respect, conducting an organizational assessment is an effective way to more clearly recognize the ambivalence and complexities of organizational change.

Besides, organizational assessment is a useful method to minutely observe various technologies-in-practice resulting from the use of robots. In fact, assessment can confirm or reject the presenting problems (McLean, 2006). In other words, some technologies-in-practices can be proved to be critical to readiness or resistance to organizational change.

Other technologies-in-practice can be proved to be trivial to the organizational change although they look like important to people. HRD professionals will be required to deal with evaluating the importance of each technology-in-practice while conducting an organizational assessment. Collecting various technologies-in-practice and evaluating them will be a foundational task for understanding organizational implications of human-robot interaction.

*Designing Appropriate Interventions for an Organization*

The term *intervention* refers to a set of sequenced planned actions or events intended to help an organization increase its effectiveness (Cummings & Worley, 2005). According to Cummings and Worley (2005), three major criteria define an effective intervention: the extent to which it fits the needs of the organization; the degree to which it is based on causal knowledge of intended outcomes; and the extent to which it transfers change-management competence to organization members.

Generally, two major sets of contingencies that can affect intervention success have been discussed: those having to do with the change situation and those related to the target of change (Cummings & Worley, 2005). Both kinds of contingencies need to be considered in designing interventions. In fact, understanding the contingencies is strongly related to recognize the making priorities among various technologies-in-practice. Deciding critical technologies-in-practice depends on how people are aware of the importance of a number of contingencies.

For example, HRD professionals need to consider both change situation and target of change. Several situation factors will be examined and organizational issues

will be also analyzed. According to situational factors and organizational issues, types of interventions will be selected differently. I believe that the introduction of robots will require an organization to equip with an appropriate human process interventions and human resource management interventions. After the organizational assessment, HRD professionals should be able to decide which interventions are effective to improve their conditions. Of course, an assessment will be able to first allow the organization to prioritize areas that have the potential for improving the organization. I hope that this dissertation will be able to contribute to making more specific suggestions for the effective interventions.

*Establishing the Code of Work Ethics in the Robotic Age*

Professional service robots work for humans in the workplace. In the future, many people will commonly work with professional service robots. Besides, robots will intellectually and emotionally evolve as time goes on. It implies that people will be required to cooperate with robots and to compete with them. Regarding the identity of the robots, people might be confused or embarrassed because they would not exactly know how to define this kind of human-like creature.

According to Shibata and Tanie (2001), methods of human-robot interaction can be classified into two categories in terms of duration of interaction: short-term interactions and long-term interactions. When people interact with a robot at an exhibition or a similar event, the appearance of the robot has a large influence on subjective interpretation of the behavior of the robot (Shibata, 2004). However, in the long-time interaction, it is important that the robot has some learning function to avoid

the human becoming bored by the interaction (Shibata, 2004). If the robot always displayed the same reaction or behavior during these interactions, the human would soon become bored with the robot.

Robots used in the workplace will usually involve in the long-term interaction. Unlike short-term interaction, people are required to continuously interact with the robot for achieving the professional purpose. Even though the purpose of the interaction is not for fun, it is critical to consider how to stimulate people's motivation to interact with the robot. If the robot encourages people to make new patterns of thought or behavior, working with the robot will be more enjoyable to human workers.

On the other hand, at the same time, the long-term interaction would result in the serious abuse of robots and artificial agents by human. There is already empirical evidence that various forms of mistreatment of robots by humans will be common. This behavior can be aggravated by the provision of anthropomorphic interfaces (De Angeli, Brahnam, & Wallis, 2006) or by placing the robot into an intimate setting (Fogg & Tseng, 1999).

Regarding the ethical debate about the abuse of the robot, Whitby (2008) raised interesting questions: To what extent do we consider it acceptable to deliberately mistreat artifacts, particularly substantially human-like artifacts?; To the degree that we find deliberate mistreatment of robots morally unacceptable, what ethical limits can we justly place on such behavior?; Are these essentially a new set of ethics, or familiar ethics applied to this field?

Of course, these ethical problems first need to be considered for the designers of robots and intelligent systems. However, governments, their appointed agents, legal

opinion formers, and moral opinion formers also have responsibilities in this area because they are in charge of the real problem-solving related to the ethical consequences of the use of robots. At the same time, within an organization, HRD professionals need to be aware of the ethical issues arising from the use of robots. For example, working on the ethical questions Whitby (2008) suggested will be an important assignment for HRD professionals being responsible for employee training and development. Besides, as the robot will intelligently evolve, HRD professionals will be required to deal with equity issues between robotic workers and human ones. It implies that HRD professionals will need to contribute to creating ethical business culture in the robotized workplace. Therefore, it is necessary to begin to contemplate the plausible ethical issues from now on in order to keep up with the speed of the robotic technology development.

## Problem Statement

Research indicates that robots will be more frequently used in the workplace, assisting old and handicapped people with sophisticated interactive equipment, carrying out surgery, inspecting pipes and sites that are hazardous to people, and fighting fire and bombs. Although robots seem to give us several benefits, there is little information on how they influence organizations, work processes, and services created by organizations. Therefore, it is necessary to contemplate organizational implications of the use of robots. This study's focus is not on "what is technologically possible?" but on "what is desirable?" It is related to behavioral, cognitive, and social aspects of human–robot interaction and the socio-cultural contexts surrounding them.

## Statement of Purpose and Research Questions

The purpose of this Delphi study was to identify critical causes of both work stress and job satisfaction of nurses, which can contribute to finding appropriate organizational support to help nurses to effectively work with surgical robots. It is anticipated that through a better understanding of nurses' work experiences using surgical robots, the issues and challenges they face, and the availability of supportive resources, more informed decisions can be made by medical staffs as well as by hospital management. To shed light on the problem, the following research questions will be addressed:

1. What are the key stressors of nurses working with a surgical robot?
2. What are the critical causes of job satisfaction of nurses working with a surgical robot?
3. When you consider both your opinion and average response of all participants about the identified stressor/job satisfaction statements, what organizational support should be provided to help nurses work effectively with a surgical robot?

# Chapter 2: Literature Review

## Introduction

In this research, the researcher investigates the relationship between a surgical robot and nurses within a hospital. The surgical robot belongs to the professional service robots used for assisting surgeons in surgical procedures. The surgical robot can be defined as a powered computer controlled manipulator with artificial sensing that can be programmed to move and position tools to carry out a range of surgical tasks (Davies, 1999). Although a robot has a functionality similar to that of a surgeon, it should not replace the surgeon because it can only assist the surgeon under his/her supervision (Davies, 1999).

According to Davies (1999), surgical robots are said to enhance the accuracy and safety of the surgical procedure, when compared with conventional surgery and computer-assisted surgery (CAS). However, at this point, it is necessary to recognize the fact that the new technology may function as stressors (sources of strain) for individuals (Cooper, Dewe, & O'Driscoll, 2001). Unless adequate preparation is provided, employees may potentially experience stressful situations when the new technology is introduced into the workplace and may be unable to cope with the innovations (Cooper et. al., 2001). Therefore, the robots need to be used on the basis of adequate preparation of an organization.

To investigate the organizational implications of robots, the researcher first discusses the major perspective of how organizations see innovation and change. Even

though the perspective is not directly related to the use of a robot, dealing with its approaches to the change in an unpredictable and unknowable world can give us important clues about organizational implications about new technology. After reviewing the major perspective, the researcher critiques relevant theories discussing how they can be applied to human–robot interaction in the workplace.

The following literature review deals with both innovation-related stress/satisfaction and an organization's innovation effectiveness. The innovation represented by the use of robots needs to be evaluated according to its contribution to employees' stress or satisfaction as well as organizational effectiveness. In the first section, the researcher reviews how medical organizations will deal with organizational innovation, such as the use of robots. Next, the characteristics of robotic surgery and its effect on medical staffs are reviewed. In the following sections, work stressors and the causes of job satisfaction are discussed.

## Organizations as Complex Adaptive Systems

Since the 1990s, new organizational concepts and theories have begun to absorb and apply recent developments in quantum theory and chaos theory (Begun, 1994; Plsek, 2001; Stacey, 1995; Zimmerman, 1999). While classic theory in physics suggests that we can accurately predict the future state of a physical system if we have enough information about the current state (Capra, 1982; Wheatly, 1992), quantum theory denies this possibility, noting that the very act of measurement such as collecting the information alters the physical system we hope to understand (Begun, 1994). A quantum theory asserts that continuous change, activity, and interconnectedness add an element of

unpredictability to any system. Therefore, planned, controlled, and orderly approaches to innovation or change are not likely to perfectly achieve their intended outcomes (Stacey, 1995).

Chaos theory also suggests that the future state of the world is unknowable because physical systems are highly sensitive to initial conditions. Given the sensitivity of systems to initial conditions, chaos theory warns that programs, processes, or practices that work well in one organization may work poorly even when faithfully implemented (Wheatley, 1992). It implies that small differences in initial conditions can lead to radically different outcomes even if two organizations look very much like.

These two theories suggest that organizations are more than simply open systems; they are complex adaptive systems (Shortell & Kaluzny, 2006). According to Plsek (2001), complex adaptive systems are composed of the individual agents who have the freedom to act in ways that are not always predictable and the actions of these agents. If we assume that future states of an organization are unknowable as suggested by both quantum theory and chaos theory, is there a still a possibility for planning, organizing, deciding, and controlling in complex adaptive systems?

Some scholars and practitioners argue that organizational survival depends on managers giving up their "obsession with control, knowing what is going on, and seeking stability" (Berquist, 1992; McDaniel, 1997; Vaill, 1989; Wheatley, 1992). On the other hand, others contend that classical management tasks still have a place in complex adaptive systems. For example, Stacey (1996) proposes that, in complex adaptive systems, selecting the appropriate management or leadership approaches depends on two factors: the amount of certainty about cause-effect linkages (e.g., "If we

do X, then Y occurs.") and the amount of agreement about an issue or decision (e.g., "What should we do?"). When high certainty and high agreement exist, classical management tasks works well. However, when uncertainty is high and disagreement reigns, chaos and anarchy often result. In such circumstances, few management or leadership approaches work. When only modest levels of certainty and agreement exist, organizations enter the "zone of complexity" or the "edge of chaos" where high levels of creativity and innovation become possible. At this point, traditional management approaches lose their effectiveness.

Stacey's suggestion seems to be plausible because it is elaborating the contexts and limits in which both quantum theory and chaos theory reside. Although it is clear that we cannot accurately predict future, it is possible to expect more concrete boundaries to which our anticipations will be applied. In other words, when organizations are assumed to be complex adaptive systems, we can qualify our expectations about organizational change considering some factors such as the degree of certainty and agreement. In this respect, if we want to assess the innovation such as the use of robot in the workplace, it is also important to spell over the fact that we need to find reasonable standards and guidelines about the overall technology assessment although all organizations are different and unique. For instance, considering the degree of certainty and agreement will be a kind of option to decide the scope of using robots.

While the researcher admits the assumption that organizations are complex adaptive systems, it is believed that traditional management tasks still play a role in some settings as Stacey (1996) suggested. However, as of now, we do not make a definite decision about the degree of certainty and agreement in the use of a robot

because of the lack of previous research and the recent use of robots. Stacey's suggestion assigns us a question about identifying the degree of certainty and agreement. Therefore, if we want to make a rough prediction about organizational change, we are first required to have enough information about cause-effect linkages of the change and a variety of views on change. As I mentioned before, we do have little information about the influence of new technology represented by the use of robots. In other words, we have not thoroughly discussed the cause-effect linkages regarding the use of robot and have not deeply contemplated various views on the new technology.

At this stage, we need to concentrate on accumulating knowledge on how people perceive cause-effect linkages in the process of working with a robot and how people feel and think about the experience of working with a robot. This dissertation is written to provide knowledge on people's recognition about working experience with a robot. Of course, this research is not looking for clear-cut "yes" or "no" answers. Rather, it is searching for the best fit between new technology and organizations.

## Studying Technology in Organizations

Certainly, working with robots is an unfamiliar experience for most people. For this reason, the robotic technology has made it possible for people to rethink about new technology's influence on organizational structures, processes, and outcomes. Because the researcher have found little previous research on the robotic technology's influence on organizations, this research focuses on critiquing existing theories checking its appropriateness to human-robot interaction in the workplace.

Over the years, different research perspectives on technology have developed in

parallel with research perspectives on organizations (Orlikowski, 2000). These perspectives come from the need for explaining the dynamics of organizational change. Here, this research deals with contingency theory and strategic choice theory because these theories clearly reveal the opposing viewpoints about the relationship between technology and organizations.

Proponents of contingency theory suggest that different subunits of the organization may be organized differently depending on the specific environments and technologies with which they are involved (Burns & Stalker, 1961; Lawrence & Lorsch, 1967; Perrow, 1967; Rundall, Starkweather & Cook, 1988; Thompson, 1967). Contingency theorists prioritized the importance of environment asserting that specific organizational form is more effective according to the characteristics of environment. For example, a more bureaucratic or mechanistic form of organization is more effective when the environment is relatively simple and stable, tasks and technology are relatively routine, and a relatively high percentage of nonprofessional workers are employed. In contrast, a less bureaucratic or more organic form of organization is likely to be more effective when the environment is complex and dynamic, tasks and technologies are non-routine, and a relatively high percentage of professionals are involved. Empirical support for contingency theory ideas is mixed depending on whether one is studying the organization as a whole, particular subgroups, or specific individuals (Schoonhoven, 1981).

Given the wide variety of organizations and different environments in which they operate, the contingency theory perspective has wide application to many organizations. In addition, it seems to be reasonable that considering various aspects of the

environment can make us catch a bigger picture influencing management style and organizational structure. However, if we just depend on contingency factors, it is possible to ignore the role of intrinsic self-actualizing aspects of work. In addition, as the researcher mentioned in the previous section, if the organizations are assumed to be complex adaptive systems, we need to consider the importance of initial condition as well as contingency factors.

Strategic choice theory was advanced as a corrective to the view that the way in which organizations are designed and structured is determined by their operational contingencies (Child, 1972). In addition, strategic choice theory paid attention to the active role of leading groups who had the power to influence the structures of their organizations through an essentially political process (Child, 1997). 'Strategic choice' was defined as the process whereby power-holders within organizations decide upon courses of strategic action (Child, 1972). Strategic choice articulates a political process, which brings agency and structure into tension and locates them within a significant context. It recognizes that the evaluation of information, from within an organization and from its environment, can lead to the identification of opportunities and problems. This encourages a learning process which proceeds towards action through debate, negotiation, and the exercise of choice. In so doing, the strategic choice approach adopted a non-deterministic and potentially evolutionary position.

Strategic choice theory gave people an opportunity to think about sense-making process within an organization. Even though the environment has been radically changing, the political power of leading groups strongly affects the organizational process and outcomes. If the leading groups stick to inappropriate unchangeable beliefs

and values, changing contingent factors cannot help losing their influence on organizations. Strategic choice theory seems to be plausible because organizational decision-making is based on a set of values as well as an adaptation to the internal or external environment. However, just considering strategic choice theory is not useful in that we would ignore the interrelationship between organizations and environment. Recognizing strengths and weaknesses of each theory is more helpful to understand the whole organizational phenomena.

If so, what are the implications of these theories regarding the influence of robot in the workplace? The contingency theory implies that the use of robot itself would transform organizational structure, processes, and outcomes. In other words, just using new technology enables people to change their thinking and behavior, which leads to new organizational change. On the other hand, the strategic choice theory implies that organizations are mostly shaped by leading groups' choice despite of the use of new technology. That is, organizations will not be changed, if the leading group does not change their beliefs, even though the different environmental needs are so powerful that employees cannot help choosing different sets of behaviors.

These two theories are showing an example of extreme opposite views on the technology's influence on organizations. Rather than this kind of dichotomy, we need not to assume that the use of new technology always triggers similar organizational changes among organizations. It happens or it does not happen. As of now, we do not exactly know what happens after working with robots and it is premature to determine its definite effects. It is possible that nothing happens after the use of robots in some organizations because they are well designed to working with robots. However, it is also

possible that other organizations are required to wholly transform their system because they are not well designed to working with robots. In this respect, this dissertation will be written to clarify the best organizational support appropriate for working with robots. In order to identify the best fit, the researcher will use alternative lens instead of contingency theory or strategic theory for observing human-robot interaction in the workplace.

The researcher have found "a practice lens for studying use of technology" based on structurational model in which humans are posited as constituting structures in their recurrent use of technology. The practice lens is more reasonable to understand the work experience with robots because the viewpoint gives us more abundant information about human-robot interaction. In the next section, the researcher will further explain the practice lens based on structurational model in terms of new technology's influence on organizations.

## Practice-oriented Understanding about Human–Robot Interaction

Structurational model regards technology as embodying structures that are appropriated by users during their use of the technology (Orlikowski, 2000). Human action is a central aspect of this model. The actions are associated with embedding structures within a technology during its development and with appropriating those structures during the use of technology. Orlikowski (2000) extended the structurational perspective on technology by proposing a practice-oriented understanding of the recursive interaction between people, technologies, and social action.

In fact, the structurational model of technology has been strongly influenced by the

intellectual tradition of social constructivism (Woolgar, 1991; Bijker & Law, 1992). When it comes to the relationship between technology and an organization, social constructivists examine how interpretations, social interests, and disciplinary conflicts shape the production of a technology through shaping its cultural meanings and social interactions among relevant social groups. Therefore, the structurational model posits that technology is developed through a social-political process, which results in structures (rules and resources) being embedded within in the technology (Orlikowski, 2000).

Existing structurational models of technology examine what people do with technologies in use, positing such use as an appropriation of the "structures" inscribed in the technologies. While the notion of appropriation captures well the importance of human action in shaping the situated use of technology, it frames such human agency in terms of interaction with the structures embedded within the technology. This view starts with the structures presumed to be embedded within the technology, and then analyzes how those structures are used, misused, or not used by people in various contexts.

However, Orlikowski (2000) suggested that we need to focus on emergent rather than embodied structures. Rather than starting with technology and examining how actors appropriate its embodied structures, this view starts with human action and examines how it enacts emergent structures through recurrent interaction with the technology at hand. The notions of emergent structure and enactment afford a practice-based extension to existing structurational models of technology. This practice lens regards humans as constituting structures in their recurrent use of technology. Users repeatedly enact a set of rules and resources, which structures their ongoing interactions

with that technology through their regularized engagement with a particular technology in particular ways and conditions (Orlikowski, 2000).

In this practice lens, technology structures are not external or independent of human agency; they are not embodied in technologies simply waiting to be appropriated, but are virtual, emerging from people's repeated and situated interaction with particular technologies. Orlikowski (2000) termed *technologies-in-practice* as the enacted structures of technology use, which signifies the sets of rules and resources that are reconstituted in people's recurrent engagement with the technologies at hand. In other words, *technology-in-practice* refers to the specific structure routinely enacted as we use the specific machine, technique, appliance, device, or gadget in recurrent ways in our everyday situated activities (Orlikowski, 2000). According to Orlikowski (2000), the *technology-in-practice* is a kind of behavioral and interpretive template for people's situated use of the technology. Continual habitual use of a technology will tend to reenact the same technology-in-practice, thus further reinforcing over time, so that it becomes taken for granted. Besides, in Orlikowski's empirical research (2000), the empirical illustrations support that people enact different technologies-in-practice with the same type of technology across various contexts and practices.

Using the above-mentioned practice lens is more effective to initiate research on human–robot interaction in the workplace, because it observes the relationship between human agency and open-ended set of emergent structures. If we recognize the importance of emergent structures related to new technology, we need to pay attention to the particular instances and contexts through the technology-in-practice. As Orlikowski (2000) mentioned, we need to know whether and how people interact with technology in

their day-to-day activities. It is not enough to appreciate the mere presence of the technology on the factory floor. In this respect, we need to be more sensitive about improvisation of new technology.

Orlikowski's framework can give us insights about how human–robot interaction will be in the workplace. The use of robot can lead to different technologies-in-practice across various contexts and practices. Through the practice lens, we have to try to understand when, where, how, and why people choose to reinforce, ignore, enhance, undermine, change, work around, or replace their existing structures of technology use. For example, we can ask this kind of question: What kinds of situations robots can help with and cannot help? To answer this question, we need in-depth information about how an organization makes a variety of technologies-in-practice across various contexts. In other words, it requires us to make a preparation for various scenarios resulting from the improvisation of new technology represented by the use of a robot.

## Examples of Practice-oriented Understanding about Human–Robot Interaction

To clearly apply Orlikowski's framework to human–robot interaction, the empirical research examples of practice-oriented understanding in human–robot interaction were sought. Currently, many examples could not be found because of limited research on human–robot interaction in the workplace. Fortunately, two articles were found and have been reviewed to explain their connection to practice-oriented understanding. The chosen articles were worthwhile to review for the purpose of understanding the real research applications of practice-oriented understanding.

First, Forlizzi and Mutlu (2008) performed ethnographic research to examine how

organizational factors affect the way its members respond to robots and the changes engendered by their use. In other words, they investigated the impact of technologies (e.g. professional service robots) on social dynamics and work practices of many groups. Throughout the research, they showed how the aspects of work flow, and social/emotional, political, and environmental context intertwine the perceptions and interactions of hospital workers. They found that when different groups in an organization have different goals, their perceptions of the robot vary accordingly. For example, while hospital management perceived the use of the robot as an instrument for improved efficiency, medical units resisted the use of the robot because they perceived it as decreasing the quality of the healthcare that they delivered. In addition, interestingly, medical staffs recognized the emotional tone of the interactions differently according to their job. For instance, nurses who treated cancer patients found the robot "annoying," while nurses at the birth units thought the robot was "delightful" (Forlizzi & Mutlu, 2008).

The research by Forlizzi and Mutlu (2008) was based on practice-oriented understanding because they intended to design their research to examine behavioral and interpretive templates for people's situated use of robots. Besides, their research on the relationship between organizational structures and technology has focused not only on how interpretations, social interests, and disciplinary conflicts shape the organizations' use of technology, but how people's perceptions on technology affect cultural, structural, and workplace norms. For this reason, their research is considered to be a good example to show the usefulness of practice-oriented lens in terms of researching organizational implications of human–robot interaction.

Second, Sinno and Hinds (2005) observed how sex segregation structures may shape how men and women workers make sense of professional service robots. Their ethnographic research is related to people's sense-making of robots in social environment. They found that male and female workers seemed to engage in sense-making around the robot according to their position in the hospital (Sinno & Hinds, 2005). Engineers and male administrators generally saw it as a machine that they control, while female administrators and low-level female staff workers anthropomorphized it as a human male that acted with agency, and nurses regarded it as a technology with no work utility and perhaps as further evidence of the low value placed on their jobs and work needs.

In their research, people's different recognitions about robots resulted in their different preferred use of technology. For example, while engineers and male administrators enjoyed working with the robot, female administrators, low-level female staff workers, and nurses were not favorable about the use of new technology. Although the authors did not specify the consequent organizational effect of their preference, we can speculate that some rejections about the use of robots would lead to the organizational change, such as the discouraged morale of nurses or their decreased productivity. On the other hand, those who were favorable about the use of robots will develop continual habitual use of a technology, which would result in new taken-for-granted organizational norms about the robots. For this reason, their research is also a good example to show the new behavioral and interpretive templates for people's situated use of the robots.

As these two above-mentioned examples eloquently used practice-oriented lens,

they can give us the clues about how to approach the organizational implications of the use of robots. The researcher maintains practice-oriented view in this dissertation and further develops arguments based on the practice-oriented framework.

## Organizational Innovation

Innovation refers to the process by which an organization puts a technology or practice to use for the first time, regardless of whether other organizations have previously used the technology or practice (Emmons, 2000; klein & Sorra, 1996; Nord & Tucker, 1987; Rogers, 2003). Innovation researchers often distinguish technical innovations from administrative innovation (Weiner, Helfrich, & Hernandez, 2006). In health care, technical innovations include ideas for new technologies (e.g., magnetic resonance imaging, or MRI), new products (e.g., new drugs), new services (e.g., telemedicine), and new clinical processes (e.g., administering aspirin immediately following a heart attack). Administrative innovations include new ideas or practices in the areas of personnel selection, resource allocation, task design, and organizational structure.

According to the above category, the introduction of a robot belongs to technical innovation. In order to explain the technical innovation represented by the use of robots, this research utilized the five-stage model of the organizational innovation process Rogers (2003) suggested. Rogers (2003) suggested a five-stage model of the organizational innovation process: agenda setting, matching, restructuring, clarifying, and routinizing. In fact, although innovation is perhaps the best-studied phenomenon in management research, one of the most consistent findings is how unpredictable and

complex the process is (Meyer & Goes, 1988).

However, the five-stage model offers a useful vehicle for discussing what we know, and do not know, about innovation even though innovation in complex adaptive systems rarely occurs through the linear process described by the model (Weiner, Helfrich, & Hernandez, 2006). Besides, the best preparation may simply be to know the basic stages that most organizations go though when they want to innovate, as the saying goes, "change favors the prepared mind."

### *Agenda Setting*

Agenda setting refers to the ongoing process within organizations through which organizational members identify important problems and search for innovations to address these problems (Weiner, Helfrich, & Hernandez, 2006). Generally, performance gap often triggers innovation processes as organizational members look for new ideas or technologies to bridge the gap (Rogers, 2003). In some cases, organizational members begin with a perceived need and then search for innovations. In other cases, they first learn about an innovation and then find a need for it. Regardless of whether the problem or the solution comes first, the innovation process is largely driven by how organizational members perceive and prioritize needs.

Given the hierarchical structure of most health care organizations, senior managers wield considerable influence over both the course and the outcomes of agenda setting (Weiner, Helfrich, & Hernandez, 2006). Although senior managers typically dominate agenda-setting processes, middle managers can contribute in significant ways by synthesizing and interpreting information from the external environment for the

organization (Pappas, Flaherty, & Wooldridge, 2004), discovering new opportunities, and accumulating and managing resources for strategic change (Floyd & Wooldridge, 1994). Similarly, physicians, nurses, and other clinical professionals possess valuable information and unique perspectives on clinical workloads, patient care issues, intraorganizational coordination, and new technologies (Blumenthal & Edwards, 1995; Kirkley, 2004; McDaniel & Ashmos, 1986). The participation of these two groups increases not only the amount of information available but also the diversity of perspectives brought to bear on that information permitting new insights and alternative meanings to emerge (Ashmos, Huonker, & McDaniel, 1998).

*Matching*

In the matching stage, the organization's needs and capacities are matched to the innovation and the decision to adopt or not to adopt is made (Rogers, 2003). Matching is often not a formal, explicit process; moreover, matching may continue even after the innovation has been normally adopted. Matching involves the interplay of two set of factors: innovation characteristics; social systems characteristics.

*Innovation characteristics.* Five attributes of innovations affect the matching process and, ultimately the adoption decision (Rogers, 2003). *Relative advantage* refers to the degree to which the innovation is perceived as superior to current practice. Innovations perceived as superior are more readily adopted (Dirksen, Ament, & Go, 1996). *Compatibility* refers to the degree to which that innovation is consistent with the values, beliefs, history, and current practices of the potential users (Rogers, 2003). *Complexity* refers to the degree to which organizational members perceive the

innovation as difficult to understand or use. Simpler innovations spread faster than complicated ones (Rogers, 2003). *Trialability* refers to the degree to which organizational members can experiment with the innovation on a limited basis. The ability to try an innovation without significant investment or irreversible commitment reduces uncertainty about expected consequences (Grilli & Lomas, 1994). *Observability* refers to the degree to which the results of an innovation are visible to others. Innovations that generate benefits visible to intended adopters get adopted more readily (Grilli & Lomas, 1994; Meyer & Goes, 1988). Rogers (2003) emphasized the fact that these attributes are perceptions, not objective features of innovations. Therefore, health care managers can increase an innovation's attractiveness by influencing organizational member's perceptions of innovation attributes (Rogers, 2003).

*Social system characteristics.* Social system characteristics also influence organizational members' perceptions of an innovation as well as their assessments of the feasibility of adoption and implementation. Studies of technology diffusion among hospitals show that almost all of the geographic variation in technology adoption occurred between local communities of medical professionals, not within individual communities. In other words, medical professionals are keen to adopt innovations that their local colleagues had adopted (Greer, 1988). Doctors tend to operate in informal, horizontal networks, and nurses more often have formal, vertical networks (West, Barron, & Newton, 1999). *Homophily* refers to the degree of similarity between individuals, groups, or organizations. Individuals are more likely to adopt innovations if they are homophilous in terms of socioeconomic, cultural, or professional backgrounds (Fennell & Warnecke, 1988). *Opinion leaders* serve as hubs in social and professional networks

and strongly influence how innovations are perceived, both within their organizations as well as others (Becker, 1970). Opinion leaders can help both raise awareness about innovations and lend them credibility (Rogers, 2003). *Boundary spanners* play a pivotal role in capturing ideas that become innovations (Rogers, 2003). Boundary spanners refer to employees who have significant social ties both inside and outside the organizations. Organizations with greater absorptive capacity more readily identify and adopt innovations (Cohen & Levinthal, 1990; Zahra & George, 2002). *Absortive capacity* refers to an organization's ability to acquire, assimilate, and apply new knowledge. Finally, *organizational readiness for change* also plays an important role in shaping organizational members' assessments of adoption desirability and implementation feasibility (Zahra & George, 2002).

*Restructuring*

Restructuring marks the beginning of the implementation phase of the innovation process. Implementation refers to the transition period during which targeted organizational members ideally become increasingly skillful, consistent, and committed in their use of an innovation (Klein & Sorra, 1996). Implementation begins with restructuring because implementation almost always involves mutual adaptation of the innovation and the organization (Yin, 1979; Goodman & Steckler, 1989; Rogers, 2003). Few innovations get implemented without undergoing some reinvention (Rogers, 2003). Permitting organizational members to adapt or modifying the innovation can facilitate implementation by reducing the complexity of innovation and increasing its compatibility with existing structures and practices.

Organizational adaption generally takes the form of implementation policies and practices, a shorthand phrase for the formal strategies that an organization employees in order to put the innovation into use, and the actions that follow from those strategies (Klein & Sorra, 1996). Implementation policies and practices vary from innovation to innovation but generally include training, technical support, recognition and reward, reorganization, job reclassification, workflow changes, and workload changes.

*Clarifying*

As organizational members gain experience with an innovation and learn about its implications for them and for the organizations, they begin comparing the actual versus expected benefits and costs of innovative use (Rogers, 2003). According to Klein and Sorra (1996), an important distinction exists between implementation effectiveness and innovation effectiveness. Implementation effectiveness concerns the overall consistency and quality of organizational members' use of an innovation (e.g., do providers regularly update and use information in the clinic's diabetes registry?). Innovation effectiveness refers to the benefits the organization realizes from innovation use (e.g., does the diabetes registry improve patient outcomes?). Generally, an innovation must be effectively implemented for the innovation to deliver the expected outcomes, but effective implementation does not guarantee that the innovation will be effective.

Regarding the spread of innovations within an organization, diffusion is a passive process in which a growing body of information about an intervention, product, or technology is initially absorbed and acted upon by a small body of highly motivated recipients (Lomas, 1993). By comparison, dissemination is an active process whereby

special efforts are made to ensure that intended users become aware of, receive, accept, and use an innovation (Lomas, 1993). Research consistently demonstrates that informational strategies only raise awareness and knowledge; they do not alter behavior (Bero, Grill, Grinshaw, Harvey, Oxman, & Thompson, 1998; Davis, Thompson, Oxman, & Haynes, 1995). Hence, managers seeking to transfer innovative knowledge, technology, or practice from one part of an organization to another would far better using dissemination strategies such as cross-training, staff rotation, opinion leaders, and academic detailing (i.e., offering brief one-on-one education and feedback) (Weiner, Helfrich, & Hernandez, 2006).

*Routinizing*

Routinization is the final stage in the innovation process where the innovation becomes incorporated into the regular activities of an organization and loses its distinct identity (Rogers, 2003). Routinization depends in part on the extent to which organizational members perceive the innovation as a legitimate and valued practice (Kanter, 1983). Routinization does not necessarily depend on either implementation effectiveness or innovation effectiveness. Rather, routinization depends on the continued allocation of five types of resources: budgetary resources, personnel resources, training programs, organizational policies and procedures, and supply and maintenance operations (Goodman & Bazerman, 1980; Yin, 1979). Beyond committing resources and monitoring on an ongoing basis, organizational leadership can improve the chances that an innovation will become routinized (Rogers, 2003).

## Innovation in Healthcare Industry

The innovation in the healthcare sector needs to be treated with extra caution because the healthcare organizations are all struggling with the environment in which medical information, technologies, and relationships with other healthcare systems are constantly changing (Cohen, McDaniel, Crabtree, Ruhe, Weyer, & Tallia, 2004). Furthermore, governments of developed countries suffer from the pressure to reduce healthcare costs while improving quality (Howie & Ericson, 2002).

According to Lee and Alexander (1999), fundamental structural and regulative changes have already altered the entire industry. In Europe, people are already discussing structural changes that would radically reform the healthcare system in many ways (West & Anderson, 1996). On the one hand, new kinds of cooperative networks have been made by public and private players in the field for the purpose of providing more efficient healthcare services of better quality for patients who have increasing expectations (Berman, 2000; Lee & Alexander, 1999). On the other hand, rapid advances in medicine and technology provide promising opportunities for radically new medical practices (Jadad & Delamothe, 2004).

According to Anderson, De Dreu, and Nijstad (2004), innovation implies three important characteristics: novelty; an application component; and an intended benefit. Innovations in healthcare organizations are generally new services, new ways of working and/or new technologies. From the patient's point of view, the intended benefits are better health or less suffering due to illness (Faulkner &Kent, 2001). From an organizational point of view, the desired benefits are often increased efficiency of internal operations and/or the quality of patient care (Faulkner & Kent, 2001).

Regarding the attitudes toward innovations in the healthcare sector, several researchers asserted that it is difficult to change the behaviors of clinicians (Greco & Eisenberg, 1993), current medical practices, and healthcare organizations (Shortell, Bennett, & Byck, 1998). In fact, innovations in patient care, treatment practices and hospital procedures would include serious health risks related to financial, social, and ethical issues (Collier, 1994; Faulkner & Kent, 2001). The adoption of healthcare innovation is often controlled by laws, making changes more onerous (Faulkner & Kent, 2001).

Because performance gaps, typical starting points of an innovation process, may lead to death, disability, or permanent discomfort, the potential discomfort can stimulate a culture of blame and secrecy that prevents organizational learning and generation of innovations (Huntington, Gilliam, & Rosen, 2000). Of course, the clinicians' tendencies to protect their individual autonomy and reputation have been helping the stimulation.

Furthermore, healthcare organizations are very wary of the possibility that potentially harmful innovations are adopted. For this reason, new medical practices are thoroughly examined in their early development phases (Faulkner & Kent, 2001). In fact, clinicians tend to prefer experimental research methods because they are feasible for clinical research. On the other hand, because non-experimental research methods are used in the evaluation of organizational practices or structure innovations, medical practitioners are not likely to rely on the evaluation which does not give quantified answers to research questions (Pope, 1995; Pope & Mays, 2000). As can be seen above, the generation of innovations and their adoption is tricky in the healthcare organization context.

Concerning the internal factors facilitating or inhibiting innovation, the research showed that strong leadership, shared and clear objectives, task orientation, participative safety, reflective team practices, active internal marketing, correct timing, motivation and participation personnel, lack of stress, and sufficient resources (financial, instrumental, and personal) were positively related to innovation in healthcare organizations (Becker et al., 2000; Castle, 2001; Cohen et al., 2004; Edmondson, Bohmer, & Pisano, 2001; Ericson, 2001; Evashwick & Ory, 2003; Felton, 2003; Lansisalmi & Kivimaki, 1999; West & Anderson, 1996).

According to West and Poulton (1997), primary healthcare teams scored lower on clarity of objectives, participation, and support for innovation than did teams used in the oil industry, in National Health Service management, and in community mental health and social service teams. In addition, the demographic characteristics of the top management team were related to the adoption of new technology. Tenure, level of education, and involvement in a professional society by the top management team was positively related to the adoption of new technology in nursing homes (Castle, 2001).

In the empirical research, several external factors that were identified to have a positive relationship with the adoption of innovations were found: involvement; motivation; and support (in the form of training consultants and technical support) provided by key stakeholders in the organizational context (Becker, Dumas, Houser, & Seay, 2000; Cohen et al., 2004; Evashwick, & Ory, 2003). Furthermore, active communication with external parties were found to improve the quantity of service innovations and the quantity of new technologies adopted by hospitals over time (Goes & Park, 1997). A highly competitive county, with wealthy residents combined with a

high number of hospital beds, was positively related to the early adoptions of service and technology innovations among healthcare service providers (Castle, 2001). Finally, when announcing organizational structure innovations publicly, hospitals tend to employ defensive management techniques, such as excuses, justification, and concealment (Arndt & Bigelow, 2000).

Regarding leadership and leader behavior, Locock, Dopson, Chambers, and Gabbay (2001) found that different types of opinion leaders as well as an assigned project leader were influential in the different phases when adopting new clinical practices. Involvement of different types of opinion leaders varies from expert academic through expert clinician to peer clinical leaders (Locock et al., 2001). The closer the project progressed to the practical implementation phase, the more important the peer opinion leaders' views became (Locock et al., 2001). Ambivalent and resistant opinion leaders also played an important role in the adoption (Locock et al., 2001). In addition, Ericson (2001) found that the top management's differing sense-making processes resulted in a lack of shared vision and resistance among the team members when implementing a new matrix structure in a hospital organization.

Evidence about the effects of the interventions was inconsistent (Länsisalmi, Kivimäki, Aalto, & Ruoranen, 2006). Some of the interventions aiming at enhancing group interaction patterns, supervisor support, and innovation skills of the personnel are positively related to innovation and creativity (Berg & Hallberg, 1999; Bunce & West, 1996; Kylen & Shani, 2002; Lantz & Severinson, 2001; Newmann & Fitzgerald, 2001), whereas in other studies no effect was observed (Lökk & Arnetz, 2002) or the effects were mixed (Magnan, Solnberg, Giles, Kottle, & Wheeler, 1997). Besides, when

comparing the different styles of intervention implementation in role innovation, internal customers perceived the bureaucratic style would improve performance, whereas external customers perceived that person-job integration caused better role performance (Drach-Zahavy, Somech, Granot, & Spitzer, 2004).

The intervention studies implied that the systematic clinical supervision provided for nurses enhances creativity in the organization through generating trust, liberating time for idea creation, and reducing conflicts in the group (Berg & Hallberg, 1999). Furthermore, an intervention that promoted innovative alternatives for stress management for health workers resulted not only in reduced stress but also in more frequent innovations implemented in the workplace (Bunce & West, 1996). According to Länsisalmi, Kivimäki, Aalto, & Ruoranen (2006), these studies supported the idea that specific innovations for improving supervisor support and personnel skills systematically stimulated innovation capability. On the other hand, Lökk and Arnetz (2002) found that external support provided for the staff of a geriatric hospital hindered the organizational change process compared to the control ward which received no support. Regarding a possible reason for this contradictory finding, Lökk and Arnetz (2002) pointed out that excessive intervention in group dynamics might lower the group's self-esteem and its natural ability to cope with changes in the environment.

Although the results of the above intervention studies are mixed, the researcher agrees with Lökk and Arnetz (2002) that interventions would be helpful to facilitate the innovation when they are not too excessive. In fact, it is difficult to decide the appropriate degree of involvement in front of new innovation. In reality, finding 'what not to do' is sometimes more complicated than choosing 'what to do'. For this reason,

when interpreting the empirical data given in this dissertation, the researcher also contemplated ‘what not to do’ as well as ‘what to do’ in order to explore more helpful priorities for healthcare organizations.

## Robotic Surgery

Medical robots may be classified in many different ways: by manipulator design (e.g., kinematics, actuation, degrees-of-freedom) (Taylor & Stoianovici, 2003); by their level of autonomy (e.g., preprogrammed, image-guided, teleoperated, synergetic); by the targeted anatomy/technique (e.g., cardiac, intravascular, percutaneous, laparoscopic, microsurgical); by the intended operating environment (e.g., operating room, imaging scanner, hospital floor); or by context of their role in computer-integrated surgery systems (surgical planner, surgical assistants).

One of the most important recent developments to surgical practice has been the adoption of computer assisted robots. To date since 1998, there have been approximately 80,000 robotic assisted surgical procedures and currently about 400 medical centers in the United States have surgical robotic systems (Sullivan, Frost, & Lew, 2008).

A robotic device is defined as a powered, computer controlled manipulator with artificial sensing that can be reprogrammed to move and position tools to carry out a wide range of tasks (Davies, 2002). The robots used in surgery should ideally be part of a computer-integrated surgery system. The robot is just one element of a larger system designed to assist a surgeon in performing a surgical procedure (Cepolina, Challacombe, & Michelini, 2005). According to Sullivan et al. (2008), robotic systems used in surgery today are computer assisted devices and are not true robots because they lack

independent motions or preprogrammed actions. On the other hand, they offer significant advantages such as three-dimensional view, visibility of difficult to reach areas, easier instrument manipulation and the possibility of remotes site surgery (Sullivan et al., 2008).

Surgical robots are required to work within properly structured constraints to ensure patient safety. However, the working environment cannot always be predicted and potentially dangerous situations can quickly develop. Thus, any changes in the robot's environment need to be swiftly recognized and the crisis response and safe recovery autonomously initiated, with this information displayed to the surgeon, along with possible options for subsequent safe continued use. The proper setting of autonomous limitations is a subtle question, and adjustment to an individual surgeon's requirements or complete overriding must be possible (Challacombe & Stoianovici, 2008).

In fact, a more accurate descriptor for the surgical robots is a computer enhanced telemanipulator (Fuchs, 2002). For example, the surgeon is teleported to the operative site and is able to manipulate surgical instruments as if he or she were in the surgical field. Thus, surgical robots perform tasks under the surgeon's control in what is referred to as a "master-slave" relationship. The robot does not replace the surgeon, but instead performs and enhances the precision of the surgeon's hands (Sullivan et al., 2008).

The first concept of surgical robotics was developed in the late 1980s at the National Aeronautics and Space Centre (NASA) (Murphy et al., 2008). Together with the Stanford Research Institute, virtual reality and surgical robotics were integrated and the first steps towards telepresence surgery were made. The commercialization of the

robotic surgery started in the early 1990s. The next step was the development of complete robotic systems. The Zeus robotic system (Computer Motion, Goleta, CA, USA) and the da Vinci robotic system (Intuitive Surgery, Mountain View, CA, USA) were introduced in the late 1990s. Both systems have remote manipulators that are controlled from a surgical workstation; in less than 20 years' time, there had been a major development in robotic surgery. In 2003, Computer Motion was taken over by Intuitive Surgery and today the Zeus system is no longer commercially available. The da Vinci platform is the only telerobotic system currently commercially available. The da Vinci system was approved for general surgery by the US Food and Drug Administration (FDA) in 2000, for the use in urology in 2001 and for gynaecology in 2005.

According to Sullivan et al. (2008), the da Vinci system is composed of 3 distinct parts:

> The first part is a control console where the surgeon sits to view and control the robot from a remote location. The console has a place where the surgeon attached his hands and his hand motions are translated into surgical instrument motion. The surgeon's fingers are connected via the console and robot to the surgical instruments. The console also has a three dimensional viewer. With the surgeon sitting at the console, manipulating the robot and simultaneously looking into the viewer, he/she has the simulated experience of being present in the operating field. Foot pedals on the console allow the surgeon to control electrocautery, ultrasonic instruments, adjust the focal point of the video camera, disengage the robot instruments, and alternate between robotic arms as the need arises. The second

> component consists of a tower which contains video equipment to record and display images of the surgical site onto two dimensional monitors for the convenience of the rest of the operating room team. Other laparoscopic instruments such as insufflators are on this tower. Finally, the third component is the robot itself which consists of three or four arms. The original da Vinci robot had three arms. The central arm holds the video telescope while a right and left arm perform manipulations. A four arm robot was later added. It is identical to the other two arms in functionality. It can be positioned and locked into place, acting as a stationary retractor. The surgeon can then assist him/herself when retraction is needed. (p.969)

Recently, there has been an enormous push toward increasing use of minimally invasive surgery. The advantages of laparoscopic assisted surgeries include postoperative pain, improved cosmesis (smaller incision), shorter hospital stays, faster postoperative recovery, potentially lower costs, and improved patient satisfaction (Fuchs, 2002). One advantage of computer assisted robotic surgery over standard laparoscopy includes improved operative field visibility with three dimensional imaging systems (Sullivan et al., 2008). Another advantage of the robotic system, computer assisted scaling, improves control of fine movements and reduces the "fulcrum effect" which amplifies unwanted motions such as hand tremor (Sullivan et al., 2008). Finally, robotic systems allow for more ergonomic, anatomic control of instruments which closely mimics the movement of the human wrist (Lanfranco, Castellanos, Desai, & Meyers, 2004).

On the other hand, robotic surgery has some limitations. First of all, several pieces of equipment require large amounts of precious operating room space (Sullivan et al., 2008). In smaller or older operating rooms, such space constraints may be the limiting factor to adoption of robotic surgery. Second problem is the large size of the robot itself. In order to avoid collision with its own arms, assistants and the patient, positioning the robot is an important task (Lanfranco et al., 2004). For example, patients must be correctly positioned for surgery from the start since repositioning a patient is almost impossible once the robot has been stationed for surgery. The staff must be trained and prepared to quickly detach and remove the robot from the patient in the event of an emergency.

In addition, current robotic systems lack tactile feedback from the instruments (Fuchs, 2002). Surgeons must therefore rely solely on visual cues to modulate the amount of tension and pressure applied to tissues to avoid organ damage. Besides, cost is another limitation to using robotic systems, especially for smaller community hospitals. There is a large initial cost of approximately $1 million dollars to purchase the robotic equipment and a recurring annual service contract fee of about 10% of the purchase price (Sullivan et al.,2008).

With the implementation of robot-assisted surgery, there is also an increasing need for training. Together with the approval of FDA, the manufacturer of the da Vinci robotic system (Intuitive Surgery) was demanded to provide comprehensive training for all teams and surgeons planning to use the robot clinically. The registered training centers, located all over the world, can be found on their website. As of now, 23 official training centers are noted (Schreuder & Verheijen, 2009). The first training curriculum

for robotic surgery was developed at the East California University, California (Chitwood, Nifong, Chapman, Felger, Bailey, & Ballint, 2001).

## The Robotic Team in the Operating Room

With the growing interest in robotic surgery and the promising results, there is an increasing need for information how to set up a robotic program. Palmer, Lowe, Coughlin, Patil, and Patel (2008) described five essential phases to set up a successful robotic program. The first step is the development of a business plan, defining the initial robotic program and arranging proper administrative support. In the second phase, one must think of the theatre design, the theatre team, the purchase of a robotic system, sterilization facilities, marketing and an expert lead surgeon. The third phase is the execution of the program. In the fourth phases followed by a phases of maintenance, one should have a proper data system for quality control and efficiency and outcomes as well as patient satisfaction should be registered. A structured program for training and education of fellow's/residents should be available. The last phase is growth to make the program profitable, where one could think of a recruitment or training of new surgeons working together with other subspecialities (Palmer et al., 2008). Especially, there is need for a dedicated theatre team (Patel, 2006). Transforming an existing high-volume conventional laparoscopic program to a robot-assisted program for radical prostatectomy can be achieved while maintaining reasonable profits. However, equal profit is not possible without a substantial increase of caseload (Palmer et al., 2008). All the above programs were launched in the USA. However, the situation in Europe is different from country to country because of different healthcare systems and insurance systems

(Palmer et al., 2008).

Specifically, Rocco, Lorusso, Coelho, Palmer, and Patel (2009) explained the role of robotic team in the operating room as following:

*The Leading Surgeon*

The role of the leading surgeon is not only to perform the procedure but also to coordinate and to take care of the team and its training. A surgeon who starts a robotic program should accompany other colleagues to facilitate the development of common scientific programs, to share the costs increasing overall surgical volume and to raise the visibility of the facility and therefore patients' recruitment. The essential skills to run a program are surgical proficiency and ability to communicate and to create scientific network.

The key to train leading surgeons are based on improving their knowledge of the da Vinci system with lab exercises on cadavers or porcine models; the next steps are case observations and video based learning and it is advisable to perform the first procedures with a proctor. Following a complete training, patient selection is important.

*The Operating Room Nursing Staff*

Contrary to traditional open surgery, robotic surgery implies that the leading surgeon does not have direct contact with the patient being completely immersed in the console and the scrub nurse (SN) and physician assistant (PA) are the only ones in direct contact with the patient. A complete understanding of the procedure and the surgical steps are crucial. The scrub nurse should coordinate with the PA during the entire

procedure, providing sutures, instruments and helping taking care of the camera. A scarce coordination between PA and SN can cause significant delays and difficulties during the procedure.

*The Surgical Physician Assistant*

The physician assistant has one of the most important roles in the OR robotic team. Most of the programs start with two surgeons working together, but with more experience and in order to reduce costs, the bedside surgeon can be easily substituted, in the USA, by a surgical PA. The PA, at the bedside, needs to have a perfect coordination with the leading surgeon and the scrub nurse: a complete knowledge of the anatomy and the surgical operation are mandatory to provide adequate tractions, to expose the surgical field according to the surgeon's preferences, to position vascular clips and also vascular clamps. Furthermore, the surgical PA has a role in training further PA and also resident physician to learn how to assist at bedside.

*Surgical Fellows and Residents*

Training programs with "hands on" experience for fellows and residents have been recently developed for robotic surgery. Adequate teaching programs allow for an effective increase of fellows' experience with no impact on patients' outcome (Schroeck, de Sounsa, & Kalman, 2008). Robotic training for residents does provide a challenge for the supervising surgeon, due to the use of a remote console and lack of haptic feedback.

## The Role of Nurses in the Robotic Surgery

Generally, nurses are responsible for these tasks in the robotic surgery (Tabor, 2007):

1. Identifying the system's components and know how they are used;
2. Preparing the system before surgery;
3. Knowing emergency procedures if the system malfunctions or the power goes out;
4. Knowing how to clean and sterilize the robotic instruments and cleaning the nonsterile equipment;
5. Troubleshooting error messages;
6. Positioning the patient and equipment safely;

Adding to the above general tasks, some hospitals consider implementing the role of robotics nurse specialist, particularly if surgeons from multiple specialties will be using the robotic system (Francis, 2006). A robotics nurse specialist can build a comprehensive picture of how, why, and when a system is being used. This allows for accurate decisions to be made on how equipment, instruments, and supplies can best be configured for the optimal use (Francis, 2006). According to Francis (2006), having the robotics nurse specialist consistently present in all procedures allows 1) accurate assessment to be made of educational and resource needs of nursing personnel and 2) problems with the robotic equipment and instruments to be sorted out faster and with more accuracy.

In addition, Francis (2006) categorized the job roles of robotics nurse specialist:

1. Clinical practice: Act as care coordinator, provides direct patient care, and

provides clinical expertise;

2. Education: Orients and trains nursing personnel, trains and mentors health care students, and enlightens lay public;
3. Administration: Acts as liaison within institution, acts as liaison to manufacturer, and acts as liaison outside institution with lay public and outside health care professions;
4. Research: Participates in data gathering, participates in data management, and ensures data dissemination;
5. Professional: Maintains clinical expertise and professional skills, develops and engages in management and consultant skills.

In reality, when considering the medical robotics is at infancy, most hospitals would not have this kind of sophisticated system for managing nurses working with a surgical robot. However, as Francis (2006) mentioned, under the environment in which surgeons from multiple specialties will be using the robotic system, developing the robotics nurse specialist will be helpful to improve the effectiveness of robotic surgery.

In this research, the researcher referred to the above job roles of nurses and the below competencies for a perioperative robotics nurse specialist (Francis, 2006) when the researcher constructed statements for the first round:

1. Demonstrates expertise in minimally invasive surgery;
2. Demonstrates expertise in robotic surgery;
3. Demonstrates expertise in perioperative nursing (eg, three-years perioperative experience, multiple-specialty training, CNOR preferred) ;
4. Demonstrates basic knowledge of data collection, research approaches, and

protocol types;

5. Demonstrates reasonable proficiency in basic computer software applications;
6. Serves as an excellent role model and provides leadership for staff members;
7. Demonstrates self direction with excellent prioritization skills;
8. Assumes responsibility for and engages in activities that develop and maintain clinical expertise and professional skills.

## An Overview of Work Stress

Contemporary views on how stress should be defined require researchers to think of stress as being relational (Lazarus & Launier, 1978): the result of a *transaction* between the individual and the environment (Lazarus, 1990). The transactional approach draws researchers toward identifying those processes that link the individual to the environment. What distinguishes this approach from earlier approaches is the emphasis on "transaction"-identifying the processes that link the different components, recognizing that stress does not reside solely in the individual or solely in the environment but in the conjunction between the two, and accepting that no one component (i.e. stimulus, response) can be said to be stress (Lazarus, 1990) because each is part of, and must be understood within, the context of a process.

Taking this argument a stage further, job stress should now be viewed as a transaction-an ongoing relationship between the individual and the environment. The transactional model of stress endeavors to explore the essential nature of stressor-response-outcome relationships and to encapsulate an understanding of the dynamic stress process itself (Cooper et al., 2001). Following the transactional model of the stress

and the terminology suggested by Beehr and colleages (Beehr, 1998; Beehr & Franz, 1987), this research adopted the following conceptualizations:

1. Stress: the overall transactional process
2. Stressors: the events of properties of events (stimuli) that are encountered by individuals
3. Strain: the individual's psychological, physical, and behavioral responses to stressors
4. Outcomes: the consequences of strain at both the individual and the organizational level

Therefore, stressors are the antecedent conditions, and strain is the person's responses to those conditions. The researcher agrees with Beehr that the term should not be used not to describe specific elements of the transaction between the individual and his or her environment but rather to denote the overall process incorporating stressors, strains, and coping response.

One core element of the transactional model of stress-coping is awareness of the events, issues, and objects (including people) that may function as stressors (sources of strain) for individuals. Lazarus and Folkman (1984) argued that strain occurs when environmental demands or constraints are perceived by a person to exceed his or her resources or capacities. Determinants of strain can generally be grouped into three major categories: job-specific sources, organizational sources, and individual sources (Cooper et al., 2001). This section focuses on environmental rather than individual (within-person) factors because the core of my discussion lies in observing how to manage the stress in the organization dimension.

Upon the rubric of environmental sources of strain, Cartwright and Cooper (1997) have further differentiated six primary work-related stressors:

1. Factors intrinsic to the job itself
2. Roles in the organization
3. Relationships at work, such as those with supervisors, colleagues, and subordinates
4. Career development issues
5. Organizational factors, including the structure and climate of the organization as well as its culture and political environment
6. The home-work interface

This literature review checks the relationship between these above stressors and the use of robots in order to investigate the organizational influence of the use of robots. The introduction of new technology can function not only as one of stressors but also as direct or indirect cause of other stressors. Therefore, this research will exclude the investigation of the home-work interface in order to more concentrate on within-organizational factors. Of course, in the consequent research, it is possible to expand the discussion to the home-work interface area.

First of all, Cooper et al. (2001) asserted that intrinsic job characteristics as stressors are following: noise; vibration and temperature; workload; work hours; new technology; exposure to risk and hazards. The technical innovation represented by the use of robots is strongly related to these stressors such as new technology and workload. In order to clarify the relationship, how these stressors are related to the technical innovation will be reviewed and how they influence employees' stress-related health will

be discussed.

*Intrinsic Job characteristics: Workload*

Regarding the workload, the use of robots would cause overload or underload in the workplace because they influence social dynamics and work practices of many groups (Forlizzi & Mutlu, 2008). Generally, the workload is composed of two categories: quantitative; qualitative (Cooper et al., 2001). Quantitative workload refers to the sheer amount of work required and the time frame in which work must be completed (Cooper et al., 2001). Having to work under time pressure to meet deadlines is a major source of quantitative overload (Narayanan, Menon, & Spector, 1999) and has been related to high levels of strain, anxiety, and depression, as well as to job performance (Cooper & Roden, 1985; Kushimir & Melamed, 1991; Westman & Eden, 1992). On the other hand, qualitative overload occurs when individuals believe they do not have the skills or capacities to satisfactorily perform job tasks, and it has been linked to low levels of self-esteem (Udris, 1981). According to Cooper et al. (2001), an example of this qualitative overload would be a line worker who has been promoted to a supervisory capacity on the grounds of superior work performance but who has no past experience of supervision of others or work delegation.

As of now, the researcher cannot conclude that the use of robot will certainly result in specific workloads because of a lack of previous research. However, when considering that working with robots will bring about the change in social dynamics and work practices of many groups (Forlizzi & Mutlu, 2008), medical staffs would experience some kinds of workload issues because they would regard the new

technology as an unfamiliar and difficult tool. Of course, some people would feel to be interesting when they work with robots. In this dissertation, the researcher is open to any possibilities people will experience. As a part of this research, the researcher focuses on analyzing how the use of robot is related to workload issues.

*Intrinsic Job characteristics: New Technology*

In a rapidly changing environment, skills may quickly become obsolete. However, the need to constantly become familiar with new equipment and systems may pose a threat to some individuals. Unless adequate training and preparation are provided, potentially stressful situations may develop when new technology is introduced into the workplace and the individual feels unable to cope with the innovation. For instance, Korunka, Weiss, Huemer, and Karetta (1995) observed that the introduction of new technologies is related to changes in employee job satisfaction and physical health. Similarly, although computer utilization at all levels of organizations has increased dramatically in recent years, often managers are the most wary of advances in computer technology and the least inclined to adopt new systems (Beatty & Lee, 1992; Hall & Torrington, 1986). Subordinates may also experience overload if they do not receive adequate guidance and supervision from their supervisors.

Even though previous research has focused on the use of computer, they give us insights about how new technology influences organizational behaviors. If there is a great amount of performance gap in using robots, it would not be effective to totally depend on the use of robot. Besides, if the use of robots negatively influences the medical staffs' assumptions about care and expertise, hospital management should

reconsider its use. Of course, vice versa is also possible. The important point is to accurately perceive the influence of new technology on organizational behaviors, which contributes to making appropriate organizational preparations or interventions.

*Organizational Roles*

Roles encompass the behaviors and demands that are associated with the job an individual performs (Cooper et al., 2001). According to Kahn, Wolfe, Quinn, & Snoek (1964), dysfunction in roles can occur in two primary ways: role ambiguity and role conflict. In addition to these two role stressors, role overload and responsibility are also mentioned as stressors related to organizational roles.

*Role ambiguity* refers to unpredictability of the consequences of one's role performance (Kahn et al., 1964). Numerous studies have demonstrated a consistent link between substantial role ambiguity in the job and high levels of psychological strain (O'Driscoll & Beehr, 1994). Similarly, *role conflict*, which reflects incompatible demands on the person, can induce negative emotional reactions due to perceived inability to be effective on the job (O'Driscoll & Beehr, 1994). Several studies have confirmed this detrimental effect of role conflict on both self-reported strain (O'Driscoll & Beehr, 1994) and physiological indicators of strain (Kahn & Byosiere, 1990). Along with role ambiguity and conflict, *overload* has been found to be a major correlate of job-related strain (Cooper, 1987). Not only can role overload lead to excessive demands on an individual's time, but it also may create uncertainty about his or her ability to perform these roles adequately. Lastly, *responsibility* has been identified as a potential stressor associated with workers' roles in their organization. Though too much responsibility is

clearly a source of strain, lack of responsibility may also be stressful if the individual perceives this as work underload.

The use of new technology would confuse people in terms of organizational roles. If people do not have enough knowledge and experience about the use of robots, it is likely that people suffer from role ambiguity or role conflict. In order to clarify the relationship between organizational roles and the use of robots, it is necessary to perform empirical research including this dissertation.

*Work Relationships*

There is some dispute over the role of social support as a moderator of the impact of stressors on individual strain and well-being. Nevertheless, it is clear that negative interpersonal relations and the absence of support from colleagues and superiors can be a major stressor for many workers (Narayanan, Menon, & Spector, 1999). Conversely, having social support from other within the organization can directly alleviate psychological strain (Beehr & McGrath, 1992).

Working with robots can cause some changes in work relationships because a lack of knowledge and experience about the new technology would result in misunderstandings or conflicts while employees interact with robots. On the other hand, it is possible that the use of robots can stimulate positive communication through the collaboration for the adaption to the new technology. Likewise, potentially, the use of robots will be likely to reshape the work relationship. For example, if the use of robots would lead to inconsiderate or non-supportive behavior from a supervisor, employees can be more stressed out. Evaluating work relationships in terms of employees' stress-

related health will be helpful to improve the understanding of the effect of new technology.

*Organizational Factors*

Psychological strain that may be attributed to organizational factors is often due to the culture and management style adopted within an organization (Cooper & Cartwright, 1994). Hierarchical and bureaucratic organizational structures may permit little participation by employees in decisions affecting their work (Cooper et al., 2001). Inadequate communication, especially between managerial and non-managerial personnel, can also contribute to employee strain (Cooper et al., 2001). Lack of participation in the decision-making process, lack of effective consultation and communication, office politics, and no sense of belonging have all been identified as potential organizational stressors (O'Driscoll & Cooper, 1996). On the other hand, increased opportunity to participate has been associated with greater overall job satisfaction, higher levels of affective commitment to the organization, and an increased sense of well-being, even though evidence for the effects of participation on job performance and productivity is less consistent (Leana & Florkowski, 1992; Sagie & Koslowsky, 1994; Wagner, 1994).

A further organizational factor that has been closely studied is the extent of formalization of work and decision-making procedures, although the effects of formalization have been inconsistent and seem to vary between occupational groups. Overall, it is apparent that clearly outlined formal work procedures may have positive benefits for employees (O'Driscoll, 1987) but that overly formalized organizational

processes may be detrimental, particularly among professional groups.

Even though it is clear that the use of robot will influence the workflow in the workplace (Forlizzi & Mutlu, 2008), the researcher could not find any preliminary research on the use of robot in terms of employees' stress-related health. This research will be able to contribute to identifying specific organizational factors related to how employees are stressed out when working with robots.

## Work Stress in Nursing

Extensive work has been undertaken on occupational stress in nursing over the past two decades (Kirkcaldy & Martin, 2000; Chang & Hancock, 2003) with a wealth of publications since the 1990s (Lambert & Lambert, 2001). It continues to be a growing area of research (Clegg, 2001; Tully, 2004) and the prolific literature on this topic is indicative of its continuing interest to the nursing profession (Lambert & Lambert, 2001).

According to Bartlett (1998), negative connotations are usually ascribed to the term, yet some stress responses are of positive benefit. For example, 'eustress' is a term commonly applied to these more positive responses, while the term 'distress' appropriately describes negative aspects (Bartlett, 1998). Stress, therefore, should be viewed as a continuum along which an individual may pass, from feelings of eustress to those of mild/moderate distress, to those of severe distress (Bartlett, 1998).

It is the transition to severe distress that is likely to be most detrimental for nurses, and is closely linked to staff absenteeism, poor staff retention, and ill-health (Healy & McKay, 1999; McGowan, 2001). Nursing provides a wide range of potential workplace stressors as it is a profession that requires a high level of skill, team-working in a variety

of situations, provision of 24-hour delivery of care, and input of what is often referred to as emotional labor (Phillips, 1996). French, Lenton, Walters, and Eyles (2000) identified nine sub-scales of workplace stressors that might impact on nurses: conflict with physicians; inadequate preparation; problems with peers; problems with supervisor; discrimination; workload; uncertainty concerning treatment; dealing with death, and dying patients; patients/their families. As the transition from eustress to distress will depend on an individual's stress perceptions, it follows that variability between people in the identification of workplace stressors within these sub-scales might be expected (McVicar, 2003).

Although overall reported stress levels may be similar, their ranking may vary according to practice area. Foxall, Zimmerman, Standley, and Bene (1990) found that nurses working in intensive care ranked coping with 'death and dying' more highly as a source of distress that did those in medical-surgical care, who ranked workload and staffing issues higher. Tyler and Ellison (1994) found that theatre nurses ranked emotional aspects lower than did those working in a liver unit, or in haematology or oncology.

Stordeur, D'Hoore, and Vandenberghe (2001) attempted to rank stressors in order of severity of impact, the main ones being ranked as follows: high workload; conflict with other nurses/physicians; experiencing a lack of clarity about tasks/goals; a head nurse who closely monitors the performance of staff in order to detect mistakes and to take corrective action.

As McGowan (2001) mentioned, workplace stress is having a greater impact on today's workplace. This implies that stress intensity from the most frequently recognized

sources has increased, and/or additional sources are contributing to the cululative effects. In this respect, it is interesting that some recent studies (Demerouti, Bakker, Nachreiner, & Schaufeli, 2000; McGowan, 2001) also identified lack of reward and shift working as major sources of distress, but these did not appear as significant stressors in earlier studies. These sources cannot be considered as 'new', but rather they appear to have increased in relative significance.

In addition to identifying sources of distress, Demerouti et al. (2000) sought to distinguish between the factors that were most likely to result in emotional exhaustion and job disengagement, the two main components of burnout arising as a consequence of severe distress. They found that job demands (workload, time pressure, demanding contact with patients) were most associated with emotional exhaustion, whereas job resources (lack of participation in decision-making, lack of reward) were most associated with disengagement from work. These findings extend understanding by distinguishing between the type of impact that major stressors may have, but in terms of their general meaning are in broad agreement with those of Stordeur et al. (2001) noted above. However, data from these two studies also identify that there are limitations to such attempts to rank or categorize. Therefore, while Stordeur et al. (2001) identify 'workload' as the most frequently reported stressor, even this made a realatively low contribution (22%) to the variance in emotional exhaustion identified in that study. Likewise, although the impact of the combinations of stressor that contributed to exhaustion and disengagement was much higher at 55% and 66% respectively (Demerouti et al., 2000), the data still suggest that perceptions vary considerably even between nurses working the same area.

For this reason, it is too simplistic to suggest that any one, two or even three sources of distress are the casual factors for all nurses, or to consider that the transition of an individual nurse from mild to severe distress can be predicted reliably at present. This is also supported by the work of Foxall et al. (1990), who found such variability between individuals that they could not recommend generalization of their findings that sources of distress were ranked differently between samples of nurses working in intensive care and medical/surgical care. Commonality of sources of distress, therefore, cannot be assumed even for nurses within the same practice area (McVicar, 2003).

## An Overview of Job Satisfaction

For several decades, scholars have discussed the definition of job satisfaction. Maslow (1954) suggested that there is a five-level hierarchy in human needs: psychological needs, safety, belongingness, love, and esteem to self-actualization. Based on Maslow's theory, job satisfaction has been approached by some researchers from the perspective of need fulfillment (Kuhlen, 1963; Worf, 1970; Conrad, Conrad, & Parker, 1985). However, this approach has become less popular with increasing emphasis on cognitive processes rather than on underlying needs (Spector, 1997).

Unlike the above traditional view, Herzberg and Mausner (1959) proposed that two-factor theory of job satisfaction and postulated that satisfaction and dissatisfaction were two separate and sometimes even unrelated phenomena. Intrinsic factors which they named 'motivators' were found to be job 'satisfiers' and included: achievement, recognition, work itself, and responsibility. Extrinsic factors which they named 'hygiene' factors were found to be job 'dissatisfier' and included: company policy, administration,

supervision, salary, interpersonal relations and working conditions. Herzberg and Mausner's Motivation-Hygiene theory has dominated the study of the nature of job satisfaction, and formed a basis for the development of job satisfaction assessment.

When job satisfaction is the affective orientation an employee has towards his or her work (Price, 2001), it can be considered as a global feeling about the job or as a related constellation of attitudes about various aspects or facets of the job. The global approach is used when the overall attitude is of interest while the facet approach is used to explore which parts of the job produce satisfaction or dissatisfaction. Based on the review of job satisfaction instruments, Spector (1997) summarized the following facets of job satisfaction: appreciation, communication, co-workers, fringe benefits, job conditions, nature of the work itself, the nature of the organization itself, an organization's policies and procedures, pay, personal growth, promotion opportunities, recognition, security, and supervision.

The facet approach can be useful for organizations that wish to identify areas of dissatisfaction that they can improve (Spector, 1997). According to Spector (1997), the facet approach can provide a more complete picture of a person's job satisfaction than the global approach. An employee can have very different feelings about the various facets. For example, he or she might like coworkers and dislike pay.

This dissertation focuses on investigating the job satisfaction regarding the use of a surgical robot. Considering the various facets of job satisfaction is necessary because we do not have enough knowledge or information about how working with a robot would influence or would be influenced by several facets. The researcher will try to get more extensive information in the consecutive rounds as respondents can elaborate about

the issues that they are discussing. In addition, the less constrained format of a Delphi study allows for the emergence of points that are not preplanned by the researcher. Although the researcher is open to all facets of job satisfaction, this research especially focuses on understanding the nature of work itself and organizational policies in order to grasp the changing nature of expertise and organizational change resulting from the use of a robot.

In order to understand the determinants of job satisfaction, this study will utilize the framework of Hulin, Roznowski, and Hachiya (1985). Generally, determinants of job satisfaction can be classified into two major categories: environmental determinants of job satisfaction; personal determinants of job satisfaction (Spector, 1997). This dissertation focuses on environmental determinants because the purpose of the study is to identify organizational support for relieving work stress and for facilitating job satisfaction.

Hulin et al. (1985) used the bottom-up approach which analyzes the effects that external events, situations, and demographics have on job satisfaction. This framework postulates that job satisfaction depends on the balance between work-role depends on the balance between work-role inputs (such as education, working time, effort) and work-role outputs (such as wages, fringes, benefits, status, working conditions, intrinsic aspects) (Hulin et al., 1985). For example, if work-role output (“pleasures”) increase relative to work-role inputs (“pains”), then job satisfaction will increase.

According to the approach of Hulin et. al (1985), Sousa-Poza and Sousa-Poza (2000) distinguished five variables that captured the work-role inputs: years of schooling, usual working time per week, working in an exhausting job, working in a physically

demanding job, working in a dangerous job. An increase in one of these inputs should decrease job satisfaction. In addition, nine variables characterize the work-role outputs (Sousa-Poza & Sousa-Poza, 2000): work compensation, job security, advancement opportunities, interesting job, independent work, helping people, usefulness to society, good relationship with management, good relationship with colleagues. An increase in one of these should increase job satisfaction

When the researcher applies their model to nurses' experience working with robots, hospital management needs to decrease the work-role inputs like working time and work conditions. On the other hand, in order to improve nurses' job satisfaction, they need to strengthen the work-role outputs like salary and advancement. Of course, more important component will be different according to industries. However, contemplating work-role inputs and work-role outputs is helpful to understand the general determinants of job satisfaction.

## Job Satisfaction in Nursing

Job satisfaction can be defined as 'the degree of positive affect towards a job or its components' (Adams & Bond, 2000). Adams and Bond (2000) describe job satisfaction theories as discrepancy theories (examining the extent to which employee needs or wants are satisfied within the workplace), equity theories (highlighting social comparisons in the evaluation of job rewards) and expectancy theories (focusing on employee motivation). In this respect, job satisfaction can be seen as a positive concept describing work attitudes in particular. This has a connection with the philosophy of positive psychology (Seligman & Csikszentmihalyi, 2000; Sheldon & King, 2001),

which involves scientific study of ordinary human strength and virtues. According to Sheldon and King (2001), 'positive psychology revisits the average person, with an interest in finding out what works, what is right, and what is improving'.

According to the literature review of Utriainen and Kyngas (2009), three themes seem to be most significant to nurses' job satisfaction: interpersonal relationships; patient care; organizing nursing work.

First of all, human relationships between nurses and various communal factors are of major importance for nurses' job satisfaction, and several studies (Adams & Bond, 2000; Newman & Maylor, 2002; Dunn, McLennan, 2005) have indicated them to be the best predictors of job satisfaction. According to McLennan (2005), interaction with other people was the greatest source of strength. Similarly, Newman and Maylor (2002) mentioned that nurses were of the opinion that co-workers (and the patient care) were the best thing about their work. Dunn et al. (2005) also have found that relationships with other members of the nursing staff are the most important factors in creating job satisfaction (another important factor being the possibility of producing high-quality patient care).

Furthermore, for these relationships between nurses, collaboration with medical staff is essential (McNeese-Smith, 1999; Adams & Bond, 2000), as is communication between nurses and physicians (Manojlovich, 2005). Harmony between nurses and togetherness (Adams &Bond, 2000; Kovner, Brewer, Wu, Cheng, & Suzuki, 2006), nurse-to-nurse interaction (McLennan, 2005; Boyle, Miller, Gajewksi, Hart, & Dunton, 2006), collaboration and good communication (McNeese-Smith, 1999; Begat, Ellefsen, & Severinsson, 2005) are predictors of nurses' job satisfaction. Teamwork has a role as a

predictor of satisfaction linked to the people worked with (Newman & Maylor, 2002; Jackson, 2005). According to Campbell, Fowles, and Weber (2004), work environment can have a positive influence: work environments in which supervisors and subordinates consult together (concerning job tasks and decisions) and in which individuals are involved with peers in decision-making and definition of tasks are positively related to job satisfaction. McNeese-Smith's (1999) study brings forward relationships with colleagues and friendship including helping each other in patient care, conversations and the joy of coffee breaks together.

Secondly, patient care, especially high-quality patient care, is a major factor generating job satisfaction. Patients and patient-focused work allocation mean a lot to nurses (Makinen, Kivimaki, Elovainio, Virtanen, & Bond, 2003; McLennan, 2005). According to studies, patient care is the most important factor in increasing satisfaction (McNeese-Smith, 1999), in the same way as caring and helping patients, seeing patients get better and patient satisfaction are the best aspects of nurses' work (Newman & Maylor, 2002). Several studies (Newman & Maylor, 2002; Begat et al., 2005; Dunn, Wilson, & Esterman, 2005; Perry, 2005) have highlighted the importance of the ability to provide high-quality patient care. According to Perry (2005), nurses who believe they provide high-quality care and have a strong connection to patients are most satisfied with their career.

Patient care as a factor increasing job satisfaction includes the following aspects: a felt experience of providing good care, receiving personal praise from patients and their families, the joy of seeing patients get better and go home, the opportunity to be involved in major events and a sense of deep emotional and even spiritual reward for the

care given (McNeese-Smith, 1999). Similarly, Newman and Maylor's (2002) results indicate that nurses enjoy providing good patient care, meeting patients' needs, seeing them progress and receiving praise for their care. Good relationships with patients (Dunn et al., 2005; Jackson, 2005) and a strong and deep human connection with patients (Perry, 2005) seem to have a significant impact on job satisfaction. According to Perry (2005), this deep human connection with patients comes true by affirming the value of the person, defending dignity, enabling hope and helping patients to find meaning for their life in the illness experience.

Thirdly, regarding the organizing nursing work, Kacel, Miller, and Norris (2005) reveals the importance of intrinsic factors: nurse practitioners are most satisfied with intrinsic factors of their jobs and least satisfied with extrinsic factors. According to Smith, Hood, Waldman, and Smith (2005), satisfaction with compensation and benefits is not related to satisfaction setting, and they conclude that it is not just about the money. Despite the emphasis of internal factors, some studies have indicated that salary, benefits, and rewards do have a role in some cases (McNeese-Smith, 1999; Hampton & Hampton, 2004; Sparks, Corcoran, Nabors, & Hovanitz, 2005)

Studies have highlighted different predictors to be important for job satisfaction from the viewpoint of organizing nursing work, such as the work-family relationship (McNeese-Smith, 1999; Kovner et al., 2006) and working time (McNeese-Smith, 1999; Ruggiero, 2005). Other predictors of job satisfaction include a practice environment that enables nurses to fulfill their expectations (Smith et al., 2005), a balanced workload (McNeese-Smith, 1999; Adams & Bond, 2000), staffing levels on the ward, time available for doing one's work (Dunn et al., 2005), appropriateness of the system of

nursing being practiced (Adams & Bond, 2000), autonomy (Dunn et al., 2005; Kovner et al., 2006), variety of work, low organizational constraint, distributive justice (Kovner et al., 2006), work are leadership (Dunn et al., 2005) and especially supervisor support (Kovner et al., 2006). Studies (McNeese-Smith, 1999; Begat et al., 2005; Boyle et al.,2006; Kovner et al., 2006) have also revealed the importance of professionalism, professional status and professional development for job satisfaction. McNeese-Smith (1999) has found the following to be the main themes of professionalism: the centrality of nurses to patient care; opportunities for independent thinking; opportunities for input to the organization; opportunities for learning at a university medical centre and opportunities for professional growth.

## Summary and implications

Clearly, working with a surgical robot will not be a familiar experience for nurses at the introduction of new technology. To demystify the process of using robots in the workplace, this dissertation has been written to evaluate how the use of surgical robot would contribute to employee well-being and to find appropriate organizational support.

The five-stage model that Rogers (2003) suggested can give us guidelines about understanding the influence of innovation on an organization. Both the healthcare organization and employees are required to work out unique problems according to the specific innovation stage. It will be challenging to deal with the transition from “restructuring” to “clarifying,” because during the transition, organizations need to provide persuasive and concrete preparations for actual innovation. In fact, employees are likely to experience serious confusions during the transition, unless an organization

shows a reasonable roadmap to achieve innovation. This research explores the work-stress issue as one of the important obstacles that an organization would face in front of the innovation.

Currently, it is difficult to find previous research about the relationship between the use of robot and work stress or job satisfaction. For this reason, this research focuses on describing the nature of experience working with robots in terms of work stress and job satisfaction. Nevertheless, stress is not always harmful to employee's health and productivity. Rather, a certain amount of stress can stimulate human curiosity and creativity. The intention of discussing organizational stress lies in drawing a more accurate picture of human's working life with new technology. When people work with robots, organizations cannot help encountering the changes in intrinsic job characteristics, organizational roles, and relationships. In fact, observing the work stress or job satisfaction is one of the specific pathways to understand the changes in working life. This research is presumed to be a part of the puzzle grasping the effect of the technical innovation represented by the use of robots.

# Chapter 3: Methodology

## Introduction to the Delphi Method

The research questions for this study are as follows:

1. What are the key stressors of nurses working with a surgical robot?
2. What are the critical causes of job satisfaction of nurses working with a surgical robot?
3. When you consider both your opinion and average responses of all participants about the identified stressor/job satisfaction statements, what organizational interventions (support) should be provided to help nurses effectively work with a surgical robot?

To answer the above research questions, this research project used the Delphi method, a technique for the collection of opinions on a particular topic. The method is based on the premise that 'pooled intelligence' enhances individual judgment and captures the collective opinion of experts (Linstone & Turoff, 1975; Moore, 1987; Murry & Hammons, 1995; Jones, Sanderson, & Black, 1992).

The Delphi method makes use of consecutive surveys and the intuitive available information of the participants. Therefore, it delivers qualitative as well as quantitative results and has explorative, predictive, even normative elements. According to Okoli and Pawlowski (2004), forecasting and issue identification/prioritization represent one type of application of the method. The majority of the Delphi efforts during the first decade since its development were for pure forecasting, including both short- and long-range forecasts (Okoli & Pawlowski, 2004). Okoli and Pawlowski (2004) also mentioned that concept/framework development represents a second type of application of the Delphi

method. These study designs typically involve a two-step process, beginning with the identification/elaboration of a set of concepts followed by classification/taxonomy development (Okoli & Pawlowski, 2004). In addition, the Delphi method has a wide array of applications. Delphi is an expert survey consisting of two or more rounds; in the second and later rounds of the survey the results of the previous round are given as feedback. Therefore, the experts respond to the second round after referring to their colleagues' opinions experienced in the previous round. Thus, the Delphi method is a relatively strongly structured group communication process judged upon by experts (Murry & Hammons, 1995).

During the first phase, research questions are formulated and expanded upon in a set of assumptions, solutions, or options. Next, an expert panel is identified and invited to provide opinions. The responses are analyzed and ranked, using predetermined criteria for agreement and disagreement (4: Strongly agree; 1: Strongly disagree). A second questionnaire is developed using the results and feedback from the first round. Participants again record their opinions, which are collected and assessed for consensus (Jones & Hunter, 1995).

The Delphi method is flexible in that the research process is characterized as *bricolage*, which means "to use whatever resources and repertoire one has to perform whatever task one faces" (Okoli & Pawlowski, 2004). In other words, improvisation and opportunism are inherent in the Delphi research process. Besides, it is a method for structuring a group communication process to facilitate a group process so that the process effectively allows a group of individuals, as a whole, to address a complex problem (Linstone & Turoff, 1975). The method can also be used as a judgment,

decision-aiding, or forecasting tool (Rowe & Wright, 1999), and can be applied to program planning and administration (Delbeq, Van de Van, & Gustafson, 1975). The Delphi method can be used when there is incomplete knowledge about a problem or phenomenon (Adler & Ziglio, 1996; Delbeq et al., 1975). The method can be applied to problems that do not lend themselves to precise analytical techniques, but rather could benefit from the subjective judgments of individuals on a collective basis (Adler & Ziglio, 1996), and it can focus the collective human intelligence of such individuals on the problem at hand (Linstone & Turoff, 1975). The Delphi is also used to investigate issues that do not yet exist (Czinkota & Ronkainen, 1997).

In fact, the Delphi method is an adaptable research method used in many research arenas, including public health care (Adler & Ziglio, 1996), educational research (Broadly, 1998; Hunter, 2004), and business research (Olshfski & Joseph, 1991; Thach & Murphy, 1995). The Delphi method has been widely used in curriculum design and business strategy evaluation (Linstone & Turoff, 1975; Olshfski & Joseph, 1991; Wang, 2000).

Linstone and Turoff (1975) identified the following reasons why a research project would choose the Delphi method:

1. The research problem does not lend itself to precise analytical techniques but can benefit from subjective judgment on a collective basis;

2. The research population may present diverse backgrounds with respect to experience or expertise;

3. More subjects are needed than can effectively interact in a face-to-face exchange;

4. Time, cost, and logistics would make frequent meetings of all the subjects unfeasible;

5. The efficiency of face-to-face meetings can be increased by a supplemental group communication process;

6. Disagreements among individuals are so severe or politically unpalatable that the communication process must be refereed and/or anonymity assured;

7. The heterogeneity of the participants must be preserved to assure validity of the results, i.e., avoidance of domination by quantity or by strength of personality;

The above reasons are related to the strengths of the Delphi method. One of the main advantages of the Delphi method is its ability to guide a group opinion toward a final decision. This tendency to converge toward agreement is a unique aspect of the Delphi method (Sackman, 1975; Loughlin & Moore, 1979; Lyons, 1981) and a property considered to be of particular importance to the future of knowledge and policy development. According to Helmer (1983), one of the advantages of the Delphi technique is that the expert participants are more likely to generate reasoned, independent, and well-considered opinions in the absence of exposure to the persuasively stated opinions of others. Furthermore, participating in a Delphi research can be a highly motivating experience for participants because the feedback mechanism, in which relevant material is returned to the panel members, can be a novel and interesting exercise for all concerned (McKenna, 1994).

In other words, the main advantage of the Delphi is reported to be the achievement of consensus in a given area of uncertainty or given the lack of empirical evidence (Dawson & Barker, 1995). The feedback between rounds can widen knowledge

and stimulate new ideas and in itself can be highly educational for the participants (Stokes, 1997). Murphy, Black, Lamping, McKee, Sanderson, and Askham (1998) mentioned that Delphi participants bring a wide range of direct knowledge and experience to the decision-making processes.

Generally, the use of electronic communications can enhance the Delphi method in terms of costs, time, and effort (Fink, Kosecoff, Chassin, & Brook, 1984). It also enables a group of experts to be canvassed rapidly and inexpensively without geographical limitations, which makes it ideal for international research and cooperation. Experts may be drawn from a wide geographic area, and the participants' commitment in terms of time and money invested is minimal. Delbecq, Van de Ven, and Gustafson (1975) noted the advantage of the usual Delphi procedure of obtaining ideas in writing, as the act of writing forces participants to contemplate the subject thoughtfully and tends to produce a high volume of ideas. In addition, the Delphi method provides an advantage of no face-to-face meetings and anonymity. The committee-free environment and the anonymity of the Delphi method stimulate reflection and imagination while avoiding conflicts of personality and social pressure.

The Delphi process provides individual respondents with a considerable degree of freedom in the expression of their opinions on a topic, often offering the researchers new awareness of exploration (Villiers, Villiers, & Kent, 2005). Besides, unlike one-shot questionnaires, the Delphi method asks participants to reflect on the situation, to consult other members, or to refine their opinions (Linstone & Turoff, 1975). Because one-shot questionnaires are structured to yield quick responses, participants have no opportunity to re-evaluate their original answers in light of the group response. For this reason, the

Delphi study can provide the participants with an opportunity to relearn the phenomena by re-evaluating their original answers.

The Delphi method has been shown to be an effective way to conduct research when value judgments are sought rather than factual information (Dalkey & Rourke, 1972). To test the value of using Delphi procedures in obtaining non-factual data, Dalkey and Rourke (1972) conducted Delphi experiments in which university students were asked about the objectives of higher education. They concluded from the outcome of these experiments that Delphi procedures are appropriate for generating and assessing value material. Besides, Linstone and Turoff (1975) agreed that Delphi is a particularly useful for studies that call for subjective judgment rather than precise statistical analysis.

With the above advantages, the Delphi method also has some disadvantages. First, researchers using the Delphi method need to be considerate in the selection of experts. Goodman (1987) noted that researches should recruit individuals who have knowledge of a particular topic and who are consequently willing to engage in discussion upon it without the potentially misleading title of ‘expert’.

Second, the Delphi method is time consuming and takes an average of 45 days for the document exchanges to be completed (McKnight, Edwards, Pickard, Underwood, Voorgerg, & Woodcox, 1991). To achieve consensus and/or stability, a Delphi study has to involve several survey rounds and needs a longer period of time to complete.

In addition, Linstone and Turoff (1975) suggested the following as reasons for failure in the Delphi study:

1. Imposing preconceptions of a problem upon the respondent group by over-specifying the structure of the Delphi and not allowing for the contribution of

other perspectives related to the problem;

2. Assuming that the Delphi process can be a surrogate for all other human communications in a given situation;

3. Using poor techniques of summarizing and presenting the group response and ensuring common interpretations of the evaluation scales utilized in the exercise;

4. Ignoring and not exploring disagreements, so that discouraged dissenters drop out and an artificial consensus is generated;

5. Underestimating the demanding nature of a Delphi process and the fact that the respondents should be recognized as consultants and properly compensated for their time if the Delphi is not a part of their job function.

Linstone and Turoff (1975) further elaborated on the potential problems of Delphi studies with a checklist of eight pitfalls, which include discounting of the future, the prediction urge, the simplification urge, illusory expertise, sloppy execution, optimism-pessimism bias, overselling, and deception. To avoid these pitfalls, Delphi researchers must make sure that they are open-minded, not biased, and are willing to put the time into the study that it requires.

*Reliability and Validity*

Reliability is the extent to which a procedure produces similar results under constant conditions on all occasions. The Delphi process has been criticized because there is no guarantee that the same results will be obtained if the same information were given to two or more panels (Wiliams & Webb, 1978; Walker & Selfe, 1996). For the Delphi data to be reliable, it should be possible for the same results to be obtained from

multiple, similar, expert panels under similar contexts and conditions (Kastein, Jacobs, VanDerHell, & Touw-Otten, 1993). For example, Ono and Wedemeyer (1994) reported on the results of a study designed to replicate a Delphi study conducted 16 years earlier. They stated that the findings of the Delphi technique 16 years earlier reflected present findings, which were accurate in terms of forecasting communication developments. In fact, the Delphi technique was found to be more accurate when this research focused on forecasting and less accurate when the method was primarily utilized to discover facts (Kastein et al., 1993). Therefore, the Delphi technique was deemed to be appropriate to find facts in the situation selected for this research.

On the other hand, Lincoln and Guba's (1985) criteria for qualitative studies could be applied to help ensure that credible interpretations of the findings are produced. The criteria are based on four major issues, namely, credibility (truthfulness), fittingness (applicability), auditability (consistency), and confirmability.

The Delphi process is based upon the assumption of safety in numbers (i.e., several people are less likely than a single individual to arrive at a wrong decision). Decisions are then strengthened by reasoned argument in which assumptions are challenged, thus helping to enhance validity. Threats to validity result principally from pressures for convergence of predictions (Hill & Fowles, 1975), which undermine the Delphi's forecasting ability. Regarding validity, Goodman (1987) stated that the researcher can have no influence in any of the development stages of the survey, which could have implications for face validity. Goodman (1987) also stated that the use of participants who have knowledge and an interest in the topic may help increase the content validity of Delphi. In addition, the use of successive rounds of the questionnaire

helps increase the concurrent validity. According to Linstone and Turoff (1975), the use of multiple iterations, a structured response analysis, statistical consensus, and a feedback loop to expert panel members all support maximizing validity. Nonetheless, the validity of results will be affected by the response rate.

## Rationale for the Classical Delphi Method

There are four types of Delphi process, namely, classical, policy, decision, and group (Zolingen & Klaassen, 2003). Each of these methods has its advantages as well as disadvantages. In this section, the researcher will explain each type of Delphi and will discuss the best fit between this research and the classical Delphi.

### *Classical Delphi*

The main characteristics of classical Delphi are anonymity, iteration, controlled feedback, statistical group response, and stability in response. In the classical Delphi, every expert fills out the questionnaire independently, without influence from social pressure. In addition, the questionnaire is submitted multiple times, enabling the experts to revise their opinions in a number of rounds. Controlled feedback is given to each respondent from the second round, and each participant is informed of the other participants' views in the first round of the study. The controlled feedback refers to the process whereby the exchange of information between the experts is not free but is carried out by means of a study group coordinator, so that all irrelevant information is eliminated. Researchers can repeat the rounds until stability in responses is achieved. Finally, the group statistical response is acquired through the descriptive statistics in

which the experts express their opinion at the end of the procedure. The group statistical response means that all the opinions form part of the final answer. The questions are formulated so that the answers can be processed quantitatively and statistically.

In the classical Delphi, panels are composed of homogeneous expert groups with specific expertise related to the problem under investigation. Throughout the iterative process, there is interaction between researchers and the participants in the study, on the one hand, and among the participants themselves, on the other. The participants are no longer respondents who merely answer questions and the researcher is no longer just a neutral listener (Fache, 1993).

*Policy Delphi*

Policy Delphi is widely used with social and political issues because it is used as an instrument for policy development and involves obtaining as many divergent opinions as possible (Fache, 1993). Policy Delphi is characterized by selective anonymity, iteration, controlled feedback, polarized group response, and structured conflict. In this Delphi, participants individually answer the questionnaires and, subsequently, they exchange opinions in a group meeting. In other words, the process is only anonymous until the group meeting. To allow for any extreme opinions to stand out, a polarized group response is fed back to individual participants in several rounds. The structured conflict refers to a situation in which divergent opinions are discussed in the group meeting, enabling certain policy alternatives to be generated for an issue. The distinctive characteristic of policy Delphi is the use of heterogeneous groups. To discuss as diverse ideas/opinions about the problem, people with different expertise and

experiences are involved with policy Delphi.

*Decision Delphi*

Decision Delphi has five characteristics: quasi-anonymity, iteration, controlled feedback, statistical group response, and stability. The main feature of decision Delphi is quasi-anonymity, under which participants know the other participants' names and are known to each other. On the other hand, their answers in the questionnaire remain anonymous. While decision Delphi is similar to classical Delphi, the goal of decision Delphi is to make a decision on social change related to society's capacity to organize human energies and productive resources.

*Group Delphi*

The key characteristics of group Delphi are as follows: a group meeting, iteration, controlled feedback, statistical group response, and stability in responses among the experts on a specific issue. In group Delphi, it is impossible to guarantee anonymity because participants have a face-to-face meeting. Researchers should be careful about the effect of social pressure in group Delphi during the process of managing participants.

*Rationale for using Classical Delphi*

In this research, the researcher utilized classical Delphi because it is believed to represent the best type of Delphi for answering the research questions. First, anonymity provides an equal chance for each panel member to present and react to ideas unbiased by the identities of other participants (Goodman, 1987). Reactions are given

independently so each opinion carries the same weight and is given equal importance in the analysis. In this way subject bias is eliminated, as respondents are not known to each other (Goodman, 1987; Jeffery, Hache, & Lehr, 1995). This promise of anonymity facilitates respondents to be open and truthful about their views on certain issues, which in turn provides insightful data for the researcher. Furthermore, Couper (1984) suggested that this provides each participant with an opportunity to express an opinion to others without feeling pressured psychologically by the more influential panel members.

Second, acquiring consensus in responses will be helpful for this research because the goal of this research is to identify the critical issues and problems of working with a surgical robot. Unlike policy Delphi, it was not necessary in classical Delphi to elicit the structured conflict in this research project. Besides, rather than the polarized group response, the statistical group response is preferred because this research sought to identify the implications of work experience using a surgical robot.

Lastly, the selected experts were asked to fill out three successive rounds of questionnaires in the classical Delphi approach. Many Delphi theoreticians have found that repeated iteration of statements not only improves accuracy over rounds but also reduces judgment error (Critcher & Gladstone, 1998). In this research, the researcher also encouraged experts to comment on any item or to add statements to all three rounds of the questionnaire as they deemed appropriate or necessary.

## Research Procedure

As specified by Beech (1999), the Delphi stages used in this study were as follows:

1. Selection of panel (respondents) and allocation of identification numbers.

2. Construction and distribution of the first questionnaire (Round One). Completion and return of the Round One questionnaire.

3. Collection and categorization of suggestions and construction of the second questionnaire (Round Two).

4. Distribution of the second questionnaire (Round Two). Completion and return of the Round Two questionnaire.

5. Collection and analysis of individual and group scores for each suggestion.

6. Possible further rounds of voting and possible request for rationale and comments for more extreme scores.

7. Achievement of group consensus with calculation of summary statistics: maximum, minimum, and range of scores for each suggestion.

8. Construction of the third questionnaire (Round Three), which is similar to the Round Two questionnaire but with group scores for each suggestion from Round Two incorporated.

9. Distribution of the third questionnaire (Round Three). Completion and return of the Round Three questionnaire.

10. Collection and analysis of each suggestion.

In this research, the researcher utilized modified Beech's (1999) stages. Because the group reached consensus at the second round, the second round was not repeated and the researcher directly collected answers to the third research question. In fact, steps may indeed vary from the general suggestions according to the unique characteristics of the

research. For example, Whilhelm (2001) stated that the first round is structured such that the topic is presented to the respondents for them to evaluate, elaborate, or otherwise comment on the topics with their individual concerns, insights, criticisms, or agreement.

Broady (1998) reported greatest consensus movement during first re-rating process (second round) of a Delphi study, but minimal additional consensus movement during the second re-rating process (third round). In another Delphi study, Wang (2000) reported that only 6 of 42 items changed consensus level during the first re-rating process and only 1 of the 42 items changed consensus level during second re-rating process. Dillman (2007) also suggested that surveying the same people many times may decrease the effectiveness of a survey. However, the design nature of this Delphi study involved the same people during multiple rounds. When the above facts were considered, it was concluded that three Delphi rounds were appropriate.

## Research Population: Panel Selection

### *Panel Size*

There has clearly been a wide variation in the numbers of participants in prior Delphi studies. A panel typically consists of 15 to 30 participants from the same discipline, or 5 to 10 per category from different professional groupings (Linstone & Turoff, 1975; Moore, 1987). Clayton (1997) also suggested that 15 to 30 experts are adequate when incorporating heterogeneous experts in the Delphi design. In this study, the researcher initially contacted 30 persons to achieve a Delphi group of 25 respondents.

The Delphi process does not call for expert panels to be representative samples for statistical purposes (Powell, 2002). According to Powell (2002), representativeness is

assessed on the qualities of the expert panel rather than by its numbers. On the other hand, confusion abounds in the nursing literature. Williams and Webb (1994), for example, criticized a number of Delphi studies for their lack of random samples.

In fact, the number of participants can vary according to the purpose of the study, its complexity, and resources. The literature suggests that the number of participants will vary according to the scope of the problem and the resources available (Fink, Kosecoff, Chassin, & Brook, 1991; Hasson, Keeney, & McKenna, 2000). Murphy et al. (1998) believed that the more participants there are the better, suggesting that as the number of judges increases, the reliability of a composite judgment increases.

*Qualifications of the Expert Panel*

The selection of members for a panel of experts is critical to a successful Delphi study. Key aspects include panel selection (including the experts' qualifications), number of members, and the participants' commitment levels. If the Delphi process is to be successful in achieving its objectives, it is important that expert panel members are willing and able to make valid contributions. In addition, Linstone and Turoff (1975) suggested that a diversity of viewpoints that span respectable controversy will help generate interest and involvement. Although agreeing with this to some extent, Jairath and Weinstein (1994) proposed that participants be experts who reflect current knowledge and perceptions, yet are relatively impartial to the findings.

Experts have been defined as members of a group of 'informed individuals' (McKenna, 1994), and as 'specialists' in their field (Goodman, 1987), or as persons who have knowledge about a specific subject (Lemmer, 1998). Often the selection of the

sample of ‘experts’ involves purposeful sampling strategies. Here participants are not selected randomly, so representativeness is not assured. Rather, they are selected for a purpose, to apply their knowledge to a certain problem on the basis of criteria developed from the nature of the problem under investigation. Purposive sampling is based on the assumptions that a researcher’s knowledge about the population can be used to handpick the cases to be included in the sample (Polit & Hungler, 1997). These assumptions are found on criteria, as Patton (1990) explains the logic of criterion sampling. Criterion sampling is one of the strategies of purposeful sampling. Criterion sampling involves the selection of cases that satisfy an important criterion.

In a Delphi study of evaluation guidelines for multimedia software, Gibbs, Graves, and Bernas (2001) used the following criteria to determine who should be selected and invited to participate: (a) participants who had published articles in the last five years on computer-based courseware design, development, or evaluation; (b) participants who had taught courses about these topics; and (c) participants whose primary employment responsibilities are related to these areas.

Although the above criteria are helpful in selecting experts, the researcher focused on the above criterion (c) because the research topic required the lively responses of nurses directly working with a surgical robot, rather than those of educators or researchers. In addition, because most nursing schools do not formally deal with robotic surgery in their curriculum at this time, it was hard to find nursing educators or researchers specializing in robotic surgery. Therefore, the panels of experts selected for this study were nurses equipped with clinical expertise related to robotic surgery.

Based on the above criterion, the researcher invited experts spanning a range of

hospitals. Before selecting the participants, the researcher sought advice on selecting hospitals from nursing experts experienced in surgical nursing. Next, the researcher gathered expert panels from South Korea. There are 28 da Vincis in South Korea, which has the most da Vincis in Asia (Kim, 2010). As of now, China has 15 da Vincis and Japan has 7 (Choi, 2010). Throughout the world, South Korea is ranked fifth in the number of robotic surgery equipment following the United States (1,028 da Vincis), Italy (45), Germany (33), and France (33) (Choi, 2010). The researcher was able to contact 28 Korean hospitals performing robotic surgery and subsequently collected members for the panel of experts.

## Development of the Research Instrument

### *First-Round Research Instrument*

At first, the titles of each category utilized in the first round of the Delphi survey were developed using the informal personal interviews with nurses as well as the related literature. For example, the key words, such as intrinsic job characteristic (new technology, workload), conflict with physicians, inadequate preparation, lack of support, conflict with other nurses, uncertainty concerning treatment, ability utilization when working with a robot, achievement/recognition, hospital policies and practices, compensation, co-workers, social service, social status, supervision, working conditions, and variety, were selected as the topic questions for each category in the first round. Next, a review of the literature discussed in the second chapter of this study regarding robotic surgery, Nursing Stress Scale (NSS), and Minnesota Satisfaction Scale (MSQ) were referred and were abstracted to develop the necessary survey statements regarding

the key cause of nurses' work stress and job satisfaction for input into this Delphi study.

Following development of the initial draft, a review of the survey questionnaire draft with the researcher's academic adviser and a professor in nursing school was conducted. The survey questionnaire draft was revised based upon their feedback to guarantee the correct implications of the statements. Once the changes and improvements to the draft survey questionnaire were made and approved by the researcher's academic adviser and university IRB, the survey questions were emailed to the participants. The purpose of the first-round survey was to generate and to rate the key stressors and job satisfaction of nurses working with a surgical robot. The first-round survey questionnaire was a mix of open-ended and close-ended questions, because it was necessary to obtain both the participants' responses to the developed questionnaires and their ideas for the second-round survey statements. See Appendix A for survey questions that were utilized in the first round of this survey.

*Second-Round Research Instrument*

The responses to the open-ended questions on the survey questionnaire in the first round were coded into concepts and categories. The coding process was conducted by reading each of the questionnaire documents and attributing a code (identifying document as a concept or a category) to the sentences. The concept or category was constantly reread after initial coding, until the researcher concluded that no new concepts were emerging. These themes or categories were used to generate statements. The statements were edited to a manageable summary of items that were identified as the key stressors or job satisfaction of nurses working with a surgical robot. These key

stressors and the causes of job satisfaction became the basis of the surveys utilized in the second- and third-round survey questionnaires.

The final second-round survey questionnaire included 7 groups of stressors and 10 groups of job satisfaction. The purpose of the second-round survey was to rate the degree of agreement on key stressors and job satisfaction based on a four-point Likert-type rating scale (Strongly Disagree (1), Disagree (2), Agree (3), Strongly Agree (4). Additional space was provided to the panel members at the end of each section for any justifications why his/her rating for the second round was not the most frequent response. Appendix B includes survey questions that were utilized in the second round of this study.

*Third-Round Research Instrument*

The third round of the survey required participants to provide their opinions about the organizational support to help nurses effectively work with a surgical robot. After participants reviewed the average response of each statement, they were asked to comment on the necessary organizational support. See Appendix C for survey questions.

## Data Collection and Analysis

During this research, the researcher first contacted the HRD departments of the Korean hospitals performing robotic surgery. Through the HRD department, the researcher asked for assistance from each hospital's nursing department. Each research participant was contacted via email to confirm whether he or she would join this study. Invited research participants utilized email to express their opinions. The survey was

sent out to participants as a Word attachment via email. Respondents were asked to return the survey by email, fax, or postal mail. Throughout three rounds, each respondent received three to four invitations requesting a survey response and one additional email thanking the respondent if he or she participated. The response deadline for the data collection for each round was 10 days to 2 weeks. After 10 days, a follow-up email was sent to non-responding experts.

*Data Collection: Round 1*

The first-round steps were as follows:

1. Develop research questionnaire for the first round including open-ended and close-ended questions;
2. Conduct the first-round survey;
3. Collect and analyze the data;
4. Summarize and report the findings;
5. Generate key stressors and job satisfaction of nurses working with a surgical robot.

The first round was conducted in September and October of 2010. The survey emails were sent out to 32 participants, and a total of 30 (93%) completed the survey by October 31st. It took approximately four weeks to receive all the survey responses from the panel members. The 30 participants who completed this round received a thank-you email as soon as the researcher received their returned survey response.

During the first round, each panel member received an email containing the following: (a) a cover letter for participation explaining the procedure being used in the

Delphi study and assuring confidentiality; (b) a survey attached as a Word document; (c) the estimated time to complete the survey; and (d) the due date for returning the survey. These items are appended at the end of this document. The participants were asked to return the first-round survey no later than 10 days from the date the email was sent. A second reminder email message containing another copy of the survey was sent to those participants who had not completed the survey by the day before the due date. Another reminder email message was repeated once a week to the participants who did not complete the survey by the due date, with an indication that the due date had been extended.

The first part of the first-round instrument asked participants to rate the agreement of each statement indentified in the literature review. The second part of the instrument requested participants to make additional comments to be included for rating in the second round in the Delphi. In addition, participants could comment on any of the items in each section. This was designed to help improve the clarity and scope of the second round of the study. Finally, panelists were asked to provide additional statements and their detailed descriptions for rating in subsequent rounds of the Delphi.

*Data Collection: Round Two*

The second-round steps were as follows:

1. Develop the research questionnaire for the second round, which included a Likert-type survey scale (1-4) for agreement rating;
2. Conduct the second-round survey;
3. Collect and analyze the data;

4. Summarize the findings.

The second round was conducted from late October to early December of 2010. The email announcing availability of the survey was sent on October 25th to all 30 participants who completed the first round. All 30 panel members (100%) completed the second round of the survey. Each participant who completed this round received a thank-you email as soon as the researcher received the second-round survey response. It took approximately four weeks to receive all second survey responses.

During the second round, each panel member received an email that contained the following: (a) a cover letter for participation explaining the procedure being used in the second round and assuring confidentiality; (b) a survey attached as a Word document; (c) the estimated time to complete the survey; and (d) the due date for returning the survey. The participants were asked to return the second-round survey no later than two weeks from when the first request was sent. An email reminder message containing the survey attached as a Word document was sent to participants who failed to complete the survey a day before the due date. The same email reminder message was repeated once a week to the participants who did not complete the survey by the due date, with an indication that the due date had been extended and the survey was still ongoing.

Panel members were asked to rate their degree of agreement with each key stressor and job satisfaction using a four-point Likert-type rating scale: Strongly Disagree (1), Disagree (2), Agree (3), Strongly Agree (4). Additional space was provided at the end of each section for clarifying the participant's reasons if the rating for this round was not the most frequent response for any of the key stressors or job satisfaction.

The Delphi panel members were provided with the statistical results from the

first round arranged from the highest to the lowest levels of consensus. To reach consensus, respondents had an opportunity to reconsider their initial ratings and were asked to indicate the level of consensus based on a four-point Likert-type scale: Strongly Disagree (1), Disagree (2), Agree (3), Strongly agree (4). All participants could move their ratings toward consensus or could provide a reason of modification.

All data from the returned questionnaires were summarized. With the number of respondents to each statement, the mean, standard deviation, and interquartile deviation (IQD) of the each key stressor and job satisfaction were computed because the Delphi process required measures of central tendency and variability. In addition, the number of respondents who added written comments and the percent of respondents for each statement who added comments were computed. The third-round survey questionnaire was developed on the results of the second round.

*Data Collection: Round Three*

The third-round steps were as follows:

1. Utilize feedback obtained in the second round to develop the third-round research questionnaire;
2. Conduct the third-round survey;
3. Collect and analyze the data;
4. Summarize the Delphi findings.

The purpose of the final round was to collect opinions about organizational support in terms of the stressors and job satisfaction of nurses working with a surgical robot. During the third round, each panel member who completed the second-round

survey received an email that contained the following: (a) a cover letter for participation explaining the procedure being used in the third round and assuring confidentiality; (b) a survey attached as a Word document; (c) the estimated time to complete the survey; and (d) the due date for returning the survey. Participants were asked to return the third-round survey no later than three weeks from when the email was sent. One day prior to the due date, a short reminder email message containing the survey attached as a Word document was sent to the participants who had not yet completed the survey. The same email reminder message was sent to the participants who had not completed the survey by the due date, with an indication that the due date had been extended and the survey was still ongoing. At the end of the round, a gift for participation and a thank-you note were mailed to the participants who completed all three rounds.

During the third round, the researcher sent emails to participants to ask what organizational intervention (support) is needed for nurses working with a surgical robot. If respondents agreed with the key stressors or the causes of job satisfaction, they could think about the ways of resolving conflicts and facilitating changes. For this reason, they were asked to respond with a list of desired organizational support. Specifically, the experts were required to answer the following question:

1. When you consider both your opinion and average responses of all participants about the identified stressor/job satisfaction statements, what organizational interventions (support) should be provided to help nurses effectively work with a surgical robot?

Responses were analyzed by qualitative data analysis using themes and

categories.

*Data Analysis*

In the first round, the data obtained from the open-ended questions during the generation of the key components were summarized and coded into themes and categories. The coding process was conducted by reading each of the questionnaire documents and attributing a code to the sentences, paragraphs, or sections. Each theme or category was constantly revisited after initial coding until it was clear that no new themes were emerging. These themes or categories were used to generate new statements. The statements were edited to a manageable summary of items that were identified as the key stressors or job satisfaction of nurses working with a surgical robot. These statements were added in the second survey questionnaire. In addition, the responses from the third round were analyzed by the same data analysis method.

The above data analysis was founded on the grounded theory. A grounded theory consists of plausible relationships (Strauss & Corbin, 1990) among sets of concepts, which are directly developed from data analysis. Theory, in this sense, provides a set of testable propositions that help us understand our social world more clearly, rather than absolute truths. The appeal of grounded theory analysis is the structured and detailed procedures for the generation of a theory from data.

In terms of analyzing the qualitative data generated, at the heart of grounded theory is the idea of the constant comparative method. In this method, concepts or categories emerging from one state of the data analysis are compared with concepts emerging from the next. The researcher looks for relationships between these concepts

and categories, by constantly comparing them, to form the basis of the emerging theory. The researcher continues with this process of constant comparison until what is called 'theoretical saturation' is reached, that is, no new significant categories or concepts are emerging. In terms of the process of doing grounded theory analysis, the researcher typically goes through several procedures. These are not linear stages; rather, the process of grounded theory is cumulative and can involve frequent revisiting of data in the light of new analytical ideas that emerge as data collection and analysis progresses (Strauss & Corbin, 1990):

1. Open coding (initial familiarization with the data)
2. Delineation of emergent concepts
3. Conceptual coding (using emergent concepts)
4. Refinement of conceptual coding schemes
5. Clustering of concepts to form analytical categories
6. Searching for core categories
7. Core categories lead to identification of core theory

Member checking was applied to assess data trustworthiness. Phone calls and emails were utilized to check with panel members for clarification of words and meanings. During member checking, the researcher shared interpretations of the data with participants to eliminate miscommunication, identify inaccuracies, and help obtain additional useful data. The member checking process allowed the participants to review and critique the researcher's interpretations of the returned questionnaire for accuracy and meaning.

With the stressors and job satisfaction statements, a four-point Likert-type scale

was developed. The specific range scale included the following descriptors: Strongly disagree (1), Disagree (2), Agree (3), Strongly Agree (4). At the last moment of the second round, statistical means, standard deviation, and IQD were calculated to determine the level of consensus achieved for each item. Quantitative data, including interquartile deviation (IQD), mean, median, mode, standard deviation, and percentage of the key stressor/job satisfaction, were analyzed using Microsoft Excel 2003 and SPSS 16.0 for Windows.

Delphi researchers frequently use IQD as a common indication for determining consensus level. IQD refers to the difference between the 75th and the 25th percentiles of responses for a variable. In general, an IQD score for an item of 0.00 or less indicates consensus. Besides, lower IQD scores indicate a greater degree of consensus. In the Delphi study utilizing a four-point Likert rating scale, the consensus level for rating of the key stressor/job satisfaction was defined as follows: (a) an IQD of a key stressor/job satisfaction that is equal to zero was defined as having achieved a high level of consensus; (b) an IQD of a key stressor/job satisfaction that is 0.50 was defined as having achieved a medium level of consensus; (c) an IQD of a key stressor/job satisfaction that is 1.00 or higher was defined as having achieved a low level of consensus.

## Summary

This chapter provided a detailed description of this study's research methodology. The Delphi method was employed to identify the critical stressors and the key causes of job satisfaction of nurses working with a surgical robot. The panel of experts was made

up of purposefully selected nurses having expertise in robotic surgery. Throughout three rounds, participants expressed their opinions and built up consensus about the critical stressors and job satisfaction of nurses working with a surgical robot. Based on their responses to the open-ended questions, desirable organizational supports for nurses were identified.

# Chapter 4: Findings

This chapter presents the findings obtained through the modified Delphi technique employed for the purpose of this research, which was to identify and achieve consensus on nurses' key stressors and their key causes of job satisfaction when they work with a surgical robot. In addition, based on the responses of participants, appropriate organizational interventions were identified. The following research questions were asked to achieve the objective:

1. What are the key stressors of nurses working with a surgical robot?
2. What are the critical causes of job satisfaction of nurses working with a surgical robot?
3. When you consider both your opinion and the average response of all participants on the identified stressor/job satisfaction statements, what organizational support should be provided to help nurses effectively work with a surgical robot?

## *Research Question One*

*Delphi Round One Data.* During this round of this Delphi study, panel members were requested to rate all statements presented by applying a four-point Likert-type scale (see Appendix A. Consensus was achieved on 31 items (90%). Table 1 presents consensus data by category which comes from the first round instrument. During this round, the highest level of consensus was achieved by the categories *New Technology* (100%), *Workload* (100%), *Conflict with Physicians* (100%), and *Inadequate Preparation* (100%). The category *Conflict with Other Nurses* achieved consensus on

four of five items. Item categories *Uncertainty Concerning Treatment* (75%) and *Lack of Support* (67%) achieved the lowest level of consensus during this round.

Table 1

Delphi Round One Consensus Data by Category

| Category | Total Items | Consensus Items | % |
|---|---|---|---|
| Intrinsic Job Characteristics: New Technology | 6 | 6 | 100 |
| Intrinsic Job Characteristics: Workload | 5 | 5 | 100 |
| Conflict with Physicians | 5 | 5 | 100 |
| Inadequate Preparation | 3 | 3 | 100 |
| Conflict with Other Nurses | 5 | 4 | 80 |
| Uncertainty concerning Treatment | 4 | 3 | 75 |
| Lack of Support | 3 | 2 | 67 |
| Total Items | 31 | 28 | 90 |

Table 2 shows the number of respondents who added written comments for each category and the percentage of respondents for each category who added comments. The category *New Technology* gained the most comments (20%) from respondents. Respondents also added many comments to *Workload* (13%) and *Conflict with Physicians* (13%). The category *Inadequate Preparation* (3%) and *Lack of Support* (3%) obtained a few comments, while respondents did not add any comments to *Conflict with other Nurses* (0%) and *Uncertainty Concerning Treatment* (0%).

*Round One Participant Comments*. The researcher extracted most frequent mentioned items from participants' comments and these were added in the second round:

1. Need to be extra careful when dealing with a very expensive Da Vinci

2. Working overtime
3. When nurses have to do the work of doctors in robotic surgery
4. When the Da Vinci is not working well, nurses shoulder the responsibility to make it work.
5. Nurses who do not participate in robotic surgery do not understand our stress.

Table 2

Respondents Adding Comments by Category: Round One

| Category | Total Items | Respondents Adding Comments | |
|---|---|---|---|
| | | No. | % |
| Intrinsic Job Characteristics: New Technology | 6 | 6 | 20 |
| Intrinsic Job Characteristics: Workload | 5 | 4 | 13 |
| Conflict with Physicians | 5 | 4 | 13 |
| Inadequate Preparation | 3 | 1 | 3 |
| Lack of Support | 3 | 1 | 3 |
| Conflict with Other Nurses | 5 | 0 | 0 |
| Uncertainty concerning Treatment | 4 | 0 | 0 |

*Delphi Round Two Data.* During this round, panel members were requested to rate all statements presented by applying a four-point Likert-type scale (see Appendix B). Consensus was achieved on 36 items (100%). Table 3 presents consensus data by category representing the discrete items.

Table 4 shows the number of respondents who added written comments for each category and the percentage of respondents for each category who added comments. The categories *New Technology* and *Workload* gained the most comments (27%) from respondents. Respondents also added many comments to *Inadequate Preparation* (20%) and *Conflict with Physicians* (10%). The categories *Lack of Support* (7%) and *Conflict*

*with other Nurses* (7%) obtained a few comments, while respondents added the least comments to *Uncertainty Concerning Treatment* (3%).

Table 3

Delphi Round Two Consensus Data by Category

| Category | Total Items | Consensus Items | % |
|---|---|---|---|
| Intrinsic Job Characteristics: | | | |
| New Technology | 7 | 7 | 100 |
| Intrinsic Job Characteristics: Workload | 6 | 6 | 100 |
| Conflict with Physicians | 7 | 7 | 100 |
| Inadequate Preparation | 3 | 3 | 100 |
| Lack of Support | 4 | 4 | 100 |
| Conflict with Other Nurses | 5 | 5 | 100 |
| Uncertainty concerning Treatment | 4 | 4 | 100 |
| Total Items | 36 | 36 | |

Table 4

Respondents Adding Comments by Category: Round Two

| Category | Total Items | Respondents Adding Comments No. | % |
|---|---|---|---|
| Intrinsic Job Characteristics: | | | |
| New Technology | 7 | 8 | 27 |
| Intrinsic Job Characteristics: Workload | 6 | 8 | 27 |
| Inadequate Preparation | 3 | 6 | 20 |
| Conflict with Physicians | 7 | 3 | 10 |
| Lack of Support | 4 | 2 | 7 |
| Conflict with Other Nurses | 5 | 2 | 7 |
| Uncertainty concerning Treatment | 4 | 1 | 3 |

Table 5

Conflict with a Physician by Mean Rating

| Item | Conflict with Physician Statement | IQD | $\bar{x}$ | SD |
|---|---|---|---|---|
| 3b | Criticism by a physician | 0.5 | 3.70 | .54 |
| 3g | When Da Vinci is not working well, nurses undertake responsibility to make it work | 0.5 | 3.40 | .68 |
| 3f | When nurses have to do doctors' work in robotic surgery | 0.5 | 3.23 | .68 |
| 3a | Conflict with a physician | 0 | 3.03 | .41 |
| 3d | Fear of making a mistake in treating a patient | 0 | 2.93 | .37 |
| 3c | Disagreement concerning the treatment of a patient | 0 | 2.90 | .31 |
| 3e | Making a decision concerning a patient when the physician is unavailable | 0 | 2.87 | .51 |

(N = 7)

Table 6

Intrinsic Job Characteristics (New Technology) by Mean Rating

| Item | New Technology Statement | IQD | $\bar{x}$ | SD |
|---|---|---|---|---|
| 1g | Need to be extra careful when dealing with very expensive Da Vinci | 0.5 | 3.30 | .60 |
| 1f | Unexpected events in the operation and functioning of Da Vinci system | 0 | 3.17 | .53 |
| 1b | Dealing with emergency procedures if the system malfunctions or the power goes out | 0 | 3.13 | .51 |
| 1c | Cleaning and sterilizing the robotic instruments and cleaning the nonsterile equipment | 0 | 2.97 | .24 |
| 1d | Troubleshooting error messages | 0 | 2.97 | .41 |
| 1e | Positioning the patient and equipment safely | 0 | 2.90 | .40 |
| 1a | Preparing the Da Vinci system before surgery | 0.5 | 2.63 | .49 |

(N = 7)

The experts agreed that new technology as an intrinsic job characteristic would result in stress among nurses. Table 6 indicates that three of the items achieved a mean rating of 3 or higher on a scale of 4. Three other items are close to a mean rating of 3, indicating that experts tend to agree that new technology is an important stressor for

nurses working with a surgical robot.

Table 7

Intrinsic Job Characteristics (Workload) by Mean Rating

| Item | Workload Statement | IQD | $\bar{x}$ | SD |
|---|---|---|---|---|
| 2f | Working overtime | 0 | 3.17 | .53 |
| 2e | Not enough staff to adequately cover the unit where I work | 0 | 3.03 | .32 |
| 2d | Not enough time to complete all of my nursing tasks | 0 | 2.97 | .32 |
| 2b | Too many non-nursing tasks required such as clerical work | 0 | 2.90 | .40 |
| 2a | Unpredictable staffing and scheduling | 0 | 2.83 | .53 |
| 2c | Not enough time to provide emotional support to a patient | 0.5 | 2.30 | .54 |

(N = 6)

Items under the broad category of *Intrinsic Job Characteristics (Workload)* indicate support for working overtime through a mean rating of 3.17, followed by item 2e, not having enough staff to adequately cover the unit where they work, achieving ratings above 3/4 mean rating. The lowest mean rating was item 2c, not having enough time to provide emotional support to a patient, which achieved a 2.30 rating as indicated by Table 7.

Table 8 supports the contention that conflict with other nurses is an important stressor for nurses. The highest rated item was item 6d, criticism by a supervisor, with a mean rating of 3.13, followed by item 6c, conflict with a nurse supervisor ($\bar{x}$ = 3.03). Although all other items were rated as disagree, their mean ratings are close to 3.00. This category also had the highest level of consensus based on interquartile range. This result supports the position that there is high level of agreement among experts that conflict

with other nurses is a critical stressor.

Table 8

Conflict with Other Nurses by Mean Rating

| Item | Conflict with Other Nurses Statement | IQD | $\bar{x}$ | SD |
|---|---|---|---|---|
| 6d | Criticism by a supervisor | 0 | 3.13 | .43 |
| 6a | Conflict with a nurse supervisor | 0 | 3.03 | .41 |
| 6e | Difficulty in working with a particular nurse (or nurses) on the unit | 0 | 2.87 | .51 |
| 6b | Floating to other units that are short-staffed | 0 | 2.83 | .53 |
| 6c | Difficulty in working with a particular nurse (or nurses) outside the unit | 0 | 2.80 | .48 |

(N = 5)

Table 9

Uncertainty concerning Treatment by Mean Rating

| Item | Uncertainty concerning Treatment Statement | IQD | $\bar{x}$ | SD |
|---|---|---|---|---|
| 7c | A physician not being present in a medical emergency | 0 | 3.13 | .43 |
| 7a | Inadequate information from a physician regarding the medical condition of a patient | 0 | 3.00 | 0 |
| 7b | A physician ordering what appears to be inappropriate treatment for a patient | 0 | 2.90 | .31 |
| 7d | Not knowing what a patient or a patient's family ought to be told about the patient's condition and its treatment | 0.5 | 2.57 | .57 |

(N = 4)

Table 9 presents the *Uncertainty Concerning Treatment* category. Expert panel members indicate their being stressed out due to the uncertainty concerning treatment. While the absence of a physician (item 7c) produced high agreement (3.13), not knowing what a patient or a patient's family ought to be told about the patient's condition and its treatment (item 7d) was rated lower than any other stressors across all

categories (2.57). Inadequate information from a physician regarding the medical condition of a patient was also rated 3.00, with high consensus among experts (IQD = 0)

Table 10 presents the item category *Lack of Support*. The experts did not tend to agree on lack of support as an important stressor, except for the item regarding nurses who do not participate in robotic surgery not understanding their stress (item 5d). The experts tended to agree that they were likely to be stressed out because of the misunderstanding of nurses who do not participate in robotic surgeries. On the other hand, nurses thought that they could freely share their experiences in the unit.

Table 10

Lack of Support by Mean Rating

| Item | Lack of Support Statement | IQD | $\bar{x}$ | SD |
|---|---|---|---|---|
| 5d | Nurses who are not participating in robotic surgery do not understand our stress | 0 | 3.07 | .58 |
| 5b | Lack of an opportunity to share experiences and feelings with other personnel on the unit | 0 | 2.17 | .46 |
| 5a | Lack of an opportunity to talk openly with other unit personnel about problems on the unit | 0 | 2.10 | .40 |
| 5c | Lack of an opportunity to express to other personnel on the unit my negative feelings toward patients | 0 | 2.10 | .40 |

(N = 4)

Regarding the *Inadequate Emotional Preparation* category, the experts disagreed that the category is an important stressor (Table 11) because nurses in an operating room have few opportunities to emotionally contact patients. The mean ratings of all items were below 3, with high consensus among the experts (IQD = 0).

Table 11

Inadequate Emotional Preparation by Mean Rating

| Item | Inadequate Emotional Preparation Statement | IQD | $\bar{x}$ | SD |
|---|---|---|---|---|
| 4c | Being asked a question by a patient for which I do not have a satisfactory answer | 0.5 | 2.30 | .54 |
| 4b | Feeling inadequately prepared to help with the emotional needs of a patient | 0 | 2.10 | .40 |
| 4a | Feeling inadequately prepared to help with the emotional needs of a patient's family | 0 | 2.07 | .37 |

(N = 3)

*Consensus Levels of the Stressors in the First and Second Rounds.* In this Delphi study, the consensus levels of the stressors were defined as follows: (a) an IQD of a stressor equal to zero was defined as having achieved a high level of consensus; (b) an IQD of a stressor of 0.50 was defined as having achieved a medium level of consensus; (c) an IQD of a stressor of 1.00 or higher was defined as having achieved a low level of consensus. Table 12 summarizes the IQD of the stressors in the first round and the second rounds.

As shown in Table 12, the IQD of 20 of the 31 stressors decreased from the first round to second round, which means an increase in consensus. The decreases in IQD resulted in higher consensus levels of 20 stressors. These consensus level changes include 18 stressors moving from medium consensus to high consensus and one stressor moving from low consensus to high consensus. However, the consensus level of one stressor did not change during re-rating in the second round (3b: Criticism by a physician).

Table 12

Degree of Consensus Level of Items Sorted by Mean Rating

| Item | Statements | First Round | | | Second Round | | |
|---|---|---|---|---|---|---|---|
| | | $\bar{x}$ | IQD | Consensus Level | $\bar{x}$ | IQD | Consensus Level |
| 3b | Criticism by a physician | 3.57 | 0.5 | Medium | 3.70 | 0.5 | Medium |
| 3g | When the Da Vinci is not working well, nurses undertake responsibility to make it work | | | | 3.40 | 0.5 | Medium |
| 1g | Need to be extra careful when dealing with very expensive Da Vinci | | | | 3.30 | 0.5 | Medium |
| 3f | When nurses have to do doctors' work in robotic surgery | | | | 3.23 | 0.5 | Medium |
| 1f | Unexpected events in the operation and functioning of Da Vinci system | 3.30 | 0.5 | Medium | 3.17 | 0 | High |
| 2f | Working overtime | | | | 3.17 | 0 | High |
| 1b | Dealing with emergency procedures if the system malfunctions or the power goes out | 3.37 | 0.5 | Medium | 3.13 | 0 | High |
| 6d | Criticism by a supervisor | 3.27 | 0.5 | Medium | 3.13 | 0 | High |
| 7c | A physician not being present in a medical emergency | 3.03 | 0.6 | Medium | 3.13 | 0 | High |
| 5d | Nurses who are not participating in robotic surgery do not understand our stress | | | | 3.07 | 0 | High |
| 2e | Not enough staff to adequately cover the unit where I work | 3.13 | 0.5 | Medium | 3.03 | 0 | High |
| 3a | Conflict with a physician | 3.27 | 0.5 | Medium | 3.03 | 0 | High |
| 6a | Conflict with a nurse supervisor | 3.13 | 0.1 | High | 3.03 | 0 | High |
| 7a | Inadequate information from a physician regarding the medical condition of a patient | 2.93 | 0 | High | 3.00 | 0 | High |

The IQD of the other 11 stressors did not change between the first and the second round. Therefore, their consensus levels of the key stressors did not change during re-rating in the second round.

Of the 31 stressors, 19 changed their consensus levels between the first and the second round. Thus, 61% of the stressors did not change their consensus levels during re-rating in the second round.

As also shown in Table 12, five new stressors were generated in the first round. Two of the five stressors (2f, 5d) generated from the second round reached a high consensus level; the other three stressors (1g, 3f, 3g) reached a medium consensus level.

Overall, based on the IQD at the end of this study, the *Conflict with Physician* category had four stressors reaching high consensus level and three stressors reaching medium consensus level. The *Intrinsic Job Characteristics (New Technology)* category had five stressors reaching high consensus level and two stressors reaching medium consensus level. Another *Intrinsic Job Characteristic (Workload)* category had five stressors reaching high consensus level and one stressor reaching medium consensus level. The *Uncertainty concerning Treatment* category had three stressors reaching high consensus level and one stressor reaching medium consensus level. The *Lack of Support* category had four stressors reaching high consensus level and no stressor reaching medium or low consensus level. The *Inadequate Preparation* category had two stressors reaching high consensus level and one stressor reaching medium consensus level.

*Summary.* As shown in Table 13, 10 stressors that had a high mean reached a high consensus level. Four other stressors reached medium consensus level with high mean. In conclusion, these 14 stressors can be considered critical for nurses working with a

surgical robot. Table 14 summarizes the mean rating of the grouped stressors at the second round.

Table 13

Combinations of Mean Rating and Consensus Level of the key stressors at the End of Second Round

| Consensus | Mean Rating | |
|---|---|---|
| | No. of Items (MN≥3) | No. of Items (MN< 3) |
| High | 10 | 18 |
| Medium | 4 | 4 |
| Low | 0 | 0 |
| Total | 14 | 22 |

Table 14

Summary of Grouped Stressors at the End of Second Round

| Category | Total Items | $\bar{x}$≥3.00 & High Consensus | |
|---|---|---|---|
| | | No. | % |
| Uncertainty concerning treatment | 4 | 2 | 50 |
| Intrinsic job characteristics: Workload | 6 | 2 | 33 |
| Conflict with other nurses | 5 | 2 | 40 |
| Intrinsic job characteristics: New Technology | 7 | 2 | 28 |
| Lack of support | 4 | 1 | 25 |
| Conflict with physicians | 7 | 1 | 14 |
| Inadequate emotional preparation | 3 | 0 | 0 |

*Round Two Participant Comments*. Participants were asked this question: If your rating for this round is not the most frequent response (%) for any of the key stressors in this section, please give your reason(s). The following summarizes the participants' comments.

1. Nurses tend to be more stressed out because of the robot's malfunction or

errors during the surgery, not before the preparation for the surgery.

2. Regarding preparation for the robotic surgery, the contents are familiar and are not changed often. For this reason, the preparation is not a critical stressor.
3. When the respondent first dealt with robotic surgery, it was very stressful. As time went by, however, working in robotic surgery was no longer so hard.
4. It is hard to support patients emotionally because the respondents find themselves too busy taking care of such patients before the surgery.
5. It is not easy to communicate with other nurses who do not participate in robotic surgery.
6. Supervisors do not understand robotic surgery well.
7. Because the respondents usually work in robotic surgery, they do not have enough information about other nursing jobs.

*Conflict with a Physician* produced among the highest ratings with experts across categories (Table 5). Except for three items (*fear of making a mistake in treating a patient*, *disagreement concerning the treatment of a patient*, and *making a decision concerning a patient when the physician is unavailable*), four items were rated above the meaning rating of 3.0.

*Research Question Two*

Second research question was "What are the critical causes of job satisfaction of nurses working with a surgical robot?"

*Delphi Round One Data.* Panel members were requested to rate all statements

presented by applying a four-point Likert-type scale (See Appendix B) during this round. Consensus was achieved on 34 items (94%). Table 15 presents consensus data by category. During this round, the highest level of consensus was achieved by the categories *Achievement/Recognition* (100%), *Hospital Policies and Practices* (100%), *Compensation* (100%), *Co-workers* (100%), *Social Service* (100%), *Social Status* (100%), *Supervision* (100%), and *Variety* (100%). The category *Ability Utilization when Working with a Robot* achieved consensus on three of four items. *Working Conditions* (0%) achieved the lowest level of consensus during this round.

Table 15

Delphi Round One Consensus Data by Category

| Category | Total Items | Consensus Items | % |
|---|---|---|---|
| Ability utilization when working with a robot | 4 | 3 | 75 |
| Achievement/Recognition | 6 | 6 | 100 |
| Hospital policies and practices | 5 | 5 | 100 |
| Compensation | 3 | 3 | 100 |
| Co-workers | 3 | 3 | 100 |
| Social service | 1 | 1 | 100 |
| Social status | 3 | 3 | 100 |
| Supervision | 8 | 8 | 100 |
| Working conditions | 1 | 0 | 0 |
| Variety | 2 | 2 | 100 |
| Total Items | 36 | 34 | 94 |

Table 16 shows the number of respondents who added written comments for each category and the percentage of respondents for each category who added comments. The category *Achievement/Recognition* gained the most comments (3%) from respondents.

Respondents did not add any comments to any other categories.

Table 16

Respondents Adding Comments by Category: Round One

| Category | Total Items | Respondents Adding Comments No. | % |
|---|---|---|---|
| Ability utilization when working with a robot | 4 | 0 | 0 |
| Achievement/Recognition | 6 | 1 | 3 |
| Hospital policies and practices | 5 | 0 | 0 |
| Compensation | 3 | 0 | 0 |
| Co-workers | 3 | 0 | 0 |
| Social service | 1 | 0 | 0 |
| Social status | 3 | 0 | 0 |
| Supervision | 8 | 0 | 0 |
| Working conditions | 1 | 0 | 0 |
| Variety | 2 | 0 | 0 |

*Round One Participant Comments.* One participant pointed out that she was given few opportunities for advancement and did not expect advancement resulting from the robotic assistance in terms of achievement and recognition.

*Delphi Round Two Data.* During this round, panel members were requested to rate all statements presented by applying a four-point Likert scale (See Appendix B). Consensus was achieved on 36 items (100%). Table 17 presents consensus data by category representing the rate discrete items.

Table 17

Delphi Round Two Consensus Data by Category

| Category | Total Items | Consensus Items | % |
|---|---|---|---|
| Ability utilization when working with a robot | 4 | 4 | 100 |
| Achievement/Recognition | 6 | 6 | 100 |
| Hospital policies and practices | 5 | 5 | 100 |
| Compensation | 3 | 3 | 100 |
| Co-workers | 3 | 3 | 100 |
| Social service | 1 | 1 | 100 |
| Social status | 3 | 3 | 100 |
| Supervision | 8 | 8 | 100 |
| Working conditions | 1 | 1 | 100 |
| Variety | 2 | 2 | 100 |
| Total Items | 36 | 36 | 100 |

Table 18

Respondents Adding Comments by Category: Round Two

| Category | Total Items | Respondents Adding Comments No. | % |
|---|---|---|---|
| Ability utilization when working with a robot | 4 | 8 | 27 |
| Achievement/Recognition | 6 | 1 | 3 |
| Hospital policies and practices | 5 | 5 | 17 |
| Compensation | 3 | 6 | 20 |
| Co-workers | 3 | 3 | 10 |
| Social service | 1 | 1 | 3 |
| Social status | 3 | 5 | 17 |
| Supervision | 8 | 8 | 27 |
| Working conditions | 1 | 1 | 3 |
| Variety | 2 | 1 | 3 |

Table 18 shows the number of respondents who added written comments for each category and the percentage of respondents for each category who added comments. The category *Ability Utilization when Working with a Robot* (27%) and *Supervision* (27%) gained the most comments from respondents. Respondents also added many comments to *Compensation* (20%), *Hospital Policies and Practices* (17%), *Social Status* (17%), and *Co-workers* (10%). The categories *Achievement/Recognition* (3%), *Social Service* (3%), *Working Conditions* (3%), and *Variety* (3%) obtained a few comments.

*Achievement/Recognition* produced among the highest ratings with experts across categories (Table 19). Within this category, one item (the recognition I get for the work I do) was rated above the mean rating of 3.0, and it was the only one above the mean rating of 3.0 in all job satisfaction items. The mean rating of four items (being able to do something worthwhile, the feeling of accomplishment I get from the job, and the opportunities for advancement on this job) were close to 3.0.

Table 19

Achievement/Recognition by Mean Rating

| Item | Achievement/Recognition Statement | IQD | $\bar{x}$ | SD |
|---|---|---|---|---|
| 9e | The recognition I get for the work I do | 0.5 | 3.60 | .56 |
| 9c | Being able to do something worthwhile | 0 | 2.97 | .41 |
| 9d | The feeling of accomplishment I get from the job | 0 | 2.97 | .41 |
| 9f | The opportunities for advancement on this job | 0 | 2.97 | .41 |
| 9b | Being able to take pride in a job well done | 0 | 2.93 | .37 |
| 9a | Being able to see the results of the work I do | 0 | 2.87 | .43 |

(N = 6)

Experts tended to agree that *Ability Utilization when Working with a Robot* would cause job satisfaction. Table 20 indicates that three of the items approached a mean rating of 3, although one other item is closer to a mean rating of 2, indicating that

experts tended to disagree that robotic surgery gives them opportunities to develop new and better ways to do the job.

Items under the broad category of *Social Status* indicate support for the chance to be important in the eyes of others through a mean rating of 2.93, followed by item 14c, the chance to have a definite place in the community. The lowest mean rating was for item 14a, the chance to "rub elbows" with important people, which achieved a 2.80 rating as indicated in Table 21.

Table 20

Ability utilization when working with a robot by Mean Rating

| Item | Ability utilization when working with a robot Statement | IQD | $\bar{x}$ | SD |
|---|---|---|---|---|
| 8a | The chance to try my own methods of doing the job | 0 | 2.93 | .37 |
| 8b | The chance to do work that is well suited to my abilities | 0 | 2.87 | .43 |
| 8c | The chance to try out some of my own ideas | 0 | 2.80 | .41 |
| 8d | The chance to develop new and better ways to do the job | 0.5 | 2.37 | .56 |

(N = 4)

Table 21

Social Status by Mean Rating

| Item | Social Status Statement | IQD | $\bar{x}$ | SD |
|---|---|---|---|---|
| 14b | The chance to be important in the eyes of others | 0 | 2.93 | .45 |
| 14c | The chance to have a definite place in the community | 0 | 2.87 | .51 |
| 14a | The chance to "rub elbows" with important people | 0 | 2.80 | .55 |

(N = 3)

Table 22 supports the contention that *Co-workers* and *Social Service* are among the important causes of job satisfaction. The highest rated item was 12b, the chance to develop close friendships with co-workers, with a mean rating of 2.90, followed by 12c, the way co-workers get along with each other ($\bar{x}$ = 2.87). Regarding the *Social Service* category, experts tended to agree that the chance to be of service to patients is one of the causes of job satisfaction. Although all items in the two categories were rated as disagree, their mean ratings are close to 3.00. These categories also had the highest level of consensus based on interquartile deviation. This result supports a slight agreement between experts that co-workers and social service are critical causes of job satisfaction.

Table 22
Co-workers and Social Service by Mean Rating

| Item | Co-workers Statement | IQD | $\bar{x}$ | SD |
|---|---|---|---|---|
| 12b | The chance to develop close friendships with my co-workers | 0 | 2.90 | .40 |
| 12c | The way my co-workers get along with each other | 0 | 2.87 | .35 |
| 12a | The spirit of cooperation among my co-workers | 0 | 2.83 | .38 |
| Item | Social Service Statement | IQD | $\bar{x}$ | SD |
| 13a | The chance to be of service to patients | 0 | 2.80 | .48 |

(N = 3, N = 1)

Table 23
Work Conditions and Variety by Mean Rating

| Item | Work Conditions Statement | IQD | $\bar{x}$ | SD |
|---|---|---|---|---|
| 16a | Physical surroundings where I work | 0 | 2.87 | .43 |
| Item | Variety Statement | IQD | $\bar{x}$ | SD |
| 17b | The chance to do many different things on the job | 0 | 2.83 | .38 |
| 17a | The chance to do different things from time to time | 0 | 2.80 | .41 |

(N = 1, N = 2)

Table 23 presents the *Work Conditions* and *Variety* categories. The expert panel members were likely to slightly disagree that they were satisfied with the work conditions and variety of their job. Even though all items were rated as disagree, their mean ratings are close to 3.00. These categories also had highest level of consensus based on IQD.

Table 24

Supervision by Mean Rating

| Item | Supervision Statement | IQD | $\bar{x}$ | SD |
|---|---|---|---|---|
| 15e | The technical "know-how" of my supervisor | 0 | 2.77 | .43 |
| 15f | The competence of my supervisor in making decisions | 0.5 | 2.63 | .49 |
| 15a | The way my supervisor and I communicate with each other | 0.5 | 2.57 | .57 |
| 15g | The way my boss delegates work to others | 0.5 | 2.57 | .50 |
| 15h | The way my boss trains his/her employees | 0 | 2.20 | .41 |
| 15d | The way my boss provides help me with hard problems | 0 | 2.17 | .38 |
| 15b | The way my boss handles his/her employees | 0 | 2.13 | .35 |
| 15c | The way my boss addresses the complaints of his/her employees | 0 | 2.13 | .43 |

(N = 8)

Expert panel members disagreed that they were satisfied with supervision (Table 24). While three items (15f, 15a, 15g) obtained medium consensus, the rest of the items achieved a high level of consensus. Nurses were especially dissatisfied with the way their bosses address employee complaints and the way their bosses handle employees ($\bar{x}$ = 2.13).

Table 25 presents the item category *Hospital Policies and Practices*. Experts tended

to strongly disagree that hospital policies and practices are not an important cause of job satisfaction. Experts rated all five items as irrelevant to job satisfaction, and their decisions achieved a high level of consensus among expert panel members.

Table 25

Hospital Policies and Practices by Mean Rating

| Item | Hospital Policies and Practices Statement | IQD | $\bar{x}$ | SD |
|---|---|---|---|---|
| 10c | The way employees are informed about hospital policies | 0 | 2.13 | .43 |
| 10b | The way in which hospital policies are administered | 0 | 2.07 | .45 |
| 10d | The way hospital policies are put into practice | 0 | 2.07 | .37 |
| 10e | The way the hospital treats its employees | 0 | 2.03 | .49 |
| 10a | The policies and practices toward employees of this hospital | 0 | 1.97 | .32 |

(N = 5)

Table 26

Compensation by Mean Rating

| Item | Compensation Statement | IQD | $\bar{x}$ | SD |
|---|---|---|---|---|
| 11a | How my pay compares with that of other workers | 0 | 2.00 | .74 |
| 11c | My pay and the amount of work I do | 0 | 1.93 | .34 |
| 11b | How my pay compares with that for similar jobs in other companies | 0.5 | 1.83 | .74 |

(N = 3)

Regarding the *Compensation* category (Table 26), the experts on average were dissatisfied with their compensation. They disagreed that their pay matched the amount of work they do, and their average response obtained a high or medium level of consensus.

*Round Two Participant Comments.* Participants were asked this question: If your

rating for this round is not the most frequent response for any of the key causes of job satisfaction in this section, please give your reason(s). The following summarizes the participants' comments:

1. During the process of newly developed robotic surgery, doctors discuss problems with nurses. I am satisfied with these opportunities to stimulate nurses' new involvement.
2. I think my opinions can be reflected well in the process of robotic surgery.
3. I am not familiar with my current job assisting robotic surgery.
4. Because I usually follow the fixed job process, it is hard to try creative ways of problem solving.
5. My salary is higher than those other nurses working in different hospitals.
6. Even though I have gained expertise about robotic surgery, it has not influenced my salary in reality.
7. It is rarely possible to meet people with a high social status even though I am involved in robotic surgery.
8. I would like to directly communicate with my supervisor rather than an indirect way.
9. I wonder how my boss delegated the work to subordinates. The standard was inconsistent and unreliable.
10. Due to the worn-out facilities, the working conditions are not pleasant.
11. It is stressful for me to substitute others' jobs.

Table 27.

Degree of Consensus Level of Items Sorted by Mean Rating

| Item | Statements | First Round | | | Second Round | | |
|---|---|---|---|---|---|---|---|
| | | $\bar{x}$ | IQD | Consensus Level | $\bar{x}$ | IQD | Consensus Level |
| 9e | The recognition I get for the work I do | 3.43 | 0.5 | Low | 3.60 | 0.5 | Low |
| 9c | Being able to do something worthwhile | 3.20 | 0.5 | Low | 2.97 | 0 | High |
| 9d | The feeling of accomplish--ment I get from the job | 3.03 | 0.1 | High | 2.97 | 0 | High |
| 9f | The opportunities for advancement on this job | 2.87 | 0.5 | Low | 2.97 | 0 | High |
| 9b | Being able to take pride in a job well done | 3.10 | 0.1 | High | 2.93 | 0 | High |
| 8a | The chance to try my own methods of doing the job | 2.90 | 0.1 | High | 2.93 | 0 | High |
| 14b | The chance to be important in the eyes of others | 2.73 | 0.5 | Low | 2.93 | 0 | High |
| 12b | The chance to develop close friendships with my co-workers | 2.97 | 0 | High | 2.90 | 0 | High |
| 12c | The way my co-workers get along with each other | 3.07 | 0 | High | 2.87 | 0 | High |
| 16a | Physical surroundings where I work | 3.03 | 0.6 | Non-Consensus | 2.87 | 0 | High |
| 8b | The chance to do work that is well suited to my abilities | 2.97 | 0.6 | Non-Consensus | 2.87 | 0 | High |
| 9a | Being able to see the results of the work I do | 2.87 | 0.5 | Low | 2.87 | 0 | High |
| 14c | The chance to have a definite place in the community | 2.73 | 0.5 | Low | 2.87 | 0 | High |
| 12a | The spirit of cooperation among my co-workers | 2.93 | 0 | High | 2.83 | 0 | High |
| 17b | The chance to do many different things on the job | 2.47 | 0.5 | Low | 2.83 | 0 | High |
| 8c | The chance to try out some of my own ideas | 2.87 | 0.5 | Low | 2.80 | 0 | High |
| 13a | The chance to be of service to patients | 2.67 | 0.5 | Low | 2.80 | 0 | High |
| 14a | The chance to “rub elbows” with important people | 2.57 | 0.5 | Low | 2.80 | 0 | High |
| 17a | The chance to do different things from time to time | 2.50 | 0.5 | Low | 2.80 | 0 | High |

*Consensus Levels of the Causes of Job Satisfaction in the First and Second Rounds.* Table 27 summarizes the IQD of causes of job satisfaction in the first round and the second rounds.

As shown in Table 27, the IQD of 18 of the 36 causes of job satisfaction decreased from the first round to the second round, which means an increase in consensus. The decreases in IQD resulted in higher consensus levels for 18 job satisfaction items. These consensus level changes included 17 job satisfaction items moving from medium consensus to high consensus and 1 job satisfaction item (6b) moving from low consensus to high consensus. The IQD of 18 job satisfaction items did not change between the first and the second round. Therefore, their consensus levels did not change during re-rating in the second round.

Of the 36 job satisfaction items, 18 changed their consensus levels between the first and second round. Thus, 50% of the job satisfaction items did not change their consensus levels during re-rating in the second round.

Overall, based on the IQD at the end of this study, the *Achievement/Recognition* category had five job satisfaction items reaching high consensus level and one job satisfaction item reaching medium consensus level. The *Ability Utilization when Working with a Robot* category had three job satisfaction items reaching high consensus level and one job satisfaction reaching medium consensus level. The *Social Status* category had three job satisfaction items reaching high consensus level. The *Co-workers* category also had three job satisfaction items reaching high consensus level. The *Work Condition* category had one job satisfaction item reaching high consensus level. The *Variet*y category had two job satisfaction items reaching high consensus level. The

*Social Service* category had one job satisfaction item reaching high consensus level. The *Supervision* category had five job satisfaction items reaching high consensus level and three job satisfaction items reaching medium consensus level. The *Hospital Policies and Practices* category had five job satisfaction items reaching high consensus level. Lastly, the *Compensation* category had two job satisfaction items reaching high consensus level and one job satisfaction item reaching medium consensus level.

Table 28
Combinations of Mean Rating and Consensus Level of the key Causes of Job Satisfaction at the End of Second Round

| Consensus | Mean Rating | |
|---|---|---|
| | No. of Items (MN≥2.8) | No. of Items (MN< 2.8) |
| High | 18 | 12 |
| Medium | 0 | 0 |
| Low | 1 | 5 |
| Total | 19 | 17 |

Table 29
Summary of Grouped Key Causes of Job Satisfaction at the End of Second Round

| Category | Total Items | $\bar{x}$ ≥2.80 & High Consensus | |
|---|---|---|---|
| | | No. | % |
| Achievement/Recognition | 6 | 5 | 83 |
| Social status | 3 | 3 | 100 |
| Co-workers | 3 | 3 | 100 |
| Variety | 2 | 2 | 100 |
| Social service | 1 | 1 | 100 |
| Working conditions | 1 | 1 | 100 |
| Ability utilization when working with a robot | 3 | 3 | 100 |
| Supervision | 8 | 0 | 0 |
| Compensation | 3 | 0 | 0 |
| Hospital policies and practices | 5 | 0 | 0 |

As shown in Table 28, 19 job satisfaction items that had a high mean ($\bar{x} \geq 2.5$) reached a high consensus level. Four other job satisfaction items with a high mean reached low consensus level. In conclusion, these 23 job satisfaction items would be considered critical for nurses working with a surgical robot. Table 29 summarizes the mean rating of the grouped job satisfaction items at the second round.

*Research Question Three*

Third research question was "When you consider both your opinion and the average response of all participants on the identified stressor/job satisfaction statements, what organizational support should be provided to help nurses effectively work with a surgical robot?"

*Delphi Round Three Data.* A total of 30 second-round participants responded in the third round of the Delphi procedure. The instrument was distributed by e-mail, and is included in Appendix C. The purpose of the third round was to find suggestions from the expert panel members about this study's third question: When you consider both your opinion and average response of all participants on the identified stressor/job satisfaction statements, what organizational support should be provided to help nurses effectively work with a surgical robot?

As mentioned in the previous chapter, the analysis of the final round's qualitative responses was based on the grounded theory. The 18 categories identified through the grounded theory process are:

1. Individual interventions

    1-1. Training, education, and development of nurses

1-2. Training, education, and development of supervising/managerial nurses

1-3. Training, education, and development of residents/surgeons

1-4. Mentoring

2. Team/Work group interventions

2-1. Team building

2-2. Dialogue sessions

2-3. Conflict management

3. Process interventions (Socio-technical systems)

3-1. Appropriate scheduling of work

3-2. Making a manual for working out errors

3-3. Regular inspection of a robot

3-4. Supplementing more nurses

3-5. Effective placement of nurses

3-6. Preparation for preventing damages

4. Organizational interventions

4-1. Reward systems

4-2. Organizational design

4-3. Organizational learning

*1. Individual interventions*

*Category 1-1: Training, education, and development of nurses*

Respondents cited the importance of the training and education of nurses themselves. One respondent stated, “Current training is not thorough. Hospitals should

provide nurses with systematic training on equipment and expendables." They especially emphasized both the continuity and the regularity of the training. Many participants expressed their willingness to participate in a conference on surgical robots and/or going abroad to gain new knowledge: "Nurses need the opportunity to learn the surgical robot and know what the surgical robot will do before they can be expected to integrate it into problem-solving situations."

Regarding the content of training, one participant wrote that, "It is necessary to take continuous trainings on both the equipment and clinical experience because the speed of upgrade in technology is very fast in a surgery room when compared with other medical departments." In other words, nurses want to improve their knowledge to keep abreast with rapid developments in technology. At the same time, one respondent expresses this opinion: "The training should be designed to improve nurses' understanding on the specificity of each medical department using a surgical robot." In addition, another stated, "Dealing with a surgical robot requires nurses to be very cautious. The trainings need to be different according to a trainee's personality."

However, all nurses did not agree with the way training opportunities are distributed. As one commented, "I hope entry-level nurses will also have chances for domestic/overseas field trips like long-serving nurses do." Another individual said, "Most nurses want to be trained by technical experts rather than by their colleagues. I do not like the current way in which some representative nurses are trained by experts and are sharing their knowledge with their colleagues."

*Category 1-2: Training, education, and development of supervising/managerial nurses*

Respondents pointed out that robotic surgery is a new experience to everyone. Some respondents said that supervising and managerial nurses need to be equipped with the necessary knowledge and experience. "Because supervising and managerial nurses do not have enough experience with robotic surgery, they do not tend to understand the difficulties of nurses who work with a surgical robot and are not good at problem solving in relation to robotic surgery."

One individual said, "Managerial nurses do not catch the essence of robotic surgery. The robot is not just an easy tool. It charges more responsibilities on the medical team. Managerial nurses need to understand the robotic surgery exactly and need to contribute to correcting the wrong prejudice." Another respondent stated, "Supervising nurses need to pay attention to the nursing job of robotic surgery rather than focus on the financial issues such as price, dealing with damages, and decision on repurchase. Unless they are interested in nurses' real work, it would be hard to narrow the gap between them and us."

For this reason, a number of respondents commented that managerial/supervising nurses need to be trained on the nurses' real work in robotic surgery. "All supervising/managerial nurses need to access knowledge and skills of robotic surgery to allow opportunities to learn about nurses' real work."

*Category 1-3: Training, education, and development of residents/surgeons*

Those respondents agreeing with the training of residents and surgeons thought that residents or surgeons are not well prepared for robotic surgery. "Residents who do not know robotic surgery tend to cause errors or damages to a surgical robot…Surgeons

are likely to criticize nurses in spite of their mistakes." In other words, this problem is related to the preparation of residents and surgeons. "If the residents and surgeons who first participate in robotic surgery are not prepared for it, we cannot concentrate on our nursing job because we are required to explain the robotic surgery to residents or surgeons. They need to think that they should work out robotic surgery more independently."

Respondents suggested several solutions to the above problem. One individual said, "If there are separate training sessions for residents to educate them about robotic surgery, their mistakes will be expected to decrease." Another said, "Surgeons need to have enough opportunities to learn robotic surgery. Hospitals should support their education when it comes to finance and time."

*Category 1-4: Mentoring*

A number of respondents acknowledged their not having enough opportunities to communicate with managerial nurses. "She (managerial nurses) is so busy that it is very hard to meet her. I really need time to talk to her." On the other hand, some respondents wanted to participate in the mentoring as a mentor. "Because the gap of knowledge between a mentor and a mentee is not so big regarding robotic surgery, it is more interesting to share the knowledge and experience between me and mentees. If I have mentees, we will achieve new and exciting synergy."

2. *Team/Work group interventions*

*Category 2-1: Team building*

Some respondents commented that hospitals should determine and/or clarify the roles and responsibilities of nurses in robotic surgery. One individual said, “Communication is important for robotic surgery because a surgical robot is a newest technology and everyone is learning it together. The opinions of nurses can be more respected than before.” However, another respondent said, “The medical team tends to attribute errors to nurses. Especially, surgeons are likely to regard nurses as their subordinates rather than their partners.” Generally, respondents commented that surgeons and nurses need to communicate with each other in robotic surgery more frequently than they did before they worked with a surgical robot.

A number of respondents suggested that hospitals establish and/or clarify policies and procedures on robotic surgery. Many respondents agreed that they do not have enough information on how hospital management looks upon robotic surgery and how hospitals will train nurses for robotic surgery. Some respondents said, “Working-level nurses need to participate in the decision-making policies on robotic surgery. Hospitals should provide them with regular symposiums about the policies.” They also said, “Working-level nurses need a monitoring system to observe how the hospital executes policies. It is necessary for them to know the cause and result of the policies.” One respondent said, “Hospitals should correctly evaluate surgeons and nurses participating in robotic surgery. We need more accurate policies to evaluate the medical team.”

*Category 2-2: Dialogue sessions*

Those respondents agreeing with dialogue sessions thought there was a need for continuous opportunities for communication on robotic surgery. The following statement

illustrates this contention: “Nurses participating in robotic surgery need the chance to communicate with other nurses or surgeons both inside and outside the unit.”

One reason for respondents to look for communication is a lack of understanding on the newest technology, i.e., robotic surgery. One respondent expresses this opinion: “It is hard for other nurses or surgeons to understand our difficulties because nurses or surgeons who have not experienced robotic surgery tend to regard robotic surgery as an easy surgical procedure. However, the new technology does not just make the surgery easy, and nurses participating in robotic surgery experience their unique difficulties.” Another respondent added her opinion to this contention: “Some nurses or surgeons told me that robotic surgery had no advantages for patients. What was worse, oftentimes they tend to think that robotic surgery is not moral. It is hard to endure this kind of prejudice.”

Further, many respondents pointed out their need to talk with nurses working in other hospitals. “Because the number of nurses working with a surgical robot inside the hospital is small, I was often wondering how nurses in different hospitals are working with the surgical robot. If nurses have more frequent opportunities to share their know-how and ideas both inside and outside the hospital, it would be very helpful in improving the efficiency of our work.”

To facilitate the dialogue, some respondents commented that hospitals need to be more positive about this kind of dialogue. “Hospitals should play an important role in facilitating the dialogue on robotic surgery. Because robotic surgery is new to everyone, most members within the hospital need more knowledge and skills about it. Hospitals should financially support the regular meeting for dialogue to stimulate a deeper understanding of robotic surgery.”

*Category 2-2: Conflict management*

Respondents indicated feeling stressed when dealing with damages to robots and inappropriate scheduling. One respondent said, “Working-level nurses and supervisory nurses tend to have different points of view about the damages to robots or scheduling. Oftentimes supervisory and managerial nurses attribute the problems to working-level nurses. I think it is not often reasonable.” Another respondent commented that conflict management would be an effective strategy to help teams surface and confront their conflict.

3. *Process interventions (Socio-technical systems*)

*Category 3-1: Appropriate scheduling of work*

A number of respondents indicated that, in fact, nurses working with a surgical robot commented that the unpredictability of the work schedule is stressful. “Nurses in robotic surgery do not have regular work schedules because it is hard to predict the schedule of robotic surgery. For a while, I gave up my personal schedule because of the unpredictable work schedule.” Another respondent mentioned the stress of overtime work: “After the robotic surgery, I have to sterilize devices before going back home. Although I work overtime, it is not included in my formal work time.” Another respondent said, “Unlike other surgery, we need more time to prepare and check a robot system for robotic surgery. Generally, we are so busy with the preparation before the robotic surgery. Hospitals need to arrange working time more reasonably considering the time for preparation.”

*Category 3-2: Making a manual for working out errors*

A number of respondents suggested that there be a manual for working out errors. "As of now, we do not have specified manual about the way of working out errors. If the errors happen, the medical team tends to blame nurses. However, without the help of technicians from the robot company, it is hard to solve the problems sometimes. If we have a more concrete manual for working out errors, it will be easier to deal with errors than before." Said another respondent: "Hospitals are likely to regard the capability to deal with errors of robots as an important standard of measuring performance even though they do not provide enough support for improving performance."

*Category 3-3: Regular inspection of a robot*

Many respondents asserted that regular inspection could prevent the robot system from making errors during the robot surgery. "For the safety of robotic surgery, regular check-up is necessary. Hospitals tend to emphasize the sales of expensive equipment, but it is not a good strategy. It is more important to equip with small supplies in good condition rather than stick to expensive and big equipment."

*Category 3-4: Supplementing more nurses*

A number of respondents said that although a surgical robot is an up-to-date technology, robotic surgery needs a fair number of persons. Many respondents noted, "We need more personnel to help in cleaning and sterilizing. Nurses participating in robotic surgery need to concentrate on the surgery itself. And there is also a shortage of nurses who have the training for robotic surgery." One respondent said, "It is necessary

to increase the number of nurses participating in robotic surgery in order to avoid overtime work."

*Category 3-4: Effective placement of nurses*

Many of the respondents commented that it is not efficient sending robotic surgery nurses to unfamiliar wards. "Because robotic surgeries are not so frequent, hospitals tend to place the nurses in different wards suddenly."

On the other hand, some commentators noted that hospitals need to select robotic surgery nurses taking into account their qualifications and capabilities. "When selecting nurses, hospitals need to consider their personality and capability. Hospital management needs to clarify what the qualifications of robotic surgery nurses are." Other commentators felt that hospital management needs to develop nurses' expertise in robotic surgery and that frequent rotation is not helpful in familiarizing nurses with robotic surgery. "When I began to work at the robotic surgery department, I was satisfied with the fact that I felt like an expert in the robotic surgery. However, at the same time, I was anxious about the possibility that I would move to another department soon." On the other hand, several respondents said, "Nurses participating in robotic surgery need to be rotated when they want. The rotation is helpful to overcome the boredom resulting from unified job tasks."

*Category 3-6: Preparation for preventing damages*

Respondents said that a surgical robot is so expensive that nurses are likely to feel stressed about its use. "Nurses are trained to be extra careful about the use of the surgical

robot. But even though I was cautious about the robot, the robot would have damages resulting in the delay of the robotic surgery. Medical team tends to blame me, so I am afraid of making mistakes when dealing with a surgical robot." One respondent suggested, "Hospital management needs to have insurance in case of future damages to a surgical robot. Even though nurses pay attention to caring for the robot, we cannot avoid the damages perfectly."

*4. Organizational interventions*

*Category 4-1: Reward systems*

Those who agreed with the improvement of reward systems thought that current reward systems are not enough to motivate nurses of robotic surgery. For example, "Even though the stress of robotic surgery nurses is too high, hospital management is likely to disregard their difficulties. I am not satisfied with my salary and incentive." Others felt the need for financial reward for working overtime. "Robotic surgery requires us to clean and manage the related devices and makes us work overtime. But, as of now, the hospital does not provide us with the corresponding pay for my overtime work."

Some respondents also cited the lack of opportunities for promotion and welfare. "Although hospital management pays attention to robotic surgery, they do not take care of the welfare of employees working with a surgical robot. Because the robotic surgery makes the burden too heavy for us due to its expensive price, hospital management needs to consider a corresponding bonus or vacation for us." In addition to financial support, respondents also wanted to obtain social recognition. "I hope the hospital will

develop materials to introduce the nursing job of robotic surgery and will promote them to the public. I am proud of being a member of the robotic surgery team. Dealing with a robot is a quite new and interesting experience."

*Category 4-2: Organizational design*

Several respondents stated, "Managerial nurses tend to sacrifice working-level nurses in the relationship between nurses and surgeons. If some problems occur, managerial and supervising nurses are likely to make situations more profitable to them. Traditionally, the nursing department has an inflexible organizational structure. I hope our vertical structure will transform to a horizontal one."

*Category 4-3: Organizational learning*

Respondents cited the process of organizational learning as important for nurses working with a surgical robot. "If the medical team experiences errors during the surgery, they are likely to blame nurses. But I think it is important to cooperate with each other in case we commit errors." Other respondents said, "Nurses should have more information about the robot. But we just participated in a few more training sessions than they got. We do not know everything." In addition, some respondents expressed the desire to bring out new suggestions. "I would like to talk with supervising and managerial nurses more freely. I want to talk about my thoughts with them if given the opportunity."

# Chapter 5: Discussion of Findings

The purpose of this research was to identify and achieve consensus among a panel of experts about the key stressors and key factors related to job satisfaction of nurses working with surgical robots. In addition, the respondents were asked to provide their opinions about appropriate organizational support for nurses participating in robotic surgery. Three questions were developed to achieve the objective, and the findings for each of these questions are presented below.

## *Question One*

The question asked was: What are the key stressors of nurses working with a surgical robot?

As reported in Chapter 4, this study's panel of experts identified 14 key stressors that nurses working with a surgical robot were experiencing. Approximately 71% of the 14 key stressors generated in this study were considered by the panel as high level of consensus, and 29% of the 14 key stressors were considered as medium level of consensus. As a result, according to the panel, each of the 14 key stressors obtained medium to high level of consensus regarding nurses participating in robotic surgery.

*Uncertainty concerning treatment* was rated by the panel as the most important key stressor group, in which 50% of all the items obtained high level of consensus and above 3.0 mean rating. *The workload (intrinsic job characteristics)* group and *conflict with other nurses* group were rated by the panel as the second most important key stressor group, in which 40% of all the items obtained high level of consensus and above 3.0 mean rating. The study also demonstrated that *new technology (intrinsic job*

*characteristics)* group and *lack of support* group were rated by the third most important key stressor group, in which 33% of all the items obtained high level of consensus and above 3.0 mean rating. *Inadequate emotional preparation* group was rated by the panel as an unimportant key stressor.

*Uncertainty concerning treatment.* The *uncertainty concerning treatment* group and its one of the key components were considered as essential by the panel in the second round. The panel emphasized that there is a need for full understanding of the uncertainty concerning treatment resulting from robotic surgery. One expert member stated:

"Sometimes nurses are required to do doctors' work in robotic surgery without any pre-notice. And, if the robot is not working well, nurses tend to undertake responsibility to make it work. This kind of experience made me stress out."

According to the above-mentioned note, this panel member believed that it is essential to recognize that robotic surgery's cultural norms and definitions of work roles may be different from that those in general surgery. The same panel member also warned that the standard of measuring performance in robotic surgery is not pertinent in other hospital settings. In other words, medical teams working with a surgical robot need to understand the necessity of developing their own way of preparing for unpredictable work situations.

On the other hand, another panel member in this study stated that one of the most confusing moments for her was a surgeon's lack of understanding about robotic surgery, and she hopes that surgeons can smoothly manage the robotic surgery. However, whether or not a surgical robot is used, losing confidence about surgical procedures

seemed to be an important stressor for nurses in an operating room. In other words, uncertainty concerning procedures is a universal stressor for all nurses.

*Workload (intrinsic job characteristics)* and *conflict with other nurses*. *Workload and conflict with other nurses* group obtained high consensus and a mean rating above 3.0. Two key components in each group were considered as essential by the panel. The four key components were working overtime (Workload), criticism by a supervisor (Conflict with other nurses), not enough staff to adequately cover the unit where I work (Workload), and conflict with a nurse supervisor (Conflict with other nurses). Overall, the *workload* and *conflict with other nurses* group was considered by the panel to represent important stressors of nurses working with a surgical robot.

A review of the literature founded that the key sources of nurses' stress, namely, workload, leadership/management issues, professional conflict, and emotional demands of caring, have been identified consistently by nurses for many years (McVicar, 2003). Healy and McKay (2000) found workload to be most significantly correlated with mood disturbance. However, Payne (2001) did not find a significant relationship between workload and burnout, although the levels of burnout in her study were lower than those in related studies. The reasons for this variation are still unclear, but seem likely to include differences of stress "hardiness" (Simoni & Paterson, 1997), coping mechanisms (Payne, 2001), age and experience (McNeese-Smith, 2000), or the level of social support in the workplace (Ceslowitz, 1989; Morano, 1993; Healy & McKay, 2000).

Inter- and intra-professional conflict continues to be an important source of stress for the nurses. Inter-professional conflict, particularly between the nurses and physicians, appears to the greatest problem (Hillhouse & Adler, 1997; Bratt, Broome, Kelber, &

Lostocco, 2000; Ball, Pike, Cuff, Mellor-Clark, & Connell, 2002). The role of professional conflict as a source of distress is supported by findings that bullying is prevalent (Kivimaki, Elovainio, & Vahteera, 2000). The "working well" survey for the Royal College of Nursing (Ball et al., 2002) found that 30% of the nurses on long-term sick leave reported harassment and intimidation arising from sex/gender, age, race, sexuality, or personal clashes as the main cause of their absence.

Inter-professional conflict also appears to have increased in importance for many nurses during the last 10 years or so (Ball et al., 2002). In contrast, it has been observed that the emotional aspect of caring does not appear as frequently in the recent literature as a source of distress as it did in earlier studies. The emotional costs of providing care are unlikely to have decreased, and hence, it is possible that the increased significance of sources, such as reward, has assumed a greater importance for the nurses. Accordingly, this suggests the growing dissatisfaction with the terms and conditions of employment, rather than nursing per se (McVicar, 2001).

Recent literature about nurses' stressors has not directly focused on robotic surgery. However, prior researchers' concerns and solutions were still considered appropriate to nurses working with robots. In particular, high workload also has been a frequently mentioned stressor in the robotic surgery and is expected to be necessary to develop the way of reducing the workload of nurses.

*New technology (intrinsic job characteristics)* and *lack of support. New technology* contained two key components and *lack of support* group had one important key component for nurses working with a surgical robot, respectively. The three key components were unexpected events in the operation and functioning of Da Vinci system,

dealing with emergency procedures if the system malfunctions or the power goes out, and nurses who are not participating in robotic surgery do not understand the stress. Overall, these two groups were rated as the important key stressor group, in which 33% of all the items obtained high level of consensus and above 3.0 mean rating.

Unless adequate training and preparation are provided, potentially stressful situations may develop when new technology is introduced into the workplace, and individuals may not be able to cope with the innovation. For example, subordinates may also experience overload if they do not receive adequate guidance and supervision from their supervisors (Beatty & Lee, 1992). As can be seen from the above-mentioned result, new technology and workload is closely connected to each other. For example, one respondent said:

"People tend to think a robot makes our work easy. Of course, using a robot has some advantages to patients and the hospital. But, at least, for nurses, we are required to be more sensitive about the equipment and usually have more to-do lists than before. I hope people can understand the difficulties resulting from the robotic surgery."

Regarding the lack of support, another member of the panel of experts stated:

"There are a few nurses who have enough information about robotic surgery. So, most nurses not participating in robotic surgery have their own prejudices about the robotic surgery. Although we want to be understood by nurses from other departments, it seems to be hard because they don't know robotic surgery well."

According to the above-mentioned quote, this panel member has suggested that it is essential to recognize that hospital employees need to have a certain amount of information about robotic surgery. As using a surgical robot is a new and unfamiliar

experience for everyone, it will take time and efforts to share and systemize the knowledge and experience. However, to appropriately support the nurses working with a surgical robot and to improve the understanding about robotic surgery, hospital management needs to provide opportunities to demystify the process of robotic surgery among hospital employees.

*Question Two*

The question asked was: What are the critical causes of job satisfaction of nurses working with a surgical robot? As reported in Chapter 4, the panel in this study generated 19 key items of job satisfaction that nurses working with a surgical robot tend to experience. Approximately 95% of the 19 key items of job satisfaction generated in this study were considered as high level of consensus by the panel and 5% of the 19 key items of job satisfaction obtained low level of consensus with regard to nurses participating in robotic surgery (See Table 17 and 27 of Chapter 4).

*Achievement/recognition*, *social status*, *co-workers*, *variety, social service, and working conditions* were rated by the panel as the most important key group of job satisfaction factors, in which 100% of all the items obtained high level of consensus and above 2.80 mean rating. *Ability utilization when working with a robot* group was rated as the second most important key group of job satisfaction, in which 75% of all the items obtained high level of consensus and above 2.80 mean rating. The study also suggested that *supervision*, *hospital policies and practices*, and *compensation* group were not important groups of job satisfaction, which means that nurses were not currently satisfied with them and their dissatisfaction was more related to work stress.

*Achievement/Recognition*. The achievement/recognition group and its key components were considered as essential by the panel in the second round. The panel asserted that nurses are satisfied with the recognition they receive. Especially, one panel member stated:

"I am proud of taking part in the robotic surgery. The robotic technology is so new that nurses are more involved in the surgery. Surgeons are likely to respect our opinion more than before. For these reasons, I feel my work is giving me more positive social recognition from people."

According to the above-mentioned quote, this panel member asserted that dealing with new technology made them feel more important. The same panel member also suggested that hospital management should strengthen the recognition of nurses participating in robotic surgery.

*Social status.* The items of *social status* group were similar to those of achievement/recognition. Three key components in each group obtained high level of consensus and above 2.80 mean rating by the panel. The three key components were the chance to be important in the eyes of others, the chance to have a definite place in the community, and the chance to "rub elbows" with important people. Overall, the *social status* group was considered by the panel as an essential item of job satisfaction for nurses working with a surgical robot.

However, some respondents said:

"I had few opportunities to meet important people. And people just regard me a member of one of surgery teams. I don't think the fact of participating in the robotic surgery made me a distinguishable person."

Although many panel members tended to agree with the items of *social status* group, nurses likely had different points of view depending upon the atmosphere within their organizations. Overall, the nurses were satisfied with the recognition that they received and their social status related to robotic surgery.

*Co-workers.* Three key components in this group were considered essential by the panel. Those three key components were the chance to develop close friendships with my co-workers, the way my co-workers get along with each other, and the spirit of cooperation among my co-workers. Overall, the *co-workers* group was considered by the panel to be essential stressors for nurses working with a surgical robot.

Human relationships between nurses and various communal factors are of major importance for nurses' job satisfaction. Several studies (Adams & Bond, 2000; Newman & Maylor, 2002; Dunn, McLennan, 2005) have identified them as the best predictors of job satisfaction. According to McLennan (2005), interaction with other people was one of the greatest sources of job satisfaction. Similarly, Newman and Maylor (2002) mentioned that nurses tended to be of the opinion that co-workers (and the patient care) were the best thing about their work. Dunn et al. (2005) also found that relationships with other members of the nursing staff are the most important factors in creating job satisfaction.

*Variety.* Two key components in this group were considered essential by the panel. The two key components were the chance to do many different things on the job and the chance to do different things from time-to-time. Overall, the *variety* group was considered by the panel to contain essential items of job satisfaction for nurses working with a surgical robot.

In particular, one expert member stated:

"It is interesting to learn about a robotic surgery. Because everyone is learning about the robotic surgery for the first time, we are learning from each other. And we are positive about doing different things on the job."

This study found that nurses were satisfied with the variety of experience that the robotic surgery provided. However, individual differences were observed in recognizing the variety. Another expert said that the robotic surgery is just using a mechanical device and that she was not finding variety in her work. Overall, the nurses seemed to agree that robotic surgery gave them more dynamic work routines.

*Social service and working conditions.* The *Social service* and *working conditions* group were rated as essential by the panel during the second round. The panel of nurses tended to be satisfied with the physical surroundings where they work and presumed that they have enough chances to be of service to the patients.

*Ability utilization when working with a robot.* This group scored the second greatest percentage of essential key components. Three key components in this group were considered essential by the panel. The three key components were the chance to try my own methods of doing the job, the chance to do work that is well suited to my abilities, and the chance to try out some of my own ideas. Overall, the ability utilization when working with a robot was considered by the panel to be an essential item of job satisfaction to the nurses working with a surgical robot.

For example, one respondent said:

"I am pleased with the current situation to try out some of my own ideas. Although surgeons are still conservative, they admit the fact that using a surgical robot is

an up-to-date thing. I hope to have more opportunities trying my own methods of doing the job."

According to the above-mentioned quote, the nurses have been developing their own know-how and tips about robotic surgery. This issue is closely related to the organizational culture. Specifically, according to the hospital's future policies, nurses' new experiments about robotic surgery can be encouraged or discouraged.

*Question Three*

The question asked was: When you consider both your opinion and average responses of all participants about the identified stressor/job satisfactions statements, what organizational support should be provided to help nurses effectively work with a surgical robot?

*Individual interventions.* According to the analysis results of the final round's qualitative responses, four individual interventions were identified for nurses working with a surgical robot. Most interventions were related to training, education, and development of medical teams.

According to the expert panel members, nurses need continuous and regular training on robotic surgery, and other members of the medical teams also need to improve their understanding on robotic surgery. Panel members' responses imply that most of the hospitals do not currently provide thorough training in a helpful way with medical teams. Obviously, as using a surgical robot is a new experience for everyone, including hospital management, it will be challenging to decide the policies about robotic surgery. However, hospitals need to pay attention to the necessity of training and education when

considering that using a surgical robot is an unfamiliar experience for people. In particular, hospitals must be ready to perform continuous training and education, rather than one-shot training, because people are still learning about surgical robot at this stage.

In addition, robotic surgery is a new technology that influences the dynamics of knowledge and experience. According to the responses of expert panel members, supervising/managerial nurses, residents, and surgeons are not always knowledgeable and experienced, because they began to learn robotic surgery like when working-level or subordinate nurses do. However, sometimes they do not have enough knowledge about surgical robot, which has a disruptive influence on the flow of surgery. For this reason, the ongoing training on using a surgical robot is necessary for both working-level and supervising/managerial nurses, residents, and surgeons. In addition, expert panel members pointed out that nurses do not have enough time to talk with supervising/managerial nurses. For the supervising/managerial nurses to be knowledgeable about the real work of working-level nurses, hospital management needs to allow enough time for communication between supervising/managerial nurses and subordinate nurses.

*Team/work group interventions.* Regarding team building, it is necessary to remember the fact that organizational culture in an operating room is hierarchical. Even though the newest technology is used, it is impossible for the technology to suddenly transform the existing culture. Although the speed of the change is moderate, new technology seems to stimulate the change, as stated by one respondent: “The opinion of nurses can be more respectful than before because a surgical robot is a newest technology and everyone is learning it together.”

In addition, with the emergence of new technology, people tend to be confused regarding policies related to robotic surgery. Although working-level nurses wanted to participate in the decision-making of policies on robotic surgery, they felt that they did not have opportunities to share their opinions with hospital management. In fact, expert panel members were well-informed about what is necessary and what is not necessary for robotic surgery. Despite this fact, their opinions were not well reflected in the policies, which make nurses be discouraged.

Besides, the expert panel members suggested the need for dialogue sessions. Although the need for dialogue sessions is clear, organizations using new technologies should provide opportunities to discuss difficulties that employees are having with new technologies. Particularly, respondents mentioned that they were wondering about situations of other hospitals related to robotic surgery. Nurses wanted to know how different hospitals had previously coped with the challenges related to robotic surgery. In addition, nurses hoped that hospitals could facilitate the dialogue with hospitals' patients.

During dialogue sessions, it became clear that experts were experiencing difficulties related to the damages to robots and to inappropriate scheduling. As the working-level and supervisory nurses tended to have different points of view about the problems, the working-level (subordinate) nurses felt the need to find a way to smoothly work out the problems, rather than always following the opinions of supervisory nurses. Therefore, hospital management is encouraged to provide reasonable processes to resolve their conflicts.

*Process interventions (Socio-technical systems).* Socio-technical approaches focuses on the social and technological aspects of organizations, and posit that both must

be adequate to create effective organizational change (Johnson, Beyerlein, Huff, Halfhill, & Ballentine, 2002). This approach is associated with the Tavistock Model (Johnson et al., 2002). Tavistock studied the coal-mining industry in the 1940s (Trist, 1981). The results of the research indicated that absenteeism, hostility between workers, and other problems were directly related to changes in the social patterns that resulted from new technological conditions. The socio-technical approach involves trying to jointly optimize both the key issues of physical products and social/psychological outcomes. The key assumption in this approach is that technological change must be accompanied by planned changes in social patterns to guarantee organizational effectiveness (Johnson et al., 2002).

Too often, organizations implement a new technology and expect workers to adjust automatically. Likewise, when it comes to dealing with a surgical robot, hospitals do not tend to consider the fit between the new technology and employees. Respondents said that appropriate scheduling of work, making a manual for working out errors, regular inspection of robots, assigning more nurses, and effective placement of nurses are necessary to improve the process of robotic surgery. As the nurses felt that hospitals were not ready for the new technology, they often discussed the need of related improvements in the robotic surgery process. If hospitals accept the nurses' suggestions, it is expected that the process of robotic surgery will go more smoothly than before.

*Organizational interventions.* Organizational interventions are composed of reward systems, organizational design, and organizational learning. The reward system approach focuses on performance management and feedback systems, by rewarding desired behaviors and work outcomes. Examples of rewards include pay, opportunity

(promotions, increased learning, wider job experiences), and fringe benefits (Cummings & Worley, 2005).

Most of the respondents agreed that the current reward systems are not enough to motivate the nurses working at robotic surgery. The urgent problem was the difference between working-level nurses and other hospital staff members in terms of the standards of desired behaviors. As they had different points of view about measuring performance, it was impossible to avoid the conflict resulting from these differences. In fact, to resolve such conflicts, frequent communication was found to be a necessary prerequisite for reasonable reward systems with regard to robotic surgery. This issue was also observed to be related to organizational design. Many panel members mentioned the inflexible organizational structure of their nursing department. For communicating with each other in an open and impartial way, it was considered to be necessary to specifically transform the inflexible communication structure to a more flexible one.

In addition, most of the expert panel members also stated that the process of organizational learning is important for nurses working with a surgical robot. They were afraid of being blamed by other medical staffs because of the errors made by surgical robots. Therefore, panel members wanted their organization to become a learning organization that learns from both failures and successes.

*Conclusions*

Clearly, working with a surgical robot tends to present people with both challenges and promises. The most important thing is that dealing with a surgical robot is not always challenging or promising. Especially, for nurses, a surgical robot is a

source of interesting experiments, as well as annoying discomforts. For this reason, at this stage, it is important to accurately understand the light and shadow of the experience working with a robot.

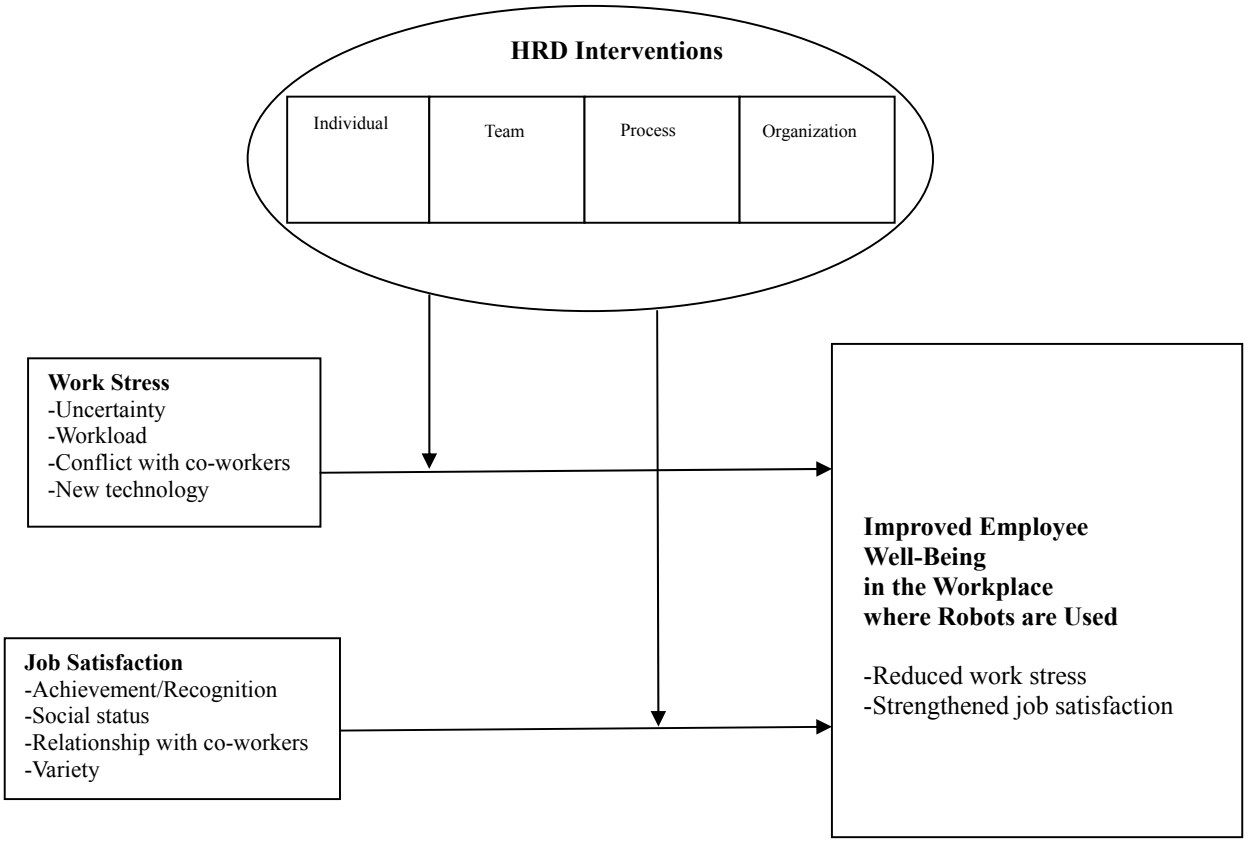


Figure 1. A model of designing HRD interventions for workers partnering with robots

Figure 1 represents the overall framework of this study. The purpose of this study was to find appropriate HRD interventions to help employees effectively work with a robot. As shown in Figure 1, critical causes of work stress and of job satisfaction were identified in the study and necessary HRD interventions were also suggested by a panel of experts. Due to the suggested HRD interventions, it is recommended that work stress

be reduced and that job satisfaction be strengthened with regard to employee-robot interaction.

Regarding research question one and two, the nurses did not tend to mention extraordinary stress or job satisfaction. Although using a surgical robot is a new experience, the causes of work stress and job satisfaction were closely related to the chronic ills of their organizations. For example, uncertainty concerning treatment and conflict with other nurses stems from a lack of communication or misunderstanding among nurses or between nurses and surgeons. As mentioned in the nurses' responses, they need more opportunities to communicate with other nurses or surgeons under free and open atmosphere. In fact, regardless of the robot's existence, communication opportunities are important outlets to express nurses' difficulties (Narayanan, Menon, & Spector, 1999). After the introduction of surgical robot, frequent and free communication was observed to be more important than before.

Next, reward systems are related to the answer of research question three. Nurses stated that their current reward systems do not reflect the real work of nurses participating in robotic surgery. For instance, although nurses tend to do extra work due to robotic surgery, they felt that hospitals were ignoring their extra efforts. In other words, they assumed that hospitals did not listen to employees' opinions when they establish reward systems. Therefore, in this case, the reward systems would not appeal to employees because they were not designed to satisfy the employees' current desires.

In addition, strengthening the process of organizational learning was not a new strategy for nurses, because they had to learn from both failures and successes regardless of the use of a robot. In fact, solidifying the organizational learning tends to be more

important for the nurses working with a surgical robot than to other staff members. As medical teams tend to blame nurses for the robots' errors, nurses were stressed out when they were making mistakes or were not grasping the causes of errors. Therefore, applying the strategies of organizational learning strategies in such situations is likely to be helpful for nurses working with a surgical robot, because the strategies were valuable in the past.

Evidently, there are direct issues resulting from the use of a surgical robot. First, the nurses mentioned that there is a need for training and education of working-level nurses, supervisory/managerial nurses, and residents/surgeons. As the knowledge of robotic surgery is evolving quickly, the nurses felt the need to keep up with the pace of related knowledge development. Especially, they mentioned the training of supervisory/managerial nurses and residents/surgeons in comparison to the training of nurses. Nurses were not generally satisfied with the supervision of supervising/managerial nurses. They expected that the relationship between working-level nurses and supervising/managerial nurses would be better if the supervising/managerial nurses received training about robotic surgery and if they were aware of the difficulties of working-level nurses. These interventions are more directly related to the emergence of a surgical robot rather than ordinary practices.

In addition, process interventions are up-to-date policies about robotic surgery. These interventions are totally new because they were created for only purpose of supporting robotic surgery. If hospitals pay more attention to the new characteristics of robotic surgery, they will be able to develop improved policies for effectively aiding the use of robots. At any rate, as the interventions are based on the emergent features of

robotic surgery, hospital management is likely to overlook them because they are not fully aware of them.

In conclusion, except for the process interventions, most of the suggested interventions are not very new. In other words, common strategies for improving better organizations are still believed to be effective for nurses partnering with a surgical robot. In fact, when people often recall a breakthrough change, such as working with a robot, they tend to assume that. Of course, it is true that hospitals need to pay attention to some emergent interventions resulting from robotic technology. However, hospital management should concentrate on taking care of their employees before making special preparations for surgical robots. For example, if hospital management intends to wholeheartedly communicate with nurses, they can work out nurses' problems easily, because the interventions for using robots are close to well-known strategies for becoming a good organization. For this reason, to effectively support nurses working with a surgical robot, the prerequisite is still to faithful to the basic principles for becoming a better organization. Without thoroughly providing basic organizational support for workers, any new technological innovations are not likely to enhance organizations' efforts to proliferate robots. Therefore, new technology itself is not the first priority, instead the preparation of workers to interact with robots should be addressed first.

### *Limitations of the Study and Implications for Future Research*

The limitations of this study are as follows:

First, this study's findings are delimited to Korean nurses working with a surgical

robot and may not be relevant to all the employees working with a robot. This research's findings identified stressors and causes of job satisfaction among nurses of operating rooms with surgical robots.

Second, the perception of work stress or job satisfaction might be more related to personal characteristics, such as work value or personality than the sensitivity to new technology. It is possible that the study's subjects may not have been able to make a distinction between work value or personality and the sensitivity to new technology.

Third, this study did not track issues related to the implementation of surgical robots on a long-term basis, because it is a temporary observation. Future studies should be conducted using a longitudinal research designs. If future studies obtain longitudinal data, it is recommended that future researchers seek to clearly understand the dynamics of work stress and job satisfaction of nurses working with a surgical robot.

Despite the delimitations, this study provides a guideline for working with robots in the workplace. Although working with a robot currently seems to be unusual, this study found that people need not be overwhelmed by such unfamiliarity. Finally, future researchers are encouraged to conduct research focused on the following questions: (a) How can we define the expertise of employees working with a robot? (b) How is robotic technology similar to and different from other new technologies being introduced into the workplace? (c) How can we customize necessary interventions to support working with a robot? and (d) How can we establish a code of work ethics when employees are working with a robot?

*Suggestions for Future Research*

Realistically, it is hard to usually see the employee-robot interaction in the workplace nowadays. For this reason, many people tend to think that working with robots is not directly related to their lives and assume that robots are just future toys. However, throughout this research, some employees in specific industries have been already required to effectively work with robots. While they were excited about the new invention, they were also struggling with unfamiliar problems they faced.

In order to resolve the unfamiliar problems of employee-robot interaction, it is necessary to promote the interdisciplinary research for drawing conclusions from various angles. Of course, there is no right answer when making solutions. The various points of view will contribute to producing more dynamic strategies of problem-solving. For example, researchers from computer science, economics, and product design will be a good combination to support and to learn employee-robot interaction.

Currently, most literature related to human-robot interaction is focusing on drawing a future landscape of autonomous robots. Of course, it is true that autonomous robots are more up-to-dated and more inquisitive. However, at the same time, it is also valuable to investigate the socio-cultural implications of master-slave relationship robots because it will take time to usually meet autonomous robots with fully-developed intelligence. For a while, many employees will be required to deal with issues and problems related to robots equipped with low-level intelligence being close to master-slave relationship robots. Besides, it is also important to track the evolution of robots in various social contexts. Above all, in order to effectively understand current issues and problems of employee-robot interaction, it is necessary not to disregard the robots with master-slave

relationship.

On the other hand, the researcher realized that organizations adopting robots need the measurement tool assessing their preparedness about employee-robot interaction. The assessment instrument can help organizations decide the level of their involvement in working with robots. If the instruments are customized according industries and/or types of robots, it will be also helpful for organizations to make a decision about the use of robots.

Regarding the implications of employee-robot interaction, although this research invited only Korean subjects, it is necessary to observe employee-robot interaction in cross-cultural settings. In the future, people with various backgrounds will interact with intelligent robots in the same organization more commonly. Then, they will need concerted agreements about employee-robot interaction as norms for their words and behaviors like international laws do. It is necessary to establish minimum boundary not to violate human/robot rights. In order to create the standards for human/robot rights, the interdisciplinary research among related academic fields will be needed.

Lastly, the research results pointed out the importance of systemic training about employee-robot interaction. For the effective training, it is important to foster professional trainers in the field of employee-robot interaction. If necessary curriculums and instructions are developed in higher education institutions, it will be helpful to open the courses for obtaining a trainer certificate(s) in employee-robot interaction according to the types of robots. However, it will take time to see the universalization of professional trainers in employee-robot interaction because people will need them when they feel the emergence of more intelligent robots.

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Appendix A: First round research instrument

Research Title: Designing HRD interventions for employee-robot interaction
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Delphi-Round One

Directions:
This survey contains Part I and Part II.

Part I: Key stressors that Korean nurses working with a surgical robot encounter have been broken down seven sections. Please mark the one appropriate degree of agreement, Strongly Disagree (1), Disagree (2), Agree (3), Strongly Disagree, for each of the following key stressors. Spaces are provided at the end of each section for additional key stressors.

| **Do you agree that the following stressor is critical?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| **1. Intrinsic job characteristics: New technology** | | | | |
| 1) Preparing the Da Vinci system before surgery | 1 | 2 | 3 | 4 |
| 2) Dealing with emergency procedures if the system malfunctions or the power goes out | 1 | 2 | 3 | 4 |
| 3) Cleaning and sterilizing the robotic instruments and cleaning the nonsterile equipment | 1 | 2 | 3 | 4 |
| 4) Troubleshooting error messages | 1 | 2 | 3 | 4 |
| 5) Positioning the patient and equipment safely | 1 | 2 | 3 | 4 |
| 6) Unexpected events in the operation and functioning of Da Vinci system | 1 | 2 | 3 | 4 |
| **2. Intrinsic job characteristics: Workload** | | | | |
| 1) Unpredictable staffing and scheduling | | | | |
| 2) Too many non-nursing tasks required such as clerical work | | | | |
| **If you have additional stressors in this section, please write them:** | | | | |

| **Do you agree that the following stressor is critical?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| 3) Not enough time to provide emotional support to a patient | 1 | 2 | 3 | 4 |
| 4) Not enough time to complete all of my nursing tasks | 1 | 2 | 3 | 4 |
| 5) Not enough staff to adequately cover the unit where I work | 1 | 2 | 3 | 4 |
| **3. Conflict with physicians** | | | | |
| 1) Conflict with a physician | 1 | 2 | 3 | 4 |
| 2) Criticism by a physician | 1 | 2 | 3 | 4 |
| 3) Disagreement concerning the treatment of a patient | 1 | 2 | 3 | 4 |
| 4) Fear of making a mistake in treating a patient | 1 | 2 | 3 | 4 |
| 5) Making a decision concerning a patient when the physician is unavailable | 1 | 2 | 3 | 4 |
| **If you have additional stressors in this section, please write them.** | | | | |

| **Do you agree that the following stressor is critical?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| **4. Inadequate preparation** | | | | |
| 1) Feeling inadequately prepared to help with the emotional needs of a patient's family | 1 | 2 | 3 | 4 |
| 2) Feeling inadequately prepared to help with the emotional needs of a patient | 1 | 2 | 3 | 4 |
| 3) Being asked a question by a patient for which I do not have a satisfactory answer | 1 | 2 | 3 | 4 |
| **5. Lack of support** | | | | |
| 1) Lack of an opportunity to talk openly with other unit personnel about problems on the unit | 1 | 2 | 3 | 4 |
| 2) Lack of an opportunity to share experiences and feelings with other personnel on the unit | 1 | 2 | 3 | 4 |

| | | | | |
|---|---|---|---|---|
| 3)Lack of an opportunity to express to other personnel on the unit my negative feelings toward patients | 1 | 2 | 3 | 4 |
| **6. Conflict with other nurses** | | | | |
| 1) Conflict with a nurse supervisor | 1 | 2 | 3 | 4 |
| 2) Floating to other units that are short-staffed | 1 | 2 | 3 | 4 |
| **If you have additional stressors in this section, please write them:** | | | | |

| **Do you agree that the following stressor is critical?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| 3) Difficulty in working with a particular nurse (or nurses) outside the unit | 1 | 2 | 3 | 4 |
| 4) Criticism by a supervisor | 1 | 2 | 3 | 4 |
| 5) Difficulty in working with a particular nurse (or nurses) on the unit | 1 | 2 | 3 | |
| **7. Uncertainty concerning treatment** | | | | |
| 1) Inadequate information from a physician regarding the medical condition of a patient | 1 | 2 | 3 | 4 |
| 2) A physician ordering what appears to be inappropriate treatment for a patient | 1 | 2 | 3 | 41 |
| 3) A physician ordering what appears to be inappropriate treatment for a patient | 1 | 2 | 3 | 4 |
| 4) A physician not being present in a medical emergency | 1 | 2 | 3 | 4 |
| 5) Not knowing what a patient or a patient's family ought to be told about the patient's condition and its treatment | 1 | 2 | 3 | 4 |
| **If you have additional stressors in this section, please write them:** | | | | |

Part II: Critical causes of job satisfaction that Korean nurses working with a surgical robot encounter have been broken down ten sections. Please mark the one appropriate degree of agreement, Strongly Disagree (1), Disagree (2), Agree (3), Strongly Disagree, for each of the following key stressors. Spaces are provided at the end of each section for additional critical causes of job satisfaction.

| **Do you agree that the following component improves your job satisfaction?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| **1. Ability utilization when working with a robot** | | | | |
| 1) The chance to try my own methods of doing the job | 1 | 2 | 3 | 4 |
| 2) The chance to do work that is well suited to my abilities | 1 | 2 | 3 | 4 |
| 3) The chance to try out some of my own ideas | 1 | 2 | 3 | 4 |
| 4) The chance to develop new and better ways to do the job | 1 | 2 | 3 | 4 |
| **2. Achievement/Recognition** | | | | |
| 1) Being able to see the results of the work I do | 1 | 2 | 3 | 41 |
| 2) Being able to take pride in a job well done | 1 | 2 | 3 | 4 |
| 3) Being able to do something worthwhile | 1 | 2 | 3 | 4 |
| 4) The feeling of accomplishment I get from the job | 1 | 2 | 3 | 4 |
| **If you have additional causes of job satisfaction in this section, please write them:** | | | | |

| **Do you agree that the following component improves your job satisfaction?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| 5) The recognition I get for the work I do | 1 | 2 | 3 | 4 |
| 6) The opportunities for advancement on this job | 1 | 2 | 3 | 4 |
| **3. Hospital policies and practices** | | | | |
| 1) The policies and practices toward | 1 | 2 | 3 | 4 |

| | | | | |
|---|---|---|---|---|
| employees of this hospital | | | | |
| 2) The way in which hospital policies are administered | 1 | 2 | 3 | 4 |
| 3) The way employees are informed about hospital policies | 1 | 2 | 3 | 4 |
| 4) The way hospital policies are put into practice | 1 | 2 | 3 | 4 |
| 5) The way the hospital treats its employees | 1 | 2 | 3 | 4 |
| **If you have additional causes of job satisfaction in this section, please write them:** | | | | |

| **Do you agree that the following component improves your job satisfaction?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| **4. Compensation** | | | | |
| 1) How my pay compares with that of other workers | 1 | 2 | 3 | 4 |
| 2) How my pay compares with that for similar jobs in other companies | 1 | 2 | 3 | 4 |
| 3) My pay and the amount of work I do | 1 | 2 | 3 | 4 |
| **5. Co-workers** | | | | |
| 1) The spirit of cooperation among my co-workers | 1 | 2 | 3 | 4 |
| 2) The chance to develop close friendships with my co-workers | 1 | 2 | 3 | 4 |
| 3) The way my co-workers get along with each other | 1 | 2 | 3 | 4 |
| **If you have additional causes of job satisfaction in this section, please write them:** | | | | |

| **Do you agree that the following component improves your job satisfaction?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| **6. Social service** | | | | |
| 1) The chance to be of service to patients | 1 | 2 | 3 | 4 |
| **7. Social status** | | | | |
| 1) The chance to "rub elbows" with | 1 | 2 | 3 | 4 |

| | | | | |
|---|---|---|---|---|
| important people | | | | |
| 2) The chance to be important in the eyes of others | 1 | 2 | 3 | 4 |
| 3) The chance to have a definite place in the community | 1 | 2 | 3 | 4 |
| **8. Supervision** | | | | |
| 1) The way my supervisor and I communicate with each other | 1 | 2 | 3 | 4 |
| 2) The way my boss handles his/her employees | 1 | 2 | 3 | 4 |
| 3) The way my boss addresses the complaints of his/her employees | 1 | 2 | 3 | 4 |
| 4) The way my boss provides help me with hard problems | 1 | 2 | 3 | 4 |
| **If you have additional causes of job satisfaction in this section, please write them:** | | | | |

| **Do you agree that the following component improves your job satisfaction?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| 5) The technical "know-how" of my supervisor | 1 | 2 | 3 | 4 |
| 6) The competence of my supervisor in making decisions | 1 | 2 | 3 | 4 |
| 7) The way my boss delegates work to others | 1 | 2 | 3 | 4 |
| 8) The way my boss trains his/her employees | 1 | 2 | 3 | 4 |
| **9. Working conditions** | | | | |
| 1) Physical surroundings where I work | 1 | 2 | 3 | 4 |
| **10. Variety** | | | | |
| 1) The chance to do different things from time to time | 1 | 2 | 3 | 4 |
| 2) The chance to do many different things on the job | 1 | 2 | 3 | 4 |
| **If you have additional causes of job satisfaction in this section, please write them:** | | | | |

Appendix B: Second round research instrument

Research Title: Designing HRD interventions for employee-robot interaction

Delphi - Round Two

Directions:
This survey contains Part I and Part II.

Part I: You are asked to **re-rate** the degree of your agreement on key stressors. (Please note that additional key stressors suggested by the panel from the first round will be added in this survey.) Please mark the one appropriate degree of agreement, Strongly Disagree (1), Disagree (2), Agree (3), Strongly Agree (4), for each of the following key stressors. For each key component listed previously in the first round, the whole panel's responses are summarized in **percentage (%)** and your personal response is indicated with a **Check Mark (√)**. If your rating for this round is not the **most frequent response (%)** for any of the key stressors listed previously in the first round, please give your **reason(s)** in the space provided at the end of each section.

| **Do you agree that the following stressor is critical?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| **1. Intrinsic job characteristics: New technology** | | | | |
| 1) Preparing the Da Vinci system before surgery | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 2) Dealing with emergency procedures if the system malfunctions or the power goes out | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 3) Cleaning and sterilizing the robotic instruments and cleaning the nonsterile equipment | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 4) Troubleshooting error messages | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 5) Positioning the patient and equipment safely | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 6) Unexpected events in the operation and functioning of Da Vinci system | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 7) I am stressed out when I need to be careful not to make disorders of highly expensive equipment | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| **2. Intrinsic job characteristics: Workload** | | | | |
| 1) Unpredictable staffing and scheduling | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |

| | | | | |
|---|---|---|---|---|
| 2) Too many non-nursing tasks required such as clerical work | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| **If your rating for this round is not the most frequent response (%) for any of the key stressors in this section, please give your reason(s):** | | | | |

| **Do you agree that the following stressor is critical?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| 3) Not enough time to provide emotional support to a patient | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 4) Not enough time to complete all of my nursing tasks | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 5) Not enough staff to adequately cover the unit where I work | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 6) Additional work beyond regular working time | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| **3. Conflict with physicians** | | | | |
| 1) Conflict with a physician | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 2) Criticism by a physician | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 3) Disagreement concerning the treatment of a patient | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 4) Fear of making a mistake in treating a patient | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 5) Making a decision concerning a patient when the physician is unavailable | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 6) When nurses should take the job instead of doctors | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 7) The atmosphere in which nurses are in charge of solving problems of a robot | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| **If your rating for this round is not the most frequent response (%) for any of the key stressors in this section, please give your reason(s):** | | | | |

| **Do you agree that the following stressor is critical?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| **4. Inadequate preparation** | | | | |
| 1) Feeling inadequately prepared to help with the emotional needs of a patient's family | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 2) Feeling inadequately prepared to help with the emotional needs of a patient | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 3) Being asked a question by a patient for which I do not have a satisfactory answer | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| **5. Lack of support** | | | | |
| 1) Lack of an opportunity to talk openly with other unit personnel about problems on the unit | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 2) Lack of an opportunity to share experiences and feelings with other personnel on the unit | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 3)Lack of an opportunity to express to other personnel on the unit my negative feelings toward patients | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 4) Colleague nurses who are not working with a robot in my operating room do not understand my situation | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| **6. Conflict with other nurses** | | | | |
| 1) Conflict with a nurse supervisor | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 2) Floating to other units that are short-staffed | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| **If your rating for this round is not the most frequent response (%) for any of the key stressors in this section, please give your reason(s):** | | | | |

| **Do you agree that the following stressor is critical?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| 3) Difficulty in working with a particular nurse (or nurses) outside the unit | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 4) Criticism by a supervisor | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 5) Difficulty in working with a particular nurse (or nurses) on the unit | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| **7. Uncertainty concerning treatment** | | | | |
| 1) Inadequate information from a physician regarding the medical condition of a patient | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 2) A physician ordering what appears to be inappropriate treatment for a patient | 1<br>?? % | 2<br>?? % | 3<br>?? % | 41<br>?? % |
| 3) A physician not being present in a medical emergency | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| 4) Not knowing what a patient or a patient's family ought to be told about the patient's condition and its treatment | 1<br>?? % | 2<br>?? % | 3<br>?? % | 4<br>?? % |
| **If your rating for this round is not the most frequent response (%) for any of the key stressors in this section, please give your reason(s):** | | | | |

Part II: You are asked to **re-rate** the degree of your agreement on key causes of job satisfaction. (Please note that additional key causes of job satisfaction suggested by the panel from the first round will be added in this survey.) Please mark the one appropriate degree of agreeent, Strongly Disagree (1), Disagree (2), Agree (3), Strongly Agree (4), for each of the following key stressors. For each key cause listed previously in the first round, the whole panel's responses are summarized in **percentage (%)** and your personal response is indicated with a **Check Mark (√)**. If your rating for this round is not the **most frequent response (%)** for any of the key stressors listed previously in the first round, please give your **reason(s**) in the space provided at the end of each section.

| **Do you agree that the following component improves your job satisfaction?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| **1. Ability utilization when working with a robot** | | | | |
| 1) The chance to try my own methods of doing the job | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 2) The chance to do work that is well suited to my abilities | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 3) The chance to try out some of my own ideas | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 4) The chance to develop new and better ways to do the job | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| **2. Achievement/Recognition** | | | | |
| 1) Being able to see the results of the work I do | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 2) Being able to take pride in a job well done | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 3) Being able to do something worthwhile | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 4) The feeling of accomplishment I get from the job | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| **If your rating for this round is not the most frequent response (%) for any of the key causes of job satisfaction in this section, please give your reason(s):** | | | | |

| **Do you agree that the following component improves your job satisfaction?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| 5) The recognition I get for the work I do | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 6) The opportunities for advancement on this job | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| **3. Hospital policies and practices** | | | | |
| 1) The policies and practices toward employees of this hospital | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 2) The way in which hospital policies are administered | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 3) The way employees are informed about hospital policies | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |

| | | | | |
|---|---|---|---|---|
| 4) The way hospital policies are put into practice | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 5) The way the hospital treats its employees | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| **If your rating for this round is not the most frequent response (%) for any of the key causes of job satisfaction in this section, please give your reason(s):** | | | | |

| **Do you agree that the following component improves your job satisfaction?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| **4. Compensation** | | | | |
| 1) How my pay compares with that of other workers | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 2) How my pay compares with that for similar jobs in other companies | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 3) My pay and the amount of work I do | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| **5. Co-workers** | | | | |
| 1) The spirit of cooperation among my co-workers | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 2) The chance to develop close friendships with my co-workers | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 3) The way my co-workers get along with each other | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| **If your rating for this round is not the most frequent response (%) for any of the key causes of job satisfaction in this section, please give your reason(s):** | | | | |

| **Do you agree that the following component causes your job satisfaction?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| **6. Social service** | | | | |
| 1) The chance to be of service to patients | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| **7. Social status** | | | | |
| 1) The chance to "rub elbows" with important people | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 2) The chance to be important in the eyes of others | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |

| | | | | |
|---|---|---|---|---|
| 3) The chance to have a definite place in the community | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| **8. Supervision** | | | | |
| 1) The way my supervisor and I communicate with each other | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 2) The way my boss handles his/her employees | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 3) The way my boss addresses the complaints of his/her employees | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 4) The way my boss provides helps me with hard problems | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| **If your rating for this round is not the most frequent response (%) for any of the key causes of job satisfaction in this section, please give your reason(s):** | | | | |

| **Do you agree that the following component improves your job satisfaction?** | **Strongly Disagree (1)** | **Disagree (2)** | **Agree (3)** | **Strongly Agree (4)** |
|---|---|---|---|---|
| 5) The technical "know-how" of my supervisor | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 6) The competence of my supervisor in making decisions | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 7) The way my boss delegates work to others | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 8) The way my boss trains his/her employees | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| **9. Working conditions** | | | | |
| 1) Physical surroundings where I work | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| **10. Variety** | | | | |
| 1) The chance to do different things from time to time | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| 2) The chance to do many different things on the job | 1<br>??% | 2<br>??% | 3<br>??% | 4<br>??% |
| **If your rating for this round is not the most frequent response (%) for any of the key causes of job satisfaction in this section, please give your reason(s):** | | | | |

Appendix C: Third round instrument

Research Title: Designing HRD interventions for employee-robot interaction

Delphi - Round Three

Directions: You are presented with the stressors (Part I) and causes of job satisfaction (Part II) that achieved consensus across the expert panel. After examining average responses to them, please write your ideas and suggestions on what desirable organizational supports for nurses working with a surgical robot are.

Part I: Stress and Organizational Support

| Strongly Disagree (Value=1) | Disagree (Value=2) | Agree (Value = 3) | Strongly Agree (Value = 4) |
|---|---|---|---|
| **Do you agree that the following stressor is critical?** | | **Average Response** | |
| **1. Intrinsic job characteristics: New technology** | | | |
| 1) Preparing the Da Vinci system before surgery | | 2.63 | |
| 2) Dealing with emergency procedures if the system malfunctions or the power goes out | | 3.13 | |
| 3) Cleaning and sterilizing the robotic instruments and cleaning the nonsterile equipment | | 2.97 | |
| 4) Troubleshooting error messages | | 2.97 | |
| 5) Positioning the patient and equipment safely | | 2.90 | |
| 6) Unexpected events in the operation and functioning of Da Vinci system | | 3.17 | |
| 7) I am stressed out when I need to be careful not to make disorders of highly expensive equipment | | 3.30 | |
| **2. Intrinsic job characteristics: Workload** | | | |
| 1) Unpredictable staffing and scheduling | | 2.83 | |
| 2) Too many non-nursing tasks required such as clerical work | | 2.90 | |
| **When you consider both your opinion and average responses of all participants about the identified stressor/job satisfaction statements, what organizational support should be provided to help nurses effectively work with a surgical robot?** | | | |

| Strongly Disagree (Value=1) | Disagree (Value=2) | Agree (Value = 3) | Strongly Agree (Value = 4) |
|---|---|---|---|
| **Do you agree that the following stressor is critical?** | | **Average Response** | |
| 3) Not enough time to provide emotional support to a patient | | 2.30 | |
| 4) Not enough time to complete all of my nursing tasks | | 2.97 | |
| 5) Not enough staff to adequately cover the unit where I work | | 3.03 | |
| 6) Additional work beyond regular working time | | 3.17 | |
| **3. Conflict with physicians** | | | |
| 1) Conflict with a physician | | 3.03 | |
| 2) Criticism by a physician | | 3.70 | |
| 3) Disagreement concerning the treatment of a patient | | 2.90 | |
| 4) Fear of making a mistake in treating a patient | | 2.93 | |
| 5) Making a decision concerning a patient when the physician is unavailable | | 2.87 | |
| 6) When nurses should take the job instead of doctors | | 3.23 | |
| 7) The atmosphere in which nurses are in charge of solving problems of a robot | | 3.40 | |
| **When you consider both your opinion and average responses of all participants about the identified stressor/job satisfaction statements, what organizational support should be provided to help nurses effectively work with a surgical robot?** | | | |

| Strongly Disagree (Value=1) | Disagree (Value=2) | Agree (Value = 3) | Strongly Agree (Value = 4) |
|---|---|---|---|
| **Do you agree that the following stressor is critical?** | | **Average Response** | |
| **4. Inadequate preparation** | | | |
| 1) Feeling inadequately prepared to help with the emotional needs of a patient's family | | 2.07 | |

| | |
|---|---|
| 2) Feeling inadequately prepared to help with the emotional needs of a patient | 2.10 |
| 3) Being asked a question by a patient for which I do not have a satisfactory answer | 2.30 |
| **5. Lack of support** | |
| 1) Lack of an opportunity to talk openly with other unit personnel about problems on the unit | 2.10 |
| 2) Lack of an opportunity to share experiences and feelings with other personnel on the unit | 2.17 |
| 3)Lack of an opportunity to express to other personnel on the unit my negative feelings toward patients | 2.10 |
| 4) Colleague nurses who are not working with a robot in my operating room do not understand my situation | 3.07 |
| **6. Conflict with other nurses** | |
| 1) Conflict with a nurse supervisor | 3.03 |
| 2) Floating to other units that are short-staffed | 2.83 |
| **When you consider both your opinion and average responses of all participants about the identified stressor/job satisfaction statements, what organizational support should be provided to help nurses effectively work with a surgical robot?** | |

| Strongly Disagree (Value=1) | Disagree (Value=2) | Agree (Value = 3) | Strongly Agree (Value = 4) |
|---|---|---|---|
| **Do you agree that the following stressor is critical?** | | **Average Response** | |
| 3) Difficulty in working with a particular nurse (or nurses) outside the unit | | 2.80 | |
| 4) Criticism by a supervisor | | 3.13 | |
| 5) Difficulty in working with a particular nurse (or nurses) on the unit | | 2.87 | |
| **7. Uncertainty concerning treatment** | | | |
| 1) Inadequate information from a physician regarding the medical condition of a patient | | 3.00 | |

| | |
|---|---|
| 2) A physician ordering what appears to be inappropriate treatment for a patient | 2.90 |
| 3) A physician not being present in a medical emergency | 3.13 |
| 4) Not knowing what a patient or a patient's family ought to be told about the patient's condition and its treatment | 2.57 |
| **When you consider both your opinion and average responses of all participants about the identified stressor/job satisfaction statements, what organizational support should be provided to help nurses effectively work with a surgical robot?** | |

Part II: Job satisfaction and Organizational Support

| Strongly Disagree (Value=1) | Disagree (Value=2) | Agree (Value = 3) | Strongly Agree (Value = 4) |
|---|---|---|---|
| **Do you agree that the following component improves your job satisfaction?** | | **Average Response** | |
| **1. Ability utilization when working with a robot** | | | |
| 1) The chance to try my own methods of doing the job | | 2.93 | |
| 2) The chance to do work that is well suited to my abilities | | 2.87 | |
| 3) The chance to try out some of my own ideas | | 2.80 | |
| 4) The chance to develop new and better ways to do the job | | 2.37 | |
| **2. Achievement/Recognition** | | | |
| 1) Being able to see the results of the work I do | | 2.87 | |
| 2) Being able to take pride in a job well done | | 2.93 | |
| 3) Being able to do something worthwhile | | 2.97 | |
| 4) The feeling of accomplishment I get from the job | | 2.97 | |
| **When you consider both your opinion and average responses of all participants about the identified stressor/job satisfaction statements, what organizational support should be provided to help nurses effectively work with a surgical robot?** | | | |

| Strongly Disagree (Value=1) | Disagree (Value=2) | Agree (Value = 3) | Strongly Agree (Value = 4) |
|---|---|---|---|
| **Do you agree that the following component improves your job satisfaction?** | | **Average Response** | |
| 5) The recognition I get for the work I do | | 3.60 | |
| 6) The opportunities for advancement on this job | | 2.97 | |
| **3. Hospital policies and practices** | | | |
| 1) The policies and practices toward employees of this hospital | | 1.97 | |
| 2) The way in which hospital policies are administered | | 2.07 | |
| 3) The way employees are informed about hospital policies | | 2.13 | |
| 4) The way hospital policies are put into practice | | 2.07 | |
| 5) The way the hospital treats its employees | | 2.03 | |
| **When you consider both your opinion and average responses of all participants about the identified stressor/job satisfaction statements, what organizational support should be provided to help nurses effectively work with a surgical robot?** | | | |

| Strongly Disagree (Value=1) | Disagree (Value=2) | Agree (Value = 3) | Strongly Agree (Value = 4) |
|---|---|---|---|
| **Do you agree that the following component improves your job satisfaction?** | | **Average Response** | |
| **4. Compensation** | | | |
| 1) How my pay compares with that of other workers | | 2.00 | |
| 2) How my pay compares with that for similar jobs in other companies | | 1.83 | |

| | |
|---|---|
| 3) My pay and the amount of work I do | 1.93 |
| **5. Co-workers** | |
| 1) The spirit of cooperation among my co-workers | 2.83 |
| 2) The chance to develop close friendships with my co-workers | 2.90 |
| 3) The way my co-workers get along with each other | 2.87 |
| **When you consider both your opinion and average responses of all participants about the identified stressor/job satisfaction statements, what organizational support should be provided to help nurses effectively work with a surgical robot?** | |

| Strongly Disagree (Value=1) | Disagree (Value=2) | Agree (Value = 3) | Strongly Agree (Value = 4) |
|---|---|---|---|
| **Do you agree that the following component improves your job satisfaction?** | | **Average Response** | |
| **6. Social service** | | | |
| 1) The chance to be of service to patients | | 2.80 | |
| **7. Social status** | | | |
| 1) The chance to "rub elbows" with important people | | 2.80 | |
| 2) The chance to be important in the eyes of others | | 2.93 | |
| 3) The chance to have a definite place in the community | | 2.87 | |
| **8. Supervision** | | | |
| 1) The way my supervisor and I communicate with each other | | 2.57 | |
| 2) The way my boss handles his/her employees | | 2.13 | |
| 3) The way my boss addresses the complaints of his/her employees | | 2.13 | |
| 4) The way my boss provides help me with hard problems | | 2.17 | |
| **When you consider both your opinion and average responses of all participants about the identified stressor/job satisfaction statements, what organizational support should be provided to help nurses effectively work with a surgical robot?** | | | |

| Strongly Disagree (Value=1) | Disagree (Value=2) | Agree (Value = 3) | Strongly Agree (Value = 4) |
|---|---|---|---|
| **Do you agree that the following component improves your job satisfaction?** | | **Average Response** | |
| 5) The technical "know-how" of my supervisor | | 2.77 | |
| 6) The competence of my supervisor in making decisions | | 2.63 | |
| 7) The way my boss delegates work to others | | 2.57 | |
| 8) The way my boss trains his/her employees | | 2.20 | |
| **9. Working conditions** | | | |
| 1) Physical surroundings where I work | | 2.87 | |
| **10. Variety** | | | |
| 1) The chance to do different things from time to time | | 2.80 | |
| 2) The chance to do many different things on the job | | 2.83 | |
| **When you consider both your opinion and average responses of all participants about the identified stressor/job satisfaction statements, what organizational support should be provided to help nurses effectively work with a surgical robot?** | | | |