Is it Health Information Technology? Task Complexity and Work Substitution

Abstract

New technology is making it possible to replace professions built on complex knowledge, e.g. medicine. In our exploratory research we examined how Information Technologies might be replacing some of the tasks formerly processed by physician anesthesiologists (MDAs). Data (N=1178) were collected at a specialized hospital in the Netherlands. We observed the tasks carried out by fourteen MDAs during their daily work in the operating room and map these tasks to McGrath’s (1984) circumplex. Our results show that MDAs frequently carry out two or three tasks concomitantly; mainly intellective, planning and psychomotor tasks. Based on the results of the interviews, we find that MDAs feel ill equipped on conflict resolution and negotiation tasks. Yet they feel it is exactly on those segments where their added value lies. Information Technologies may outsmart MDAs where they spent most of their time: in planning, problem solving and psychomotor tasks.

Keywords

Healthcare information technology, anesthesiology, task technology fit, work substitution

Introduction

The impact of new technologies on employment and the polarization of wages have given rise to many academic debates (Goldin and Katz 2009). In the early 18th Century luddites saw job destruction by machines as a part of a greater class division. Krugman (2013) stated his sympathy for the luddites. He wrote: “Today, a much darker picture of the effects of technology on labor is emerging. In this picture, highly educated workers are as likely as less educated workers to find themselves displaced and devalued, and pushing for more education may create as many problem as it solves” (p.A27). Goos and Manning (2007) explained the decline in the number of jobs through “routinization”, where routine tasks are taken over by technologies. Apparently, the declining demand for labor is linked to how well tasks can be processed by machines instead of humans with an average level of education. Technology has a competitive advantage when it comes to conducting structured and repetitive tasks (Brynjolfsson and McAfee 2014). Nowadays, not only routine but non-routine cognitive tasks, such as complex decision-making can be substituted by technology (Frey and Osborne, 2013). Innovation ultimately creates new practices transforming our day-to-day interaction with the world and with each other (Grinbaum and Groves 2013).

In this article we examine some of the challenges posed to the Medical Doctor of Anesthesiology (MDA) with the introduction of Health Information Technology (HIT). Particularly, we focus on the way HIT may fully or partially substitute MDAs in their daily routine in the operating room. The potential advantages of HIT have been well documented in the MIS literature (Christensen et al. 2000; Goldschmidt 2005; Kaplan and Porter 2011; Kim and Michelman 1990; Romanow et al. 2012). For example, in the operating room, patients’ physiological reactions to medication are nowadays monitored in real time by medical software (Modell, 2005). It is plausible that one day MDA may ultimately be replaced by HIT.
Our motivation to choose the profession of MDA is twofold. First, in the United States, a heated debate between certified registered nurse anesthetists (CRNAs) and MDAs has been going on regarding the permission for CRNAs to provide patient care without the supervision of MDAs (Neeld 2013). In the Netherlands, a similar phenomenon is occurring, where an increasing number of tasks previously in the hands of MDAs are now fulfilled by nurses and physician assistants assisted by technologies (Klei 2008). This is providing hospitals with opportunities for cost-saving. The overarching topic of the aforementioned debates has been the value provided by MDAs. Questions were posed on what this value is exactly comprised of. Therefore, we aim to gain insight into the value provided by MDAs. Second, technological progress has manifested itself especially in the profession of MDAs. The first robot to completely automate anesthesia was developed in 2008 and a wide range of technologies has seen daylight since. Certainly, this raises questions on how technology will shape the future of the profession (Miller 2009).

Once health care costs started to spiral, anesthesiology became exposed to market forces disruptive of its business model (Shapiro 1997). Hospital administrators, managed care administrators and insurers perceive MDAs as too expensive in the light of the limited services they offer (Shapiro 1997). The prevailing view that the profession of medicine revolves around monopoly and domination make medicine in general, and anesthesiology in particular, an easy scapegoat (Larson et al. 2013).

In this article, we assume that the combination of economic challenges and the introduction of efficient HIT in the operating room is accelerating the phenomenon of work substitution of high knowledge workers such as the MDAs. We seek to answer the following research question: Is the profession of anesthesiology losing its value in the operating room to the point of being substituted by healthcare information technology (HIT)? If so, why is this the case? Also, we take a glimpse on the consequences for the future of the profession.

In this article, we report the results of an exploratory study consisting of shadowing fourteen MDA during a working day in the operating room. Our research has taken place in a Dutch hospital specialized in the treatment of various types of cancer. In order to assess the “value” of MDAs in the operating room, we adapted the circumplex model of group tasks of McGrath (1984) to classify task complexity. We then applied the classification to the tasks conducted by fourteen MDAs, resulting in a set of 1,178 observations. Additionally, after each working day we conducted interviews with the MDAs regarding their perceptions and opinions about their tasks.

The article is organized as follows. The first section presents the literature overview of task complexity in anesthesiology as well as the adaptation of McGrath’s (1984) task typology to the profession of anesthesiology. The methodology used to conduct the shadowing observations is presented in the second section. Before describing the limitations of our study and proposing further lines of research, the results of the shadowing observations are reported in detail and discussed in relation to actual technological innovations in the field.

Overview of Task Complexity Applied to the Profession of Anesthesiology

In order to answer the first research question “Is the profession of anesthesiology losing its value in the operating room to the point of being substituted by healthcare information technology (HIT)? we selected task complexity as a proxy of professional value. We consider the complexity of the profession of anesthesiology to be reflected by the task MDAs perform as well as the educational track required to enter the profession. In the Netherlands, it takes a total of 11 years to become a certified anesthesiologist: 6 years of university medical studies to become a physician (i.e. Medical Doctor) and another 5 years of university specialized education to become an MDA. In the following lines, we shall succinctly describe the profession of MDA.

The function of the MDA within the surgical team is to make sure that the patient suffers no pain and that all important functions of the body remain properly functioning during and after the surgery. During a typical surgery, the anesthesiologist will either deliver a general anesthetic or a so called regional technique to the patient. During a general anesthetic the patient sleeps and is numb to pain during the operation. For a regional technique the MDA numbs the part of the body to be operated by means of an injection. In practical terms, there is no difference in risk between general anesthetic and a regional
anesthetic technique. Another important function of the MDA is to determine potential risks prior to the surgery. In this so called preoperative screening, the anesthesiologist checks the patient's history and carries out a physical examination to determine how much risk a specific surgery might pose to the patient. For example, if the patient suffers from diabetes and needs to undergo surgery, the MDA investigates the condition of important organs such as the heart and kidneys and optimizes them prior to the day of surgery. The MDA prepares an anesthetic plan to counteract the potential effects of surgery for the patient. After the surgery, the patient spends time under observation in the so called recovery room. The function of the MDA in the recovery room is to oversee that the bodily functions function correctly and that your pain level remains acceptably low.

Improved scientific knowledge, education of the practitioners and monitoring of vital functions have contributed to the current very low risks of complications or death due to anesthesia. The risk of someone dying due to anesthesia is estimated to be less than 1 in 250,000 anesthetics. It has been calculated that a person is more likely to die struck by a lightning than to die due to an anesthetic. However, while these risks seem to be low, they are not always completely absent. Even a simple surgery is perceived by our body as an aggression to the system starting with tissue damage. For example, sometimes adverse effects to medication, or an unforeseen situation during surgery such as blood clot, can lead to severe accidents and eventually death.

The degree of organizational formalization and task-interdependence is high in the operation room (Makary et al. 2006). The surgical team is composed of smaller sub-groups such as surgeons, surgical nurses, MDA and certified registered nurse anesthetists. Research in the operating room has demonstrated that workload density of these professionals may vary significantly as function of the case complexity (Weinger and Slagle 2001). Training of MDA requires acquisition of a large set of attributes ranging from clinical knowledge to technical skills. The actual tasks processed by MDA spread from pain management, critical care medicine, pediatric anesthesia, cardiac anesthesia and other subspecialties (Miller and Pardo, 2011). Anesthesiologists play a leading role in preoperative evaluation of the patient, during surgery and in the post anesthesia care unit.

Different task classifications have been used in anesthesiology including time-motion tasks, secondary probing and self-assessment. Other examples of task classification in anesthesiology is the intubation difficulty scale (Adnet et al. 1997) and the drug/ fluid administration task categories (Fraing et al. 2002), both tracking the performance of a single manual skill. Most classification exclude inter-group negotiation, conflict resolution or programming tasks (Weinger et al. 1994; Weinger and Slagle 2001). The classification of non-technical skills in anesthesia (Fletcher et al. 2002) for example does not include psychomotor skills. Our preference to use the McGrath circumplex (1994) over other classifications used in anesthesiology was based on the comprehensiveness of the model. Indeed, tasks carried out by MDAs include problem solving, knowledge transfer, and even defense mechanisms against outside groups (Forsyth 2006). In organizational behavior, the time-tested McGrath circumplex model offers a comprehensive and exhaustive classification of all the possible tasks carried out by groups (Straus 1999).

The McGrath's circumplex (see Figure 1) consists of four quadrants: Generate, Choose, Negotiate and Execute.
As depicted in Figure 1, and based on two continua, namely Conflict-Cooperation and Conceptual-Behavioral, the quadrants are divided into two segments each: “planning” and “creating” in the Generate quadrant, “solving problems with clear-cut solutions” and “solving value-laden problems without clear solutions” in the Choose quadrant, “resolving conflicts of viewpoint” and “resolving conflicts of interests” in the Negotiate quadrant, and finally “resolving conflicts of (physical-) power” and “performing psycho-motor functions” in the Execute quadrant. Each segment represents therefore a task. Task types flow seamlessly into each other. For example, type 4 task “Deciding issues with no right answer”, where issues are value laden as in moral or ethical questions is the logical continuation of type 3 task “Solving problems with correct answers”, where answers are right or wrong, and precedes type 5 task “Resolving conflicts of viewpoint”.

In order to assess the “added value” of MDA, we adapted the model to classify the tasks performed by the MDA in the operating room. After describing each task, Table 1 provides an associated example applied to the field of anesthesiology. The examples were written by an expert MDA, and peer-reviewed by two other MDA expert in their field.

<table>
<thead>
<tr>
<th>#</th>
<th>Task</th>
<th>Description</th>
<th>Example(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Planning</td>
<td>Programming towards a goal that has been previously identified</td>
<td>Patient and operating team including surgeon(s), scrub nurses, anesthesiologist, gathers to agree on which type of procedure is about to take place, what the approach will be, what type of anesthetic will be delivered, expected problems ahead, and solutions, system checks, blood availability, pre-existing medical history, allergies, antibiotic therapy</td>
</tr>
<tr>
<td>2</td>
<td>Creativity</td>
<td>Generating and expressing ideas</td>
<td>Anesthesiologist brainstorming with surgeon about possible causes and course of action</td>
</tr>
<tr>
<td>3</td>
<td>Intellective</td>
<td>Solving problems with correct answers: true or not true</td>
<td>Patient and operating team including surgeon(s), scrub nurses, anesthesiologist, gathers to agree on which type of procedure is about to take place, what the approach will be, what type of anesthetic will be delivered,</td>
</tr>
</tbody>
</table>
Is it HIT? Task Complexity and Work Substitution

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<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4 Decision Making</strong></td>
<td>Issues with moral or ethical load for solution is not of true/ not true nature</td>
<td>End-of-life decisions (whether to resuscitate or not, and considerations that lead to decisions) in terminally ill patients</td>
</tr>
<tr>
<td><strong>5 Cognitive Conflict</strong></td>
<td>Resolving differences of viewpoint</td>
<td>Discussing acceptable positioning: preference of surgeon does not match that of anesthesiologist, the former concerned about optimal access to surgical site, and the latter concerned with possible nerve injuries.</td>
</tr>
<tr>
<td><strong>6 Mixed-motive</strong></td>
<td>Resolving differences where conflict of interests arise</td>
<td>Two different surgeons pressuring the anesthesiologist to get first access to operating room time, for example during evening hours with two different emergent cases</td>
</tr>
<tr>
<td><strong>7 Contest/battle competitive</strong></td>
<td>Resolving conflicts of power</td>
<td>Anesthesiologist and surgeon debating who has the authority to make a decision</td>
</tr>
<tr>
<td><strong>8 Performance</strong></td>
<td>Benchmarking psychomotor tasks against standard</td>
<td>Inserting intravenous catheter, positioning of the patient</td>
</tr>
</tbody>
</table>

Table 1, Adaptation of McGrath (1984) to the Profession of Anesthesiology

**Research Method**

**Participants and Data Collection**

Data was collected in a Dutch hospital specialized in the treatment of various types of cancer. In order to conduct the study, we received a waiver by the medical ethical committee of the University of Groningen to conduct the study. The fact the observer was an expert MDA was key to grant the authorization. Indeed, it was assessed that an expert MDA would be very familiar with the operating room environment, to avoid compromising patient safety. Additionally, it would have been difficult, even impossible, for a non-MDA to grasp the nature of many tasks being carried out by MDA because a non-MDA would not be able to make sense of the situation. For example, when a MDA is preparing medication he has already assessed the state of the patient and taken into account how long the operation will take. A non-MDA may interpret this task as simply intellective. In reality such observation should be classified as a dual task requiring both intellective and planning skills (i.e., choose and generate quadrant). Additionally, being observed by a fellow MDA increased trust amongst the MDA as explained by Holloway and Wheeler (2013, p. 8).

We recognize that the fact the observer was an MDA may be perceived as a bias (Kanuha 2000). To ensure objectivity, full descriptions of the tasks conducted were recorded and the categorizations on McGrath’s task typology were checked by the second author. The second author also accompanied the observer for one day to get a grasp on the work of the MDA and to understand the observation process fully. All MDAs working at the cancer hospital gave consent to be shadowed by the observer. The results were treated confidentially and were not reported to hospital management.

The MDAs were shadowed for the entirety of their workday in the operating room. In total of 87 hours and 06 minutes of observations (m=6.15 hours per MDA) were recorded. At the end of each working day the observer conducted a debriefing with the MDA. He reflected on the way data was classified. Also, he collected data on their opinions regarding the future of the profession of anesthesiology. Particularly, the participants were asked about where their strengths and weaknesses on the McGrath framework lay. Also, they were questioned about the challenges of the profession and its possible substitution by HIT.

Data was collected from fourteen MDAs, to assure that potential individual variation caused by differences in, for example, working experience between MDAs could be detected. The participants who
took part in the study were mostly female (64%) ranging from 35 to 64 years old, with a mean age of about 44 years of age. Their post-residency experience ranged from 1 to 33 years.

The unit of analysis is the work conducted by anesthesiologists at the task level. It is represented by the number of hits corresponding to one task performed in one of the segment of one of the four quadrants. Frequently, the observer reported multiple hits spanning several task types simultaneously during his observations. This way of classifying the data specially addresses multi-tasking. It also provides detailed information on the combinations between the different types of tasks, instead of just providing a purely sequential overview based on single hits. The time of the day as well as the duration in seconds of every observation were recorded.

**Results**

A total of 1,178 hits were recorded during the shadowing study. As presented in Table 2 the tasks of the MDA were concentrated around the following quadrant: Choose (46.86%), Generate (27.67%), Execute (25.21%) and Negotiate (0.25%).

<table>
<thead>
<tr>
<th>Quadrant</th>
<th>Hits</th>
<th>%</th>
<th>Task</th>
<th>Hits</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generate</td>
<td>326</td>
<td>27.67%</td>
<td>Planning</td>
<td>320</td>
<td>27.16%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Creativity</td>
<td>6</td>
<td>0.51%</td>
</tr>
<tr>
<td>Choose</td>
<td>552</td>
<td>46.86%</td>
<td>Intellective</td>
<td>552</td>
<td>46.86%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Decision making</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Negotiate</td>
<td>3</td>
<td>0.25%</td>
<td>Cognitive conflict</td>
<td>3</td>
<td>0.25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mixed motive</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Execute</td>
<td>297</td>
<td>25.21%</td>
<td>Contests/battles/ competitive</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Psychomotor performance</td>
<td>297</td>
<td>25.21%</td>
</tr>
<tr>
<td><strong>1178</strong></td>
<td><strong>100.0%</strong></td>
<td></td>
<td><strong>1178</strong></td>
<td><strong>100.0%</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2, Hits Distribution**

While categorizing hits based on the number of tasks we found out that the MDAs mostly performed two tasks in parallel during 46.4% of their time or three tasks during the other 14% of their time. A maximum of three tasks performed concomitantly was observed during the 87 hours 06 minutes of actual shadowing. For example, a MDA was observed carrying out an intellective task while performing a planning task and at the same time resolving a conflict of viewpoint with the surgeon (cognitive conflict task). Figure 2 presents the classification per hits under two tasks (dual), or more than three (multi-tasking).
Figure 2. Classification of hits and time as function of the number of tasks performed

As depicted in the upper part of Figure 2, the results indicate that when MDA process a single task they principally operate at the intellective level. The intellective level addresses features the need to find correct answers to the problem in a cooperative way. An example of intellective task in this context would be answering a query from a nurse regarding which drug to administer to a patient suffering from pain and at which dose. Often, the MDA needs to process two tasks concomitantly. In such situation the task are interrelated and require parallel processing. This is for example the case of an anesthetic induction, i.e., putting the patient to sleep prior to surgery. A standard anesthetic induction covers planning task (e.g., agreeing with the nurse on distribution of tasks, using of specific drugs, pain relief, and muscle relaxation) and intellective task (e.g., double checking medication with nurse, explaining to the patient what will happen before she falls asleep).

When handling three tasks at a time, MDAs are often engaged in psychomotor tasks, executing medical care for the patient, while generating planning and performing intellective tasks. In this situation it is clear that they are using different memory registries to execute, generate and choose. It is worthwhile noting that the time investment in these sequential tasks is less than when the MDA focuses on a psychomotor monotask of the same type.

Distribution of the hits based on the time spent per task The results presented in Table 3 show that MDA spent about 44 minutes dealing with cognitive conflict tasks at the conceptual level. Relatively, more time is spent on creativity tasks (one and a half hours), where, the MDA will be generating ideas to improve the patient situation and care.
<table>
<thead>
<tr>
<th>Quadrant</th>
<th>Total Time</th>
<th>Task</th>
<th>Total Time Spent</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generate</td>
<td>24:51:59</td>
<td>Planning</td>
<td>23:14:47</td>
<td>0:04:17</td>
<td>0:05:53</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Creativity</td>
<td>1:37:12</td>
<td>0:12:09</td>
<td>0:18:45</td>
</tr>
<tr>
<td>Choose</td>
<td>37:13:57</td>
<td>Intelective</td>
<td>37:13:57</td>
<td>0:04:02</td>
<td>0:05:28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decision making</td>
<td>0:00:00</td>
<td>0:00:00</td>
<td>0:00:00</td>
</tr>
<tr>
<td>Negotiate</td>
<td>0:44:26</td>
<td>Cognitive conflict</td>
<td>0:44:26</td>
<td>0:22:13</td>
<td>0:11:06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mixed motive</td>
<td>0:00:00</td>
<td>0:00:00</td>
<td>0:00:00</td>
</tr>
<tr>
<td>Execute</td>
<td>24:16:14</td>
<td>Contests/battles/competitive</td>
<td>0:00:00</td>
<td>0:00:00</td>
<td>0:00:00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Psychomotor performance</td>
<td>24:16:14</td>
<td>0:04:53</td>
<td>0:05:41</td>
</tr>
<tr>
<td>Total</td>
<td>87:06:36</td>
<td></td>
<td>87:06:36</td>
<td>0:04:39</td>
<td>0:05:08</td>
</tr>
</tbody>
</table>

Table 3. Distribution of the hits based on the time spent per task

The results of the interviews show that the majority of MDA does not experience many challenges on a daily basis. They operate under a certain routine or situation of “underload”. “A quiet day, without much in the way” or “I found no challenges”. Quotes such as “It was a boring day” typifies the encountered routine by MDAs. If anesthesiologists did experience some challenges it was when they encountered unexpected difficulties performing a technique “… placing the double lumen tube because of the right lung lobe” or “the fiberoptic intubation in the female patient with the difficult anatomy”.

They characterized multitasking has “the challenge of remaining friendly and stress-free”. One MDA added that “multitasking goes on the whole day, non-stop (…) if it at some points it gets too much, hopefully it does not all happen at the same time. If it does the whole situation can capsize.”

When the MDAs were asked about where on the model they felt at ease, they pointed at planning, creativity, decision making, and at dealing with psychomotor skills e.g., performing neural blocks or intubating patients. Anesthesiologists reported to feel less at ease when they had to deal with the negotiating quadrant: “I really dislike power conflicts”. Another MDA added “negotiating drains me, I tend to get angry instead of keeping a rational approach”. Interestingly, one MDA reported “I avoid conflict”. Striking, is that the MDA themselves, did not perceive their added value. However, they very clearly stated that it will be a challenge substituting them regarding creativity, decision making, cognitive conflict and mixed motive tasks.

**Discussion**

We conclude that MDAs spend most of their time in the operating room executing tasks (e.g., psychomotor and planning) which are nowadays efficiently substituted by HIT. Also, they avoid the negotiating part of their profession. Indeed, the results of our research indicate that MDAs spend their time performing psychomotor, intellective and planning tasks and significantly less time in negotiation tasks. Additionally, they explicitly recognize that they have poor negotiation skills or avoid conflict/discussion with the surgeon. However, such negotiation skills to solve tension and disagreement maybe key to the well-being of the patient.

Compared to HIT, the added value of MDA profession mostly resides in their decision-making and intellective skills rather than their psychomotor or planning skills. In other words, they should operate in the McGrath “Choose” and “Negotiate” quadrants rather than “Execute” and “Generate.” As a matter of fact, new technology will be able to take over psychomotor skills as well as planning drug concentration, assisting in the placement of nerve blocks by guiding the needle with the help of ultrasound or aiding tracheal intubations guided by a joystick (Hemmerling et al. 2013; Hemmerling, Taddei, et al. 2012; Hemmerling, Wehbe, et al. 2012; Wehbe et al. 2012).
Congruently with Sandberg (2009) and Kapur (2012), our advice to the MDA would be to expand their scope of tasks outside of the operation room. MDAs should engage in better serving patients and their families, including ethics, active patient advocacy and alliance with surgeons (Hug 2000). Additionally we support Longnecker’s (1997) argument that alternative forms of practice, education and research are necessary in a landscape of disruptive changes. MDAs are lacking such social skills and have been described in the literature as shy, inhibited, cold, and with little engagement in interacting with patients (Borges and Osmon 2001). Weinger et al. (1994) stated that “a comprehensive description of the task requirements of the anesthesia job would suggest ways to improve anesthesiology training” (p.78). It will be key to reinforce the curriculum of the MDA through extensive training of medical knowledge.

We define multitasking as accomplishing several goals within a certain period of time by switching amongst tasks (Goonetilleke and Luximon 2010). Multitasking is particularly desirable in the profession of anesthesiology. Our results show that MDAs frequently perform two or three concomitant tasks. They must typically divide their attention between planning and intellective tasks. Additionally, MDAs have to deal with various sources of physiological data to ensure the health and safety of patients delivered by HIT (Ferris and Sarter 2011). Additionally, MDAs in the Netherlands supervise two operating rooms, the holding bay and the recovery room in parallel. On top of that workload they must juggle scheduling problems in the ward while processing information through patient data management systems and their portable telephone. The financial reasons for multitasking stems from the costs that a one-on-one ratio of supervision would entail. In the United States as in the Netherlands, managed care, bundled-payment, and capitated payment models have negatively influenced the availability of the anesthesiologist to stay in one single operation room (Wagner 2006).

We argue that being pushed to multitask increases the risk that the MDA be increasingly substituted by HIT. The emergence of monitoring and mobile technologies in the operating room has in fact reinforced the idea MDAs are “absent”, or easy to substitute. MDAs are physically substituted by the technologies they are using to track the patient. Interestingly, MDA have developed and embraced new HIT such as the vibrotactile display monitoring system (Ferris and Sarter 2011). However, at the same time they have failed to consider how much technology contributes to the false perception that safety can be maintained while the MDA is absent from the operating room, or not focused enough because he or she is engaged in multi-tasking. The fact MDA are involved in several distinct locations may be resulting in the overall perception that they are absent from a specific location (Epstein and Dexter 2012). Additionally, multitasking might influence the team’s perception regarding their workload density (Gaba and Lee 1990). Paradoxical is that HIT such as monitoring systems or simple technologies such as mobile phone or beeper have increased their work flexibility from one operating room to another one (Loeb 1994). Additionally, we argue that MDAs covering several sites and relying on snapshots of data fed by technology might not get the full picture of what goes on with the patient under surgery. Inefficient attention allocation translates into a significant portion of anesthesia-related patient injuries (Cooper et al. 1984; Walsh and Beatty 2002).

When the trends described previously continue, the MDA will be to blamed and not the technology. This will open the road to even more HIT to substitute the MDAs “inability” in handling emotional and cognitive overload (Rutkowski et al. 2013). Errors will be attributed to human factors misinterpreting information delivered by HIT (Walsh and Beatty 2002).

In the future, decision-support systems will help anesthesiologists with calculations and decrease the amount of data they have to monitor. These systems reduce the chances of human error (Wehbe e al. 2014). Closed-loop systems include subsystems that can be used for general anesthesia (Zamprelli 2008) and systems that provide “minimal-to-moderate” sedation (Health Center for Devices and Radiological 2013). Ultimately, automatic monitoring in a multi-location system, such as the one in the Netherlands or in the USA, make it feasible to substitute the MDAs by professionals with a lower level of education such as nurses or physician assistants. In this context, the substitution will be caused mostly by the de-skilling in the capacity of interpreting what technology and clinical signs are pointing at.

The limited number of subjects is a caveat to this exploratory study as well as the fact it was collected at the same hospital. Data are actually being collected in two other hospitals. One of the hospitals is a teaching institution for the training of new anesthesiologists and offers a very varied palette of surgical specialties, including pediatrics, cardiac, and major organ transplantation.
Also, it appears essential to extract scientifically the “absence” of the MDAs from the operating room and its effect on team perception. Finally, it would be interesting to reproduce the study in a high-tech operating room and assess carefully HIT usage. Finally, our proxy of the MDA added value is questionable and limited to the Netherlands. It would be interesting to assess the added value in financial term, to better grasp the balance HIT/ Education cost of high knowledge worker.

Conclusion

This exploratory study is to our knowledge the first study systematically looking into task complexity, HIT and high knowledge worker work substitution. While the added-value of MDA lies in their high level of knowledge and their capacity to solve complex problems, we concluded that future HIT will probably outsmart MDA. HIT are designed to support decision making activities, planning tasks as well as executive robotic “hand-driven” procedures in the OR. The results of this study show that these three types of tasks are the very same ones where MDAs spend most of their clinical time and feel the most at ease with.

Since the 1990s, efforts of integration amongst technologies in the operating room to support the MDA workload has occurred. Using a single monitoring device, MDAs are nowadays able to monitor brain activity, vital signs and administered medication. Nowadays, computers are not only becoming better and faster, they are also learning new skills and capabilities. Even unstructured and complex tasks can be conducted by technology, in a more financially advantageous manner than if it were done by a human being (Autor and Dorn 2013; Frey and Osborne 2013). In the future so-called “fly-by-wire” technology could be applied to anesthesiology (Tremper 2011). MDAs would “fly” the patient by using rudder-like equipment displaying information in a more intelligent way. Such technological innovation may push the high knowledge professionals out of the operating room as their added value will become too expensive for our society. No doubt the road to full substitution will be long and seeded with obstacles. However it is all but unavoidable that automatization will gain ground in anesthesiology as it has gain ground in almost every single sector of the economy (Chambers and Nagel 1985; Chialastri 2012).

To conclude, organizational literature has already pointed at the political nature of redrawing structural boundaries of a profession (Abbott 1988; Freidson 1970). It is time to look at this point to what extent automation and technologies should substitute anesthesia professionals (Shelley 2008) but also other professions to avoid human deskilling.

References


Is it HIT? Task Complexity and Work Substitution


