Are "Human Factors" the Primary Cause of Complications in the Field of Implant Dentistry?

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Complications in medicine and dentistry are usually analyzed from a purely technical point of view. Rarely is the role of human behavior or judgment considered as a reason for adverse outcomes. When the role of human factors is considered, these are usually described in general terms rather than specifically identifying the factors responsible for an adverse event. The impact of cognitive and behavioral factors in the explanation of adverse events has been studied in other high-stakes areas such as aviation and nuclear power. Specific protocols have been developed to reduce rates of human error, and, where human error is unavoidable, to lessen its impact. This approach has dramatically reduced the incidence of accidents in these fields. This article aims to review how a similar approach may prove valuable in the reduction of complications in implant dentistry. Int J Oral Maxillofac Implants 2017;32:e55–e61. doi: 10.11607/jomi.2017.2.e

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Failures in the field of implant dentistry are generally analyzed from a "technical" perspective, with these failures being placed into two main categories: mechanical and biologic complications. Conversely, the role played by the practitioner and their team in the success of dental implant procedures is rarely explored.[1,2]

By contrast, in the aviation field, it has been proven that almost 80% of accidents are linked to human error. Likewise, large-scale studies in the field of medicine reveal an incidence of diagnostic errors ranging from 5% to 20%.[3] For instance, Graber et al[4] showed that the lack of knowledge only accounted for approximately 5% of the diagnostic errors in medicine. The actual reasons for medical errors are faulty synthesis, premature closure, faulty context, errors from the use of heuristics, etc. As a result of such studies, professionals in numerous medical and paramedical specialties, including surgical oncology,[5] anesthesiology,[6] and veterinary medicine[7] recognize the risk associated with "human factors" and are intervening to reduce such risks.

The aim of this article is to demonstrate how consideration of nontechnical factors, described herein as "Human Factors,"[8–12] offer a new perspective, thereby enabling a better understanding of the root causes of many complications/failures in dental implant practice. Ultimately, appreciation of these factors will result in improved practice safety and clinical outcomes.

Knowledge and Know-how

Decision-making is part and parcel of the daily routine of health professionals. The process is always very similar. Confronted by a clinical scenario, whether routine or new, the practitioner will first collect data (clinical examination), and then will analyze these data to retain the information that is useful and relevant before collating this information in such a way as to be able to establish a diagnosis.

Practitioners may discuss the prognosis and come to an assessment of the long-term effectiveness of the treatment that they are intending to use. The effort required of the practitioner to take this succession of decisions may depend on their clinical experience. Generally speaking, experts will rapidly identify the key criteria that must be taken into account. In contrast, inexperienced practitioners may fail to see the proverbial forest for the trees as they account for every possible factor, not realizing that some of those factors may be irrelevant.

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The causes for failure or adverse events are frequently unrelated to a lack of knowledge, but instead to an inability to apply this knowledge appropriately. This is well illustrated in a study by Le et al,[13] in which the authors asked dental students to administer an emergency procedure during a simulated dental emergency. Only 15% of the students managed to implement the protocol within the specified time frame. Paradoxically, almost all the students were capable of verbalizing the proper protocol for this particular emergency. This demonstrates that familiarity with a protocol does not necessarily translate into appropriate implementation. This is particularly the case for inexperienced practitioners, but it may also affect highly experienced practitioners when they are operating in an unfamiliar environment or under heightened stress levels.

Competence and Performance

If implant dentistry is considered, it is possible to say that placing implants is, in purely practical terms, a relatively straightforward procedure. Almost any dentist can insert an implant into a plastic model. However, the quality of treatment patients receive varies from practitioner to practitioner, and the quality of individual practitioners' efforts can change over the course of a day, even in the case of simple procedures.

These variations can be explained, in part at least, by considering the concepts of competence and performance.[14,15] Competence is defined as all the knowledge and experience possessed by an individual at a given moment in their career. Performance is the ability of this individual to use their knowledge and experience in a specific environment, at a specific moment in time. It may be readily understood that an individual surgeon's performance may suffer if they are tired, stressed by a particularly difficult procedure, or distracted by personal issues, despite the fact that their level of competence has by its very nature remained the same.

Numerous studies have been performed in the aviation industry to assist in identification of the factors that can negatively affect the performance of pilots and other workers. Several authors[11,16,17] have used data from these studies and applied them to the medical world, highlighting the impact that the behavior of the practitioner and their team can have on the quality of treatment received by patients. Where levels of competence are taken to be equal, variations in the quality of treatment dispensed during a given procedure may be put down to attitudes adopted by the practitioner and/or their ability to cope with stress.

The Impact of Practitioner Attitudes Upon the Incidence of Medical Errors

Fabri and Zayas-Castro[18] analyzed 9,830 surgical procedures in British hospitals. Complications were observed in 3.4% of cases, which is comparable to many European countries. In this study, 78.3% of these complications were directly linked to "nontechnical" errors, ie, errors not resulting from organizational or system errors, but rather made by members of the surgical team (overly steep authority gradient within the team, lack of communication or miscommunication, fatigue, stress, etc). Likewise, Brennan et al[19] performed an analysis of 30,121 randomly selected records from 51 randomly selected acute care, nonpsychiatric hospitals in New York state, USA. This chart review identified adverse events in 3.7% of hospitalizations, 27.6% of which were due to negligence on the part of one of the members of the medical team. Considering these studies, the practitioner's attitude— not just "technical" factors— may be a key factor in determining whether the procedure undertaken will be a success or a failure.

In the aviation field, there are five commonly identified hazardous attitudes/behaviors that will increase the likelihood of complications during the implementation of a procedure.[20,21] These are impulsiveness, anti-authority attitude, feeling of invulnerability, "macho" attitude or, conversely, attitude of resignation (Table 1). The first four attitudes lead the individual thus affected to "drop their guard." This may result in overestimation of the ability to perform complex or risky procedures. Clinicians may embark on a particular course of treatment to address a complex medical case despite less-than-ideal conditions from a patient safety point of view. Conversely, an attitude of resignation will result in extreme caution being exercised, with the attendant risk of sometimes failing to propose the optimal course of treatment for each patient out of fear of the challenges involved or worries about possible failure. Similar attitudes and behaviors were found in the medical world when Bruinsma et al[22] questioned 364 orthopedic surgeons. Responses demonstrated that 30% of those interviewed possessed attitudes that were potentially hazardous with regard to their patients. These results were confirmed by the findings of Kadzielski et al[23] from a sample of another 41 orthopedic surgeons.

To bring about improvements in the safety of everyday working practices, it is important to recognize that although experience enables knowledge of "how" to treat patients effectively, having the "right attitude" enables treatment of patients only when certainty of the appropriateness of the course of treatment or action is known. Factors influencing the individual performance of each practitioner must also be taken into account (eg, fatigue). At the same time, having the right attitude does not offer complete protection against making errors. Excess stress or poor stress management may have a negative impact on the quality of treatment dispensed.

Table 1 Five Hazardous Attitudes/Behaviors

Attitude	Characteristics
Impulsiveness	"Quick, quick, quick!" The impulsive practitioner feels the need to do everything quickly. They only think about what they are going to do, and they immediately do the first thing that comes into their head.
Anti-authority	"Don't tell me what I have to do." The practitioner affected by an anti-authority attitude thinks that rules, regulations, and procedures are of no use, or are not designed for them. They think that nobody has the right to tell them how to behave. This attitude is quite common among professions where individuals usually work on their own, such as dentists.
Invulnerability	"That couldn't happen to me." Some people think that accidents only happen to others. This analytical bias affects everyone to some degree but may be particularly marked in certain individuals.
Macho	"I can do this." Macho practitioners try to demonstrate their superiority over others. Although this is a predominantly male attitude, it may also affect female surgeons.
Resignation	"What's the use…" The practitioner affected by resignation does not believe that their actions make any difference to whether an outcome is a success or a failure. Sometimes this kind of practitioner will give in to unreasonable demands from patients just to be "nice."

From Renouard and Charrier.[21]

Stress: A Protective Behavioral Response

Stress occurs when someone feels that there is a "shortfall" between the personal resources/skills that they perceive themselves as possessing, and the skills they feel they actually need to deal with the obstacles (as they perceive them) that are encountered in their environment.[24,25] Stress may also be explained in terms of tension centering on the mobilization of hard-to-access resources: knowledge is there but it is not immediately accessible. This may perturb the individuals in question, who find themselves in an uncomfortable situation. Generally speaking, it is not the situation itself that induces stress; it is the perception of the situation.[26] For human beings, 90% of stress is endogenous, "self-inflicted," in other words, a product of the imagination rather than of actual circumstances.

Everyone will, at one time or another, have experienced the negative impact stress can have on their capacity to perform a procedure or deliver a treatment to the best of their ability. It is important to understand why stress can have so many negative effects.[27] To do so, it is necessary to consider the original evolutionary purpose of acute stress, which, like pain, is a warning signal designed to protect the individual against real danger. This stress must be distinguished from chronic stress, which is often associated with anxious personality types and the multiple stressors of day-to-day living.[28] Stress is therefore a perfectly normal physiologic and psychologic response. A suspicious sound may trigger an increase in stress levels, putting the individual on their guard, ready to react.

In the 1930s, Cannon[29] put forward the idea that the physiologic and behavioral changes triggered by stress were designed purely to facilitate either self-defense (fight) or escape (flight). Some years later, a French surgeon and neurobiologist, Henri Laborit,[30] added a third behavior to the two originally proposed: "freezing." These survival reflexes are illustrated by the theory of Flight, Fight, or Freeze.[31,32] To survive, and therefore, to flee or fight, a complex biologic and physiologic process is triggered in the human or animal. The only goal of this process is to prioritize the organs that make survival more likely, such as red skeletal muscles, over nonvital organs. This is what leads to a reduction in the production of saliva, disruption to auditory function and peripheral vision, and a slowing down of the digestive system.[33] The brain will also begin to function differently, triggering reflex actions that are both immediate and consume little in the way of cognitive resources, meaning that more considered reflection, which takes time and consumes much energy, is set to one side.[34] However, although all these changes may be useful when confronted with a real danger, they present major drawbacks in the event that the stress in question has been produced by the individual themselves rather than triggered by circumstances of genuine danger.

The Paradox of Stress

To combat stress effectively, it is important to understand how the human brain works. Cognitive processing is divided into two categories: automatic processes and controlled processes (prefrontal brain mode).[35,36] This distinction is further developed by Kahneman,[37] who demonstrates that decision-making does not occur inside a clearly defined part of the anatomy but by means of "Systems" that may involve several areas of the brain.

Kahneman describes two systems involved in decision-making: one is intuitive and emotional (System 1); the other is deliberative and logical (System 2). The first is fast, automatic, and requires little energy, whereas the second is slow, controlled, and requires a great deal of energy.[36] The switch from System 1 to

System 2 requires the triggering of a third cognitive system, called System 3. This must "shut down" System 1, enabling the individual to activate the "intelligent" System 2. This is a complex process, which is difficult to start when stressed. For this reason, it is important to be capable of pausing during a medical procedure when one starts to feel that one is no longer in control. When things have already gotten off to a bad start, carrying on regardless is unlikely to end well, insofar as the practitioner cannot identify the proper solutions to their problem because their "intelligent" cognitive system is not accessible. Moreover, as the prefrontal brain mode requires much more energy, it cannot be used on an ongoing, permanent basis. It can only manage one conscious action at a time. This means that the brain is not capable of applying the "controlled" mode of processing to every stage in a surgical procedure or other complex procedures.

Furthermore, the repeated performance of a physical or intellectual action or task facilitates a gradual "switchover" in the management of these tasks, with all or some of their management switching from prefrontal brain mode to "automatic" mode.[38,39] This is why the first surgical procedures carried out by a novice seem so complex, but with experience, the same procedures can be performed with much less mental effort.

With experience, the brain changes physically, facilitating a more rapid mobilization of intellectual resources due at least in part to the phenomenon of brain and synaptic plasticity.[40] A range of studies would seem to show that the brain operates in automatic processing mode 80% of the time, with controlled processing accounting for the rest of the time the brain is active.[32,35] In reality, no decision is entirely "controlled" or entirely "automatic"; both kinds of cognitive processing are constantly switching in and out of use. Depending on how much experience they have, different individuals will have to use their prefrontal cortex to different extents to make a decision. Over time, the brain will operate increasingly in an "intuitive" fashion.

With the onset of stress, humans have greater difficulty "tapping into" the prefrontal cortex; in fact, people may even find it impossible to do so, because this part of the brain is not employed to make those decisions that are crucial for survival: Flight, Fight, or Freeze. The individual gradually loses their ability to reason. In the event of acute stress, they may regress mentally and completely lose their ability for rational decision-making.[41–43] This is a highly surprising paradox.

For example, a practitioner who is about to embark on a complex or difficult procedure may be under a certain amount of stress due to the unknowns of this situation: "will everything be acceptable given the patient's small mouth opening?"; "was I right to take on this procedure in the first place?"; "do I actually possess the skills to carry out this procedure?"; etc. Stress, by making it harder to tap into the prefrontal cortex, will prevent the practitioner from performing a rational (analytical) assessment of the situation. This may increase their stress levels even more, which in turn will further undermine the ability for rational decision-making, and a vicious spiral begins. As the prefrontal cortex gradually "disconnects," the reins are taken up by the automatic mode. Stress usually pushes the practitioner into choosing a familiar protocol, one that can be implemented with minimal cognitive effort, even if this protocol is not the best suited to the situation at hand.

Moreover, to extricate themselves from this highly uncomfortable situation, practitioners may end up "rushing" the procedure (Flight), perhaps skipping certain steps, sometimes going as far as to neglect basic precautions and safety measures. This extreme state of mind, known as "mental tunnel vision,"[21] is one of the most common causes of accidents in the field of private aviation. This phenomenon leads the practitioner to take intellectual or procedural "short-cuts" to the detriment of patient safety, for example, by choosing not to make use of a surgical guide, even though one is available, or refusing to make an intraoperative radiograph, just in case, for no reason other than to gain time. It is only when the stress has subsided after the procedure is over that the practitioner can assess the situation objectively, thanks to their newfound ability to "tap into" the prefrontal cortex. This is when they will discover their mistakes and wonder how they could have made such ridiculous decisions.

Regarding stress:

- Stress is a normal physiologic reaction that, initially at least, is designed to protect the individual.
- For human beings, 90% of stress is endogenous, ie, "self-inflicted."
- Whether it is endogenous or exogenous (due to a real aggression), the stress leads to the same negative physiologic, psychologic, and behavioral modifications.
- Stress limits access to or even "switches off" the prefrontal brain. Under stress, humans are more prone to get down to automatic and routine procedures even if they are not appropriate.
- A refusal to acknowledge one's stress only increases its negative impact.
- It is important to draw up the list of potential sources of stress in a working environment such as in the operating rooms[44,45] (Table 2). The goal is to facilitate the development of "protective barriers," such as ensuring the entire team is familiar with the relevant protocols.

Table 2 Description of Stress-Inducing Factors in the Operating Room Environment

Factor	Description
Intraoperative stressors	Emergency cases
Surgical complications	Surgical error/unexpected bleeding/difficulties finding the source of a problem/no progress
Advanced tasks	Complex procedure/high-risk patient/multitasking/time pressure/immediate decision-making
Equipment problems	Missing equipment/equipment failure/unfamiliar equipment
Teamwork problems	Incompetent staff/inexperienced staff/language problems/staff paying no attention/ interpersonal issues
Distractions	Talking noises/people walking in and out/bleeps/phone calls
Personal factors	Tiredness/hunger/illness/physical discomfort
Personal problems	

Each item is applicable to all medical and paramedical specialties.
From Wetzel et al.[45]

Medical Safety Improvement from Aviation Experience

Considering the aviation experience, the concept of the Sterile cockpit, which consists of restricting or even forbidding any kind of conversation during the more difficult stages in a given procedure, should be implemented in all operating theaters and dental practices.[46–48] As the prefrontal cortex cannot manage several ideas at the same time, it is not possible to devote one's full attention to surgery if, for example, at the same time one is worrying about the next patient being late. This cognitive overload remains a major source of stress, with all the negative consequences on the outcome of procedures that this entails, as described earlier in this article.

Likewise, checklists should be seen as one of the safety nets that prevent the occurrence of undesirable events. There are two types of checklists: safety checklists and task checklists. Task checklists may be useful for some complex protocols (in other words, in the implementation of multiple interdependent stages of a medical procedure). Safety checklists, meanwhile, should be seen as integral to the pursuit of risky activities. Their aim is to eliminate the occurrence of undesirable events regardless of how tired, stressed, or detached from the task in hand the practitioner or other members of their team are. Gawandé[49] was the driving force behind the surgical procedure checklists that are now compulsory in all operating theaters. Subsequent to this research, a study[50] was launched to compare the number of serious undesirable events before and after the implementation of checklists. The study covered approximately 8,000 procedures and demonstrated that the systematic use of checklists reduced the postoperative mortality rate from 1.5% to 0.8% and the rate of complications from 10.3% to 7.1% ($P < .001$).

Checklists should be implemented before all surgical procedures, even those carried out in the field of private health care and under local anesthetic. Checklists should be drawn up in accordance with a number of strict criteria. It is crucial to respect the following points to create effective checklists:

- Checklists must not contain more than 10 items. Any more than 10 items, and it becomes tedious to perform the checklist properly, meaning that there is a serious risk that the various key safety issues the checklist is designed to verify will be skimmed over. It is important to keep in mind that the only checklists that do not work are those that are not used.
- Items critical to safety must have priority on the list, in other words, items that, if not checked, would engender very serious consequences, even if this is a very rare occurrence (treating the wrong patient, running out of supplies). Additionally, items that would not have very serious consequences if unchecked but represent frequent occurrences (forgetting to ask the patient to sign the informed consent form or relevant medical insurance documentation) should feature on the list.
- Questions put to the patient must not be ambiguous and should be clear enough so as not to be misunderstood or misinterpreted. For example, to identify a patient, you should ask them for their name, rather than asking them if they are called Mr or Mrs X. Stress, fatigue, the unfamiliarity of the environment or situation, and potentially even the effect of premedication could all lead to a patient replying "yes" when in fact they did not understand or misinterpreted the question.
- Questions should be capable of being translated into all languages while retaining their meaning. A good checklist should be universal. Just as the preflight checklist will be the same no matter where the pilot is operating, the same should apply to all medical safety checklists. This is why a total of 14 different experts in implant dentistry from 10 different countries (and therefore 10 different national cultures) were involved in producing and/or evaluating the preoperative checklist shown in Table 3.

Table 3 Example of Preoperative Safety Checklist

Patient preoperative steps		
Signed informed consent form in patient's file	Yes	Not applicable
Signed financial estimate in patient's file	Yes	Not applicable
Premedication taken as prescribed	Yes	Not applicable
Radiographs checked and put on display	Yes	Not applicable
Nature of operation clearly indicated and double-checked with patient	Yes	Not applicable
Tooth numbering verified with pretreatment record and confirmed with patient	Yes	Not applicable
Practitioner is aware the patient wears a removable denture	Yes	Not applicable
Surgical guide is readily available and disinfected	Yes	Not applicable
Special instrumentation is functioning and set up (eg, Piezosurgery unit, osteosynthesis screws, biomaterials, etc)	Yes	Not applicable

From www.FOR.org
Primary responsibility: clinician/surgeon or nurse/dental assistant; timing: shortly before surgery; location: chairside in OR/surgical suite/operator.
This checklist shall not substitute appropriate medical verification prior to the intended procedure and shall be used as an additional informative tool only.

- Questions must be easily understood by the people involved in the procedure regardless of their place in the medical team. It should be immediately comprehensible, even to a newly qualified assistant, what exactly is being asked of them to prevent them from giving a misleading answer, albeit in good faith.
- Ideally, checklists should be in electronic format, as this makes it possible to prove that they were completed at the appropriate time. They may also be included in the patient's medical records, as they may be used in the event of any dispute.
- Lastly, checklists must be capable of being modified in the event that some items are no longer relevant or, alternatively, new items take on critical importance due to developments in medical practice or technologies.

It is important to remember that it is not easy to gain acceptance from team members to make major changes to their habitual practices and procedures. It is sometimes difficult to get people to adopt checklists,[51] with users sometimes viewing them as just an additional layer of red tape. The use of checklists must be part of a wider drive to make medical practices safer through the fostering of a safety-first culture that is subscribed to by the entire medical team.

It is critical to have a good understanding of the causes that lie behind errors in practitioner decision-making[6,52]: inaccurate analysis due to carelessness on the part of the practitioner or cognitive biases that undermine the objectivity of the analysis,[53,54] external factors (aggressive patient, having to operate on a colleague or family member), time pressure (limited amount of time available for the clinical examination or the actual procedure itself), fatigue,[55] etc.

Lastly, it is very useful to be able to recognize the telltale warning signs of stress[56] (increase in heart rate and breathing rate; varying degrees of shaking or trembling; changes in skin color—becoming pale, or, alternatively, flushing; dry mouth, etc) to be able to quickly implement coping strategies like controlling one's breathing,[57] techniques aimed at maximizing individuals' potential, and other approaches taken from the sphere of "mental preparation."[25]

CONCLUSIONS

The attitude of practitioners and their ability to manage stress offers an explanation for the differing levels of performance within a group of individuals carrying out the same activities and tasks. Of course, the highlighting of the role of nontechnical factors should in no way be interpreted as a denial of the vital importance of solid theoretical knowledge. However, there is a pressing need to introduce the concept of "Human Factors" into both the teaching of medicine and its everyday working practices,[58] including in the field of implant dentistry. Specific protocols have been implemented in the aviation sector and in high-risk industries. These include Human Resource Management and Threat and Error Management.[59,60] The systematic use of feedback (reporting and analysis of errors by a grouping of professionals) is another way of making human activities safer. More and more medical specialties are taking these concepts onboard. There is absolutely no doubt that this has improved safety for practitioners and patients alike. Implementing these approaches in the working environment is therefore a win-win situation for practitioners and their teams.

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