

A New Electronic Approach for the Surgical Safety Checklist

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*"You cannot shake hands with a clenched fist."
Indira Gandhi*

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Abstract

To improve surgical safety, and to reduce the mortality and surgical complications incidence, the World Health Organization (WHO) developed the Surgical Safety Checklist (SSC).

The SSC is a support of information that aids health professionals to reduce the number of complications, dividing the surgery in three phases: period before induction of anaesthesia, period before skin incision and period before leaving the operating room (OR).

The SSC was tested in several countries of the world and their results shown that after introduction of the SSC the incidence of patient complication lowered from 11.0% to 7.0% ($P < 0.001$), the rate of death declined from 1.5% to 0.8% ($P = 0.003$) and the nurses recognized that patients identity was more often confirmed (81.6% to 94.2%, $P < 0.01$) in many institutions.

Recently the SSC was also implemented in Portuguese hospitals, which led us to its study in the real clinical environment. An observational study was performed: several health professionals were observed and interviewed, to understand the functioning of the SSC in an OR, during the clinical routine. The objective of this study was to understand the current use of the SSC, and how it may be improved in terms of usability, taking advantage of the technological advancements such as mobile applications.

During two days were observed 14 surgeries, only 2 surgeries met the requirements for the three phases of the SSC, as defined by the WHO. Of the remaining 12 observed surgeries, 9 surgeries completed the last phase at the correct time. It was also observed that only in 2 surgeries all the phases of the SSC were read aloud to the team and that, in 7 surgeries, several items were read aloud and answered but no one was checking the SSC, only after the end of the phase.

The observational study results disclose that several health professionals do not meet with rules of the WHO manual. This study demonstrates that it is urgent to change the mindset of health professionals, and that different features in the SSC may be useful to make it more easy to use.

With the results of the observational study, a SSC application proposal was developed with new functionalities to improve and aid the health professional in its use. In this application the user can chose between a SSC already created to a specific surgery or to create a new SSC, adding and adapting some questions from the WHO standard. To create a new SSC, the application is connected to an online questionnaire builder (JotForm). The choice for this online questionnaire builder went through three essential characteristics: number of types of questions, mainly checkbox, radio button and text; the possibility of to create sections inside sections and the API.

In addition, in this proposal the improvements are focused in forcing the user to focus in the work flow of the SSC and to save the input timestamps and any actions made by them. Therefore, the following features was implemented to achieve that goal: display one item of the SSC at a time; display the stage where the SSC is; do not allow going back to the previous step; do not allow going forward to the next item if the current is not filled; do not allow going forward to the next item if the time it took to fill the item was too short and log any action made by the user.

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Abbreviations

ACSS	Administração Central do Sistema de Saúde
API	Application Programming Interface
CNPD	Comissão Nacional de Proteção de Dados
CSV	Comma-Separated Values
DALYs	Disability-Adjusted Life Years
DGS	Direção Geral de Saúde
ICAO	International Civil Aviation Organization
INAC	Instituto Nacional de Aviação Civil
IT	Information Technology
NEJM	New England Journal of Medicine
OR	Operating Room
SIGLIC	Sistema Integrado de Gestão de Listas de Inscritos para Cirurgia
SSC	Surgical Safety Checklist
SSSL	Safe Surgery Saves Lives
TAP	Transportes Aéreos Portugueses
USA	United States of America
WHA	World Health Assembly
WHO	World Health Organization

Introduction

In an ever more fast-paced world, where technological improvements in medicine are emerging so fast, sometimes it is necessary to get away and to reflect about numbers. It is estimated that surgeries on the wrong body part take place in around 1 in each 50000 to 100000 surgical procedures in the United States of America (USA) [1].

In response to this need the World Health Organization (WHO) created the WHO Surgical Safety Checklist (SSC) and the Implementation Manual in 2008 in order to increase the safety of patients undergoing surgery [2].

This chapter summarizes the motivation and objectives of this work, the SSC development and implementation, the SSC description and the thesis' organization.

1.1 Motivation

After identifying a problem in surgical safety and complications incidence from avoidable causes, the WHO developed the SSC. In a study published in The New England Journal of Medicine (NEJM), the authors' main results were that after the introduction of the SSC the incidence of patient complications lowered from 11.0% to 7.0% ($P < 0.001$), and the rate of death declined from 1.5% to 0.8% ($P = 0.003$) in several institutions around the world [3]. These encouraging results were the motivation to further understand the impact of the SSC in Portuguese hospitals, since that the SSC plays an important role in the increase of patient safety, and the surgical treatment is an integrant part of healthcare systems all over the world.

Furthermore, the development of an application that may increase the usage and easiness of the SSC in an Operating Room (OR) is a complementary motivation to the observation of the current impact of the SSC in today's surgeries.

1.2 Objectives

The main objectives of this thesis are as follows:

- To better understand how and why SSC appears;
- To better understand the functioning of the SSC;
- To better understand if hospitals comply with the rules of the WHO for SSC.
- To design and perform an observational study in Portuguese hospitals to better understand the OR routine;
- The development of an application to improve any problems that may arise with the SSC application.

1.3 How Surgical Safety Checklist appear

Surgical care has been an essential component of health care worldwide for over a century. As the incidences of traumatic injuries, cancers and cardiovascular disease continue to rise, the impact of surgical intervention on public health systems will grow.

The WHO Global Initiative for Emergency and Essential Surgical Care and the Guidelines for Essential Trauma Care focussed on access and quality. The Second Global Patient Safety Challenge: Safe Surgery Saves Lives (SSSL) addresses the safety of surgical care. The World Alliance for Patient Safety initiated work on the Challenge in January 2007.

The focus of the Challenge is the WHO Safe Surgery Checklist. The checklist identifies three phases of a surgery, each corresponding to a specific period in the normal flow of work: Before the induction of anaesthesia (“sign in”), before the incision of the skin (“time out”) and before the patient leaves the OR (“sign out”). In each phase, a checklist coordinator must confirm that the surgery team has completed the listed tasks before it proceeds with the surgery.

The WHO suggests to implement and adapt the checklist to the necessities and specificities of each hospital.

The WHO provides an implementation manual designed to help to ensure that surgical teams are able to implement the checklist consistently. By following a few critical steps, health care professionals can minimize the most common and avoidable risks endangering the lives and well-being of surgical patients.

The SSSL initiative is also working to promote surgical improvement programs and collaboration by building a network of users.

Surgery is often the only therapy that can alleviate disabilities and reduce the risk of death from common conditions. Every year, many millions of people undergo surgical treatment, and surgical interventions account for an estimated 13% of the world's total disability-adjusted life years (DALYs).

While surgical procedures are intended to save lives, unsafe surgical care can cause substantial harm. Given the ubiquity of surgery, this has significant implications:

- the reported crude mortality rate after major surgery is 0.5-5%;
- complications after inpatient operations occur in up to 25% of patients;
- in industrialized countries, nearly half of all adverse events in hospitalized patients are related to surgical care;
- at least half of the cases in which surgery led to harm are considered preventable;
- mortality from general anaesthesia alone is reported to be as high as one in 150 in some parts of sub-Saharan Africa.

To increase safety and improve health care provided to patients, the World Assembly Health adopted a resolution (WHA55.18), persuading the countries to improve the safety and monitoring systems, requesting the WHO to establish standards and global standards for this resolution, and to support countries to prepare politics and practices of safety.

In May 2004, in the 57th World Health Assembly (WHA) the creation of an international alliance for the improvement of the safety of the patient was approved, with this alliance being launched in October 2004. The groups created are constituted by leaders of agencies, policy makers and patients of the world and those actions are concentrated in campaigns of safety to patient, designated for "Global Challenges for the Safety of the Patient". The first challenge was to decrease infection associated to healthcare (2005-2006). The problematic area for the second challenge (2007-2008) was safety of the surgical cares [4].

The surgical treatment is part of healthcare systems all over the world, with a respected value of 234 million fulfilled surgeries, annually [3]. Data of 56 countries

showed that, in 2004, the rate of incidents documented varied from 3% to 22% of the procedure in regime of internment, and the mortality rate was of 0.4% to 0.8% [5, 6]. Studies in developing countries present higher rates for the mortality associated to major surgeries, 5% to 10% [7, 8, 9]. The surgical avoidable complications represent a great percentage of complications and deaths, at world level. It is appreciated that almost 7 million surgical patients, will have significant complications and 1 million will die during or immediately after the surgery [5, 6].

In accordance with data previously presented, the surgical safety, surfaced a significant problem of public health. Therefore, there are, at least, four main problems that must be improved:

- The first problem is that surgical safety may not to be recognized like a significant problem of public health [4], but the numbers of the WHO shows the opposite, yearly, 63 million persons are subdued to surgical treatment by traumatic complications, for malignant neoplasies turn 31 millions bad and 10 millions for obstetric complications [2];
- The second problem has been the shortage of basic data. The program Safety of the Patient of the WHO determined that the data on the surgical volume were available only in a minority of countries members of the WHO, they were not standardized and the types of registered proceedings were very varied. In addition, even in countries that the data of the surgical proceedings are available there were significant failures: few outpatient proceedings reported and most countries have not information about private hospitals;
- The third problem, reported that safety practices are not used reliably in any country, like the antibiotic prophylaxis and the anaesthesia. The mortality rate for individuals undergoing anaesthesia is 1 to 200000 in industrialized countries [4], but in developing countries the rate continues to be very high: for example Zimbabwe 1 in 3000 and Togo 1 in 150, [10, 11, 12];
- The fourth problem is the complexity of the surgical safety. Even the most simple proceedings involves many steps, each one having a fault opportunity, in other words, a potential damages to patients.

All these problems have led to the development of the SSSL program.

The surgery can be defined as any proceeding which occurs in OR involving the incision, excision, handling or suture of tissue, that normally requires local, general anaesthesia or deep sedation.

The objective of the SSSL is to improve the safety of surgical care in the whole world through the definition of a set of safety norms that can be applied in all countries. For this, working teams were created with international experts for literature review, and based in health professionals' experiences reach a consensus about safety practices in four areas:

- Working team;
- Anaesthesia;
- Prevention of the infection of the surgical place;
- Indicators of evaluation of the surgery services.

In these working teams there were contributions of the specialists of the whole world and of all the areas: surgery, anaesthesia, nursing, infectious diseases, epidemiology, biomedical engineering, health systems, quality, improvement of safety and other areas, like patient recruited in each one of the WHO regions.

The program SSSL aims to improve the surgical safety and to reduce the number of deaths and surgical complications through four ways:

1. Giving to the doctors, hospital administrators and authorities of the public health information about the surgical safety standards in public health;
2. Defining a minimum set of measures or “surgical vital statistics”, for the national and international surveillance of surgical care;
3. Identifying a simple set of rules for the surgical safety that can be used in all the countries and contexts, and that are compiled in the SSC for use in OR;
4. Testing the SSC and surveillance instruments in “pilot places”, in all the WHO regions and then, to spread the SSC for the hospitals of whole world [4].

The accidents and the most common errors during the surgery are related with the patient, surgery and surgery place missed, anaesthetic incidents, malfunction of equipments, incorrect sponge and needle counts, damage of equipments, incorrect patient positioning, falls of equipments, surgery not planned in accordance with the defined permission, burns, injuries caused by pneumatic tourniquets, contamination by break of the surgical aseptic technique, cardiorespiratory arrest, people working without knowledge and competences, failure in supervision and communication [13].

Yearly, it is estimated that surgeries on the wrong body part, and to the wrong patient take place in around 1 in each 50000 to 100000 procedures in the USA, representing 1500 to 2500 adverse events of this type [14].

An analysis of events reported by the Joint Commission on Accreditation of Healthcare Organizations, USA between 1995 and 2006, pointed that 13% of the adverse events reported were surgeries in wrong places [15]. In a study with 1050 surgeons, 21% reported to have realized at least a surgery in wrong place in his careers [16].

Therefore, working teams determined that the initial intervention more effective would be the establishment of the universal standards of safety for the surgical teams and for use in the OR. These standards included the SSC and the creation of the basic indicators for the surgical services. The objective of the working teams was to identify potential standards for the improvement in four areas:

- Surgical safe teams, promoting the communication between the members of the team to secure that the preparation of each stage is realized in the opportune and appropriate form, with emphasis in the team work;
- Safe anaesthesia, through the adapted monitoring of the patient and of his advance preparation to identify potential anaesthetic problems;
- Prevention of the infection of the surgical place, through the antisepsis and the control of the contamination in all the levels of care to a patient;
- Measurement of the surgical services, through the creation of indicators of public health, to measure the provision and the basic results of the surgical cares.

The use of the SSC has several advantages, including: the help to systematize and remember, specially routine questions that are easily forgotten; to clarify the necessary steps of a complex process; to help in the team work.

The challenge SSSL was still orientated on three principles:

- Simplicity. Since an exhaustive checklist of standards and directions would be difficult to apply and to transmit;
- Broad applicability. It is a way of reducing the number of questions;
- Measurability. The measurement of the impact is a key to these challenge.

With this, the specialists groups of the whole world identified ten essential objectives for the surgical safety [2]:

1. The team will operate on the correct patient at the correct site;
2. The team will use methods known to prevent harm from anaesthetic administration, while protecting the patient from pain;
3. The team will recognize and effectively prepare for life-threatening loss of airway or respiratory function;
4. The team will recognize and effectively prepare for risk of high blood loss;
5. The team will avoid inducing an allergic or adverse drug reaction known to be a significant risk to the patient;
6. The team will consistently use methods known to minimize risk of surgical site infection;
7. The team will prevent inadvertent retention of sponges or instruments in surgical wounds.
8. The team will secure and accurately identify all surgical specimens;
9. The team will effectively communicate and exchange critical patient information for the safe conduct of the operation;
10. Hospitals and public health systems will establish routine surveillance of surgical capacity, volume and results.

These objectives are compiled in the SSC, launched officially on 25th June 2008 (Appendix A, Fig. A.1). The objective of the SSC is to reinforce the practices of safety and to provide better communication and team work, improvement of the surgical safety and to reduce deaths and surgical complications.

In September 2009, a new version of the SSC was launched (Appendix A, Fig. A.2). While the content of the 19 items remain unchanged, the text of the items has been modified to improve the SSC's usability [17].

1.4 Surgical Safety Checklist's description

A surgical team is composed by a surgeon, nurses and anaesthesiologists. In this team, a sole person should be responsible for completing the checklist. This person is referred as the checklist coordinator and normally, he/she is the circulating nurse, but it can be any element of the team. The SSC divides the surgery in three phases, each one corresponding to a specific period in the normal flow of the surgery:

1. Period before the induction of the anaesthesia;
2. Period after the induction and before skin incision;
3. Period during or immediately after the wound suture, but before patient the leaves the OR.

Each team should incorporate the SSC in their daily activities, with efficiency and least perturbation. All the phases must be checked verbally with the member of the team to guarantee that all the actions were carried out.

In the OR no item can be neglected in the course of the preoperative, intra-operating or the preparation of the postoperative period.

To designate one person responsible for the confirmation of the conclusion of each phase of the SSC can ensure that the safety measures are not omitted in the haste to move for next phase of the surgery.

A possible disadvantage of having one person to lead the SSC is that a prejudicial relation can be established with other members of the surgical team. The checklist coordinator can and must prevent the team from advancing to the next phase of the surgery without completion of each phase [4].

1.4.1 Before induction of anaesthesia

In this phase, the safety checking must be complete before the anaesthetic induction and, at least a nurse and an anaesthetist must be present.

The checklist coordinator will review with the health professionals present and with the patient: the patient identity, if the proceeding and the place are correct, and if the permission for the surgery was given. This item is essential to guarantee that the surgical team does not operate the wrong patient, in the wrong place or conduct the wrong procedure. When the confirmation from the patient is not possible (children or impaired patients) a member of the family or a guardian can

assume this role. If these people are not available, this step is jumped, as for example in emergency situations, but all the elements of the surgical team must agree before beginning the proceeding.

The checklist coordinator must confirm visually and verbally that the surgeon marked the place of the surgery.

The checklist coordinator has to ask an anaesthesiologist to check if the anaesthesia and medication equipment are ready and complete (formal inspection to the anaesthesia equipment, respiratory circuit, medication and checking the anaesthetic risk of the patient).

Also, he confirms if the pulse oximeter is placed on the patient, and working correctly. In urgent cases, this item may be dispensed, but the whole team must agree.

Also with the anaesthesiologists, the checklist coordinator will do the revision of the allergic reactions of the patient, assess difficult airway or aspiration risk. If the patient has a difficult airway or a risk of aspiration, the induction of anaesthesia may only begin when the anaesthesiologist confirms that all necessary equipment is available at the bedside of the patient.

In the last item, the checklist coordinator asks the anaesthesia team if there is risk of the patient to lose more than half a litre of blood during the surgery. If the anaesthesiologists does not know which is the risk from blood loss, he must discuss it with the surgeon before the intervention begins. If there is a risk of blood loss superior to 500 ml, it is recommendable that, at least, two i.v. lines are assured or a central venous catheter is placed, before beginning the skin incision. In addition, the team must confirm the availability of blood or fluids.

Ideally, the surgeon should be present in this phase, since he can have a clear idea of the blood loss, allergies or other factors of risk. However, the presence of the surgeon is not mandatory in this phase. [4].

1.4.2 Before skin incision

In this period, each member of the team presents themselves, indicating his name and function. If the team has been working together, the elements can confirm the presence.

The checklist coordinator will ask the whole team of the OR to do a pause to confirm, aloud, if the surgery, the patient and the place, and if the positioning of the patient is appropriated. Also they review, verbally, the procedure for surgery.

Similarly, they confirm if the antibiotic prophylaxis was administered in the last 60 minutes. The checkbox shall be left blank if no additional dose is given. If the antibiotic prophylaxis are not considered appropriate (for example, without skin incision or contamination in which the antibiotics are given for treatment), the field “not applicable” must be marked, as soon as the team confirms it verbally.

In Portugal, a choice was made to included in the SSC if the thrombotic prophylaxis was administered or not applicable.

To guarantee the communication of critical questions about the patient, the checklist coordinator promotes a quick share of information, between the surgeon, the anaesthesiologist and the nursing team about the dangers for the patient and the operational plans. The order of the discussion does not matter, but each checkbox must be filled only after each clinical area gives their informations aloud.

For the surgeon the items to check are the critical or non-routine steps; how much time will the case take, and what is the anticipated blood loss. This item is an opportunity to inform all the members of the team about any measures that place the patient in risk of blood loss, damage or another morbidity, and to revise steps that can demand special equipment, implants or preparations.

For the anaesthesiologist, the steps to check are if there is any patient-specific concerns. In patients with risk of serious blood loss, hemodynamic instability or another important morbidity; the member of the anaesthesia team must revise, aloud, the plans and special concerns.

For the nursing team, the confirmation of the sterilization and if there are equipment issues or any concerns are items for checking. The instrumentalist nurse prepares the equipments and must confirm, verbally, that the sterilization was carried out and the sterilization indicator for the instruments sterilized the steam. Any discrepancy between the expected result and the checked indicators must be informed to all the members of the team. This is also an opportunity to discuss the problems with equipments and other preparations for the surgery.

Finally, the checklist coordinator must ask a surgeon if there are necessary complementary exams. If that is the case, the coordinator must confirm verbally that the imaging exams or others are in OR and he must guarantee that these are visible for use during surgery [4].

1.4.3 Before patient leaves operating room

The third phase must be completed by a nurse, an anaesthesiologist and a surgeon and all items must be checked before the patient leaves the OR, or during suture. A nurse confirms verbally, the name of the procedure, or if the procedure has been changed during the surgery.

The instruments, sponge and needle count, is one of the items that the nurse confirms verbally, too. If the numbers are not coincident, the team must be alerted, to take appropriate measures (for example: examine the surgical fields, garbage and the surgical wound or, if necessary, to obtain x-ray images). In the labelled organic products or others, the labels (name of the patient, the description of the sample and any orientation) are confirmed aloud, since an incorrect labeling is potentially disastrous for the patient. The checklist coordinator must guarantee that the problems or damages with the equipments during the surgery are identified by the surgical team.

Finally, surgeon, anaesthesiologist and nursing team must precede to the review of the recovery plan and postoperative management. All information important for the patient recovery must be communicated to the recovery team, before the patient leaves the OR.

At this moment, the SSC of the WHO is complete. The SSC can be modified taking into account the differences between the organizations, processes, ORs and familiarity degree of each member of the team with their colleagues. The modification of the SSC must be accomplished by a critical vision, where surgeons, anaesthesiologists and nurses need to be involved in the process, and the resultant SSC must be validated with simulation and real situations to secure its functionality [4].

1.5 Thesis's organization

The present master's thesis is divided in 5 chapters. The second chapter, State of the art presents the studies which have already been developed with the implementation of the aviation checklist as a parallel problem, and the SSC, also reviewing the existing tools for the generation of forms.

The third chapter entitled An observational study of the Surgical Safety Checklist in a Portuguese operating room presents the observational study developed where several health professionals were observed and interviewed, to understand the working of the SSC in an OR, and how it may be improved in terms of usability taking

advantage of the technological advancements.

The fourth chapter, Surgical Safety Checklist application proposal, covers the choice of the best tool for the generation of forms to the SSC application that may be adapted to the type of surgery, and easily introduced in the hospital's application software.

The last chapter presents the discussion and conclusions reached with this work, and a few suggestions for improvement of the SSC use.

State of the art

The Surgical Safety Checklist (SSC) is a support of information that helps the health professionals to reduce the incidence of complications, compensating for the possible limits of memory and attention; in other words, the SSC guarantees consistency and entirety in the realization of a task [18].

This chapter describes the origin of the safety checklists including the SSC, the implementation and evaluation of the SSC in Portugal and worldwide. A review on the generation of forms is also presented. This chapter is organised into 4 sections: Aviation checklist, Results of the Surgical Safety Checklist implementation, Portuguese implementation, and Generation of forms.

2.1 Aviation checklist

Aviation is an example where safety checklists have been used with success for a long time. The concept of a checklist was first introduced by the administration and engineers of the Boeing Corporation, in sequence of the prototype B-17 accident (1935) in the field of Wright, in Dayton, Ohio, killing two pilots [19]. The investigation showed that the plane did not present any mechanical problem, and that the accident was caused by human error. The Boeing Corporation confronted with this problem, developed and implemented a checklist, and the B-17 aeroplane flew more 1.8 million of miles without further incidents [18, 20].

The first checklists were composed by seventeen phases: Before Starting, Starting Engines, Engine Run-up, Before Takeoff, After Takeoff, Before Landing, Final Approach, After Landing, End of Mission, Go-Around, Running Takeoff, Subsequent Takeoff, Subsequent Landing, Final Approach, Feathering, Unfeathering, Increasing

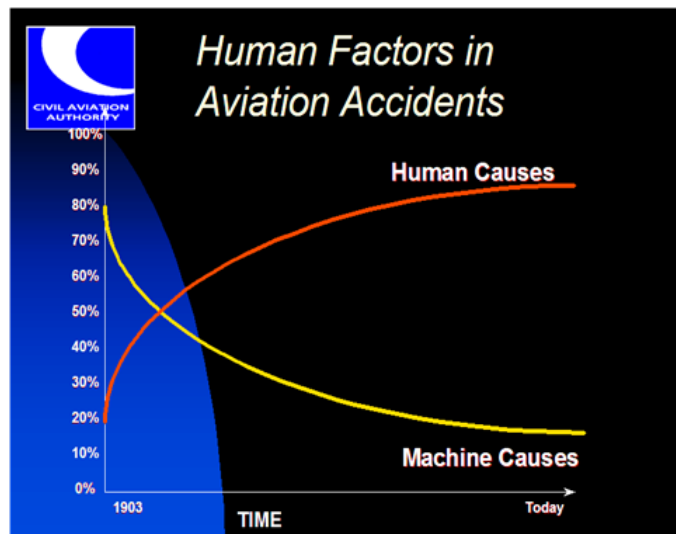


Fig. 2.2: Human mistakes in aviation accidents.

This way, the pilots develop habits of discipline in a logical sequence of proceedings, managing to increase: the communication and the interpersonal assertiveness, the standardization of proceedings, the situational awareness, and the mutual supervision (redundancy).

The environment of a cockpit consists of the reading and answer (aloud) of actions distributed and supervised by the black box, where the whole procedure is recorded by a “system register voice” (Cockpit Voice Recorder) and by a “tape recorder data” (Flight Data Recorder). In addition, either the pilot as the co-pilot can and should alert each other when any check is not performed or if is performed incorrectly.

As happens for the SSC, the aviation checklist can be in paper format or in digital format depending on the air company. There are some companies, like TAP, that use the digital format for increased safety. When the pilots check in aloud, all the steps are shown on the display of the plane, the black box saves the voice, and in simultaneously the items of the checklist that have been checked are removed from the display, leaving in display all the checkings that were not done yet. It is difficult to pass to another phase of the process, if the previous phase was not fully completed.

There are lots of benefits of working with the checklist in digital format. The pilots regard that the biggest advantage is during a flight with great turbulence, because it becomes complicated to read a leaf of paper when the plane is not stable which may lead to missed checks (Appendix B).

According to the standards of the aviation, 75% flights have to be analysed

through the aircraft safety. It check the voice recordings of the black box with the procedures done. The TAP, fourth air company more safe of the world analyses 97% of his flights.

When some problems or accidents occur, investigations are carried out and reports are presented with the called organizational mistakes. The pilotage team can be liable for not fully filling the checklist. With these reports, the “Instituto Nacional de Aviação Civil” (INAC) and the aircraft manufacturers made new updates to the checklist. Sometimes, several steps are repeated more than once in determined situations of flight. Following, the INAC sends the new events to International Civil Aviation Organization (ICAO) in a continuous loop for checklist improvements.

Even so, there is still a great dependence on the human factor. The aviation checklist already has been around for many years and there are still mistakes due to pilots fault. Each one should be responsible and maintain an individual commitment in accordance with the rules of conduct studied and trained by himself.

The indiscipline of the checklist has as result the deviation of the proceedings threatening human lives.

2.2 Results of the Surgical Safety Checklist implementation

There are many studies that demonstrate the results of the implementation of the SSC in several countries worldwide. This section is summarizes the studies considered more relevant for the study of the SSC.

2.2.1 “A Surgical Safety Checklist to Reduce Morbidity and Mortality in a Global Population”

The Surgical Safety Checklist, was tested between October 2007 and September 2008, in a multicentric study (8 hospitals in 8 different cities: Toronto, Nova Deli, Amman, Auckland, Manila, Ifakara, London and Seattle). These hospitals have been chosen according to geographical characteristics inside the WHO regions to represent a variety of socio-economics contexts in that the surgery is carried out, as Tab. 2.1 and Tab. 2.2 show [3].

In this study, in each center, there was a researcher to lead the project and an element of each institution without clinical responsibilities, to collect data. In

Tab. 2.1: Characteristics of participating hospitals.

Site	Location	No. of Beds	No. of ORs	Type
Prince Hamzah Hospital	Amman, Jordan	500	13	Public, urban
St. Stephen's Hospital	New Delhi, India	733	15	Charity, urban
University of Washington Medical Center	Seattle, Washington	410	24	Public, urban
St. Francis Designated District Hospital	Ifakara, Tanzania	371	3	District, rural
Philippine General Hospital	Manila, Philippines	1800	39	Public, urban
Toronto General Hospital	Toronto, Canada	744	19	Public, urban
St. Mary's Hospital*	London, England	541	16	Public, urban
Auckland City Hospital	Auckland, New Zealand	710	31	Public, urban

*St. Mary's Hospital has since been renamed St. Mary's Hospital-Imperial College National Health Service Trust.

accordance with the committee of the School of Public Health of Harvard, the WHO and committee of each hospital 1 to 4 ORs were selected for the study.

The SSC was implemented in a program of 2 steps. After gathering data, the information was given to each local investigator. Areas identified with problems were included in the SSC design. This was translated to the local idiom and adjusted in accordance with the service flow of each institution. Meetings and lectures were organized and written materials and videos were distributed for a better introduction of the SSC.

The SSC was introduced in the ORs during a period of 1 week to 1 month and new a data collection was performed during the first week. The elements that collected the data followed the patient processes and communicated with the clinical teams, until hospital discharge or for 30 days.

The size of the sample was calculated to detect a reduction of 20% in complications after of the SSC application, with one statistical power of 80% and a value alpha of 0.05.

The statistical analyses were carried out using statistical software SAS, version

Tab. 2.2: Surgical safety policies in place at participating hospitals before the study.

Site No.*	Routine Intraoperative Monitoring with Pulse Oximetry	Oral Confirmation of Patient's Identity and Surgical Site in Operating Room	Routine Administration of Prophylactic Antibiotics in Operating Room	Standard Plan for Intravenous Access for Cases of High Blood Loss	Formal Team Briefing	
					Preoperative	Postoperative
1	Yes	Yes	Yes	No	No	No
2	Yes	No	Yes	No	No	No
3	Yes	No	Yes	No	No	No
4	Yes	Yes	Yes	No	No	No
5	No	No	No	No	No	No
6	No	No	Yes	No	No	No
7	Yes	No	No	No	No	No
8	Yes	No	No	No	No	No

*Sites 1 through 4 are located in high-income countries; sites 5 through 8 are located in low- or middle-income countries

9.1 (SAS Institute). In this study, 3733 patients were included before the implementation of the SSC and 3955 patients after.

After the introduction of the SSC, the incidence of patient complications lowered from 11.0% to 7.0% ($P < 0.001$), and the rate of death declined from 1.5% to 0.8% ($P = 0.003$) in all institutions (Tab. 2.3). The global rates of infection of the surgical place also lessened significantly [3].

During the initial period, all the measures of safety performed to the patients passed of 34.2% to 56.7% after the application of the SSC ($P < 0.001$).

All the centers had a reduction in the complications rates of major surgeries, with a significant reduction in three centers: one of high income and two in locations of low income. The reduction in the rates of mortality and of complications suggests that the program of the SSC can improve the safety of the surgical patients even in high income countries.

The philosophy to ensure the correct identity of the patient and of the surgical site through the prior verbal confirmation in the OR among other measures proved to be useful in the the hospitals of the study.

The implementation of the SSC also stimulated the administration of antibiotics in the OR that in the wards, where the delays are frequent. The SSC allows the additional verbal confirmation of the appropriate use of antibiotic, increasing the rate of adhesion of 56% to 83%; this intervention separately demonstrated to reduce the rate of infection of the surgical site between 33% and 88% [3].

Tab. 2.3: Outcomes before and after checklist implementation, according to site.*

Site No.	No. of Patients Enrolled		Surgical-Site Infection		Unplanned Return to the OR		Pneumonia		Death		Any Complication	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1	524	598	4.0	2.0	4.6	1.8	0.8	1.2	1.0	0.0	11.6	7.0
2	357	351	2.0	1.7	0.6	1.1	3.6	3.7	1.1	0.3	7.8	6.3
3	497	486	5.8	4.3	4.6	2.7	1.6	1.7	0.8	1.4	13.5	9.7
4	520	545	3.1	2.6	2.5	2.2	0.6	0.9	1.0	0.6	7.5	5.5
5	370	330	20.5	3.6	1.4	1.8	0.3	0.0	1.4	0.0	21.4	5.5
6	496	476	4.0	4.0	3.0	3.2	2.0	1.9	3.6	1.7	10.1	9.7
7	525	585	9.5	5.8	1.3	0.2	1.0	1.7	2.1	1.7	12.4	8.0
8	444	584	4.1	2.4	0.5	1.2	0.0	0.0	1.4	0.3	6.1	3.6
Total	3733	3955	6.2	3.4	2.4	1.8	1.1	1.3	1.5	0.8	11.0	7.0
P value				<0.001		0.047		0.46		0.003		<0.001

* The most common complications occurring during the first 30 days of hospitalization after the operation are listed. Bold type indicates values that were significantly different (at $P < 0.05$) before and after checklist implementation, on the basis of P values calculated by means of the chi-square test or Fisher's exact test. P values are shown for the comparison of the total value after checklist implementation as compared with the total value before implementation.

2.2.2 “A pilot study of the implementation of WHO Surgical Checklist in Finland: improvements in activities and communication”

Published in 2011 in “The Acta Anaesthesiologica Scandinavica” and in “An International Journal of Anesthesiology and Intensive Care, Pain and Emergency Medicine”. This study was performed after approval by the “Ethics Review Committee” and by the “Ethics Committee of Nursing Science of Turku University Hospital”, Finland, following the launch of the Surgical Safety Checklist of the WHO. The SSC was adapted for national use in collaboration with the Finnish health authorities.

In 4 university hospitals a questionnaire was delivered to the surgical teams of several medical specialities (neurology and pediatry e.g.), before and after the implementation of the SSC. The questionnaire was constituted by multiple choice questions connected with the realization of controls of safety and communication. Surgeons, nurses and anaesthesiologists responded to the questions independently.

The questionnaires were returned after 1748 surgeries, 901 before and 847 after the implementation of the SSC. The objective was to investigate the applicability and possible benefits of the SSC, and to collect information in the development and validation of a national list.

For the nurses, after of the SSC implementation, the identity of the patients was more often confirmed (of 81.6% to 94.2%, $P < 0.01$), like the names and the functions of each member of the surgery team (of 87.7% to 93.2%, $P < 0.01$). Besides, the nurses reported a better communication after the implementation of the SSC, but they confirmed that no changes occurred in checking of the sterility of the surgery instruments.

For the anaesthesiologists, there were improvements in the confirmation of the identity of the patient (of 62.7% to 84.0%, $P < 0.01$), as in the knowledge of the names and functions of each member of the surgery team (of 65.7% to 81.8%, $P < 0.01$), as may be observed in Tab. 2.4. The anaesthesiologists also reported a better communication between the members of the team after the implementation of the SSC. In addition, the communication was improved in the following aspects: possible restrictions in members or movements, allergies, and medical condition. They also described that the checking of available blood and anaesthesia equipments increased, and more critical events post-surgery were discussed by the surgeons (of 22.0% to 42.6%, $P < 0.001$) (Tab. 2.5).

For the surgeons, with the SSC, the identity of the patient was more often con-

firmed (of 71.6% to 85.5%, $P < 0.01$) (Tab. 2.4), and they feel that the conscience of the whole surgery team was improved (of 85.2% to 93.2%, $P < 0.01$). After the implementation of the SSC, critical events were discussed more frequently between surgeons and anaesthesiologists (of 34.7% to 46.2%, $P < 0.001$) (Tab. 2.5). The prescriptions and instructions were reported to the post-surgery units more often. Besides, with the SSC, there was a tendency for the increase of confirmation of blood availability (of 72.0% to 81.7%, $P = 0.05$), and the preventive thrombosis was more often respected (of 86.0% to 96.4%, $P < 0.001$).

Regarding the communication between the working teams, the surgeons did not report any change in the communication, while nurses and anaesthesiologists reported less faults of communication after the SSC implementation (of 43% to 17%, $P < 0.05$) [22].

Tab. 2.4: Proportion (%) of yes replies by team members before and after implementation of the checklist. Patient's identity confirmed (I), opinion of the awareness of the whole team regarding the operation (II), and the side of operation (III), knowledge of names and roles of all team members (IV) and successful communication within the team (V). Chi-square test, statistical significance: * $P < 0.01$, § $P < 0.05$.

Checklist	Identity (I)		Operation (II)		Side of operation (III)		Names and roles (IV)		Communication (V)	
	Before	After	Before	After	Before	After	Before	After	Before	After
Circulating nurse	81.6%	94.2%*	94.7%	96.0%	90.5%	95.3%*	87.7%	93.2%*	88.7%	98.1%*
Anaesthesiologists	62.7%	84.0%*	87.1%	90.6%	79.4%	82.9%	65.7%	81.8%*	89.3%	93.7%§
Surgeon	71.6%	85.5%*	85.2%	93.2%*	91.5%	94.8%	71.1%	83.6%*	96.8%	97.4%

Tab. 2.5: Discussions on anaesthesiologists and surgeons about possible critical events and post-operative prescriptions and instructions before and after implementing the checklist. Chi-square test, statistical significance: $P < 0.05$. A - Anaesthesiologists; S - Surgeons.

Checklist	Critical events discussed				Post-operative prescriptions and instructions			
	Before		After		Before		After	
Yes	A (n = 738)	S (n = 759)	A (n = 680)	S (n = 766)	A (n = 705)	S (n = 753)	A (n = 651)	S (n = 759)
No	22.0%	34.7%	42.6%	46.2%	88.8%	86.9%	93.7%	92.1%
Not Known	41.1%	33.5%	26.2%	18.8%	2.1%	0.9%	2.5%	0.8%
Not necessary	3.7%	3.7%	3.4%	3.1%	8.5%	10.0%	3.5%	4.7%
Significance	33.3%	28.2%	30.7%	31.7%	0.6%	2.3%	0.3%	2.4%
	P < 0.001 for anaesthesiologists and surgeons				P = 0.02 for anaesthesiologists and surgeons			

2.2.3 “New scientific evidence supports WHO findings: a surgical safety checklist could save hundreds of thousands of lives”

In November 10th 2010, the WHO published on its website that the New England Journal of Medicine (NEJM), published a study performed in Holand between October 2007 to March 2009 on the SSC use. This study showed that there is reduction in surgery complications by more than a third, and a reduction of the dead rate by half.

In 2010, the Stanford University presented in the Annual Clinical Congress, that the mortality rate fell from 0.88% in first quarter to 0.80% in second quarter. In addition, the errors or complications declined from 35.2% to 24.3% and the communication between the surgery team increased.

The study indicates that the SSC is more than a simple paper, it is an effective tool that requires changes in the system, and commitment to team work for an improvement in the safety.

According to Atul Gawande the results of the news studies are a “remarkable validation” and that “it is clear that the WHO Surgical Safety Checklist has already saved many thousands of lives since its introduction. We need to keep the pressure on health care facilities around the world to ensure adoption of the checklist so that hundreds of thousands more lives can be saved”.

When the WHO launched the SSC, over the past two and half years, more than 3900 hospitals of more than 122 countries, signed up to the programme Safe Surgery Save Lives (SSSL). Of these 3900 hospitals more than 1800 reported that the SSC is already a routine procedure in at least an operating room. The commitment with the surgery safety improvement may be regarded at a governmental level, with 25 countries implementing the SSC at a national scale [23].

In a press release in November 11th the United Kingdom’s National Patient Safety Agency, and Sir Liam Donaldson, chairman of the WHO Patient Safety programme, said that “hospitals not using a surgical safety checklist are endangering patient safety” [24].

Several other studies have been published meanwhile, demonstrating the many advantages of using the SSC and its importance in the ORs.

The SSC improved in a general aspect the steps of safety, increasing the conscience of the teams for questions connected with the patient, the proceedings and the expected risks. Also it reinforces the communication of the team, when faults

were detected. Besides it is a surplus value for healthcare professionals, specially after several working hours, with fatigue and stress, as an aid for all routine procedures.

2.3 Portuguese implementation

In Portugal, June 2010, the “Direção-Geral de Saúde” (DGS) in the use of the technical or normative norms, adapted the SSC, subsequently validated by a group of national experts in partnership with the “Sistema Integrado de Gestão de Listas de Inscritos para Cirurgia” (SIGLIC), of the “Administração Central do Sistema de Saúde” (ACSS). The Department of Quality in the Health determined [25]:

1. The implementation of the SSSL, in all operating rooms of the National Health System.
2. The filling in all the surgeries of the SSC, in the informatics platform SIGLIC, straightly or through the interface with the informatics system of the Hospital.
3. The adhesion of all ORs to the SSC until the end of September 2010.
4. To proceed to the evaluation of results predicted in the point V (Monitoring) of the Circular, the compulsory register in the SIGLIC, for part of the hospitals.

In 2011 the impact of the SSC in 5 Portuguese hospitals of Alentejo (Évora, Beja, Elvas, Portalegre and Santiago do Cacém) was studied. The authors observed, after interviewing 153 health professionals, that 41.6% did not know the SSC. Another interesting result is that before September 2010 (mandatory adhesion by all the ORs to the SSC) just one hospital had implemented the SSC and of the respondents, 57.0% learned of the SSC through colleagues or other health professionals, 37.2% by congresses, journals, seminars or courses, 3.5% by official documents of the DGS, and 3.5% by social communication (Tab. 2.6).

Face to the several items of the SSC, the great majority of health professionals agree totally with the presented items and organization of the checklist [13].

In this study anaesthesiologists and surgeons presented a low participation in the questionnaires. This resistance in the involvement, and low awareness, has also been demonstrated by other authors in several studies [13, 3, 22].

In June 2013, a normative circular by the DGS, in partnership with the ACSS, has been issued reinforcing:

Tab. 2.6: Percentage distribution of respondents in the knowledge of the SSC.

Means of Circulating of the SSC	n	Respondents (%)
Colleagues / Other Health Professionals	86	57.0
Official Documents of the WHO	86	20.9
Official Documents of the DGS	86	3.5
Social Communication	86	3.5
Congresses/Journeys/Seminars/Courses	86	37.2
Internet	86	12.8
Others	86	5.8

1. The mandatory implementation of the project SSSL in accordance with the “Implementation manual - Surgical Safety Checklist”, as a minimum standard of medical quality assurance.
2. In every surgery one must proceed to the register of the use of the SSC.
3. All the hospital organizations have to, in the end of each semester, to send to the Department of the Health Quality, the monitoring of the level of implementation of the project, in accordance with the form available in the DGS website.

The described studies suggest that the use of the SSC involves changes in the usual work flow, and changes in the individual behaviour of the surgical team members, that may determine the success of its correct implementation.

2.4 Generation of forms

The SSC may be seen as a form with several items of the radio-button, check-box, multiple choice kind. Forms are everywhere in the most varied scenarios. Most people fill a form at least once a day, whether in your work or personal life, lying most of these in the daily Internet use (example Google Page). A poorly designed form can trigger serious problems, causing differing interpretations and consequent erroneous answers. On the other hand, a good form can provide a good and simple to use service.

Currently, construction, use and maintenance of dynamic forms on Web pages is available to users without the need for them to have prior knowledge in programming languages. There are several tools that build many and different forms, where the

user can add any question type, headers and footers, edit the form to the desired format, divide it into several pages and automatically receive the answers.

The Tab. C.1 of the Appendix C shows several examples of tools aiming for the construction of such forms, and their characteristics tools. The characteristics of the tools presented correspond always to the characteristics of the free packages or with the lower prices.

An observational study of the Surgical Safety Checklist in a Portuguese operating room

In an observational study, to obtain the necessary information, the choice of the appropriate methodology in order to avoid factors that have little relation to the behaviour under study, is essential [26]. The methods of the direct observation, are the only methods of the social research that capture the behaviours when they occur and in themselves, without the mediation of a document or testimony [27]. To the observer it is not enough to simply look, he should learn to see, identify and describe various types of the human interactions and processes [26].

When a study involves collection of information through interviews it is also necessary to use the appropriate methodologies to get the right information. The interviews, as they are a purposeful conversations, usually between two individuals, though sometimes can involve more people, are headed by a person, in order to obtain information about another person [28].

This observational study was performed at a Portuguese public health center, after institutional approval. The clinical setting observed was an operating room (OR) of the 11 available at the Hospital. During two days 14 surgeries were observed and several health professionals interviewed.

In this chapter we will address which observational methodologies were used and will describe the study and the interviews; obtained results will also be reported and discussed.

3.1 Observation in the operating room

During two days the clinical team in one of the hospital's OR was observed during their standard clinical practice. This observational study encompassed 14 surgeries, and the clinical team was not aware of the true intent of the observer.

3.1.1 Methods

The goal of the observations was to understand the functioning of the Surgical Safety Checklist (SSC) in the OR during the standard clinical routine, and observe how the different health professionals involved in this task, surgeons, anaesthesiologists and nurses, used the SSC. In this study, the observer degree of involvement and relation to the observed was considered to be passive, since he was not directly involved in the situation that was observed, meaning, the observer did not interact, neither intentionally affected the object of observation, although he was present in their environment (bystander). In addition, the participants did not know the objective of this observational study.

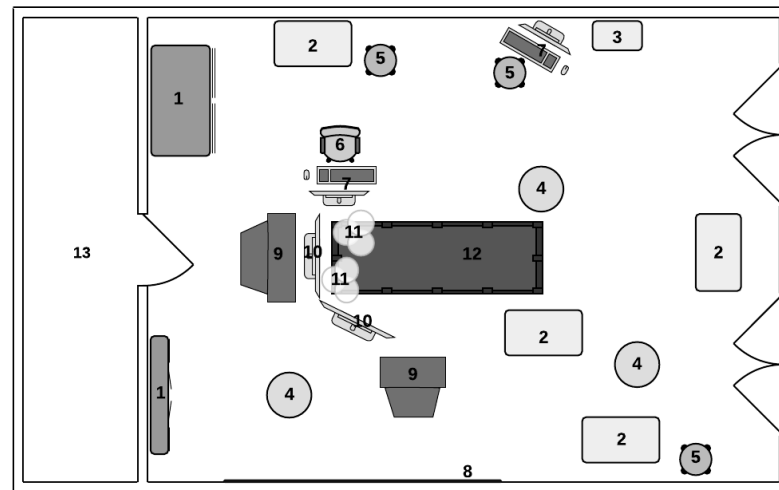
The observer focused on the same points of interest in all interventions:

- At what surgery stage is recorded each SSC phase;
- Which health professionals register each checklist phase;
- Are all items of the SSC read out loud;
- Are there items of the checklist said out loud that are not registered immediately after.

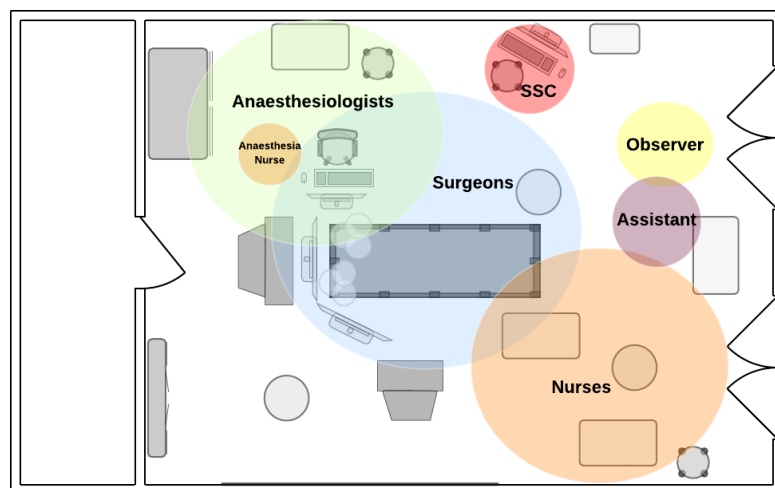
3.1.2 Environment

The Fig. 3.1 presents an overview of the OR where the observational study took place. In the Fig. 3.1 (a) is possible to see the setting organization, and display of the material in the available space, including the material trays, anaesthesia monitors and ventilator, operating table and support tables, and in Fig. 3.1 (b), we can see the action zone where health professionals and other elements usually are during surgery.

Generally, in the first phase of the SSC (before induction of anaesthesia), the surgeons are in the sterilization room or near of the operating table. The anaesthesiologists and anaesthesia nurse are in the anaesthesiologist zone, near the anaesthe-



(a)



(b)

Fig. 3.1: Operating room (view from the top): (a) 1. anaesthesia material and equipment cabinet; 2. surgical and anaesthesia equipment/material trolleys; 3. refrigerator with material; 4. trash cans; 5. stools; 6. chair; 7. computers; 8. white board, and x-ray light; 9. surgical equipment; 10. ventilator and anaesthesia monitors; 11. surgery lights; 12. operating table; 13. to sterilization room; (b) Action zones of each element.

sia material, ventilator and anaesthesia monitors. In this phase, the instrumentalist nurse is in the nurses area to prepared all material necessary to surgery and the circulating nurse can also be in the nurse zone to help the instrumentalist nurse or in the SSC zone to fill the SSC.

Before skin incision, second phase of the SSC, the surgeons are in the surgeon area, near of the operating table. The anaesthesiologist is in the anaesthesiologist zone, near surgical equipment, ventilator, anaesthesia monitors or in the computer of that area. The anaesthesia nurse can be with the anaesthesiologist, in the nurses area with other nurses or in the SSC zone to fill the SSC. The instrumentalist nurse is near the operating table to help the surgeons during the surgery or in the SSC zone to fill the SSC and the circulating nurse is all around the OR to help with anything the surgical team needs or in the SSC area to fill the SSC.

In the third phase, before the patient leaves the OR, the surgeons and anaesthesiologists are in their zones, respectively or they leave the OR. The nurses can be arranging all the equipment or in the SSC area to fill the SSC.

During the three phases, the assistant is present in the assistance zone and only intervenes when someone asks her for help, at the end of each surgery, she cleans all OR. The observer always tried to stay in the observer area, only left that space when it was necessary.

3.1.3 Acquired observations

During two days, we have followed closely all the workday of surgeons, anaesthesiologists, anaesthesia, instrumentalist and circulant nurses, and assistants. Tab. 3.1 presents how many surgeries occurred each day, the period of the day and the time of each period.

Tab. 3.1: Description of the number of surgeries and time periods observed in each day of the observational study.

Day	Number of Surgeries	Period	Time
First	2	Morning and Afternoon	10:30 am - 2:30 pm
First	6	Afternoon	3:30 pm - 9:30 pm
Second	6	Afternoon	4:00 pm - 8:30 pm

On the first day, the observer was present for the duration of 4 surgeries through the entire process of the SSC, and in 4 surgeries for part of the procedure. On the second day, the observer was present for the duration of all surgeries through the

entire SSC process. Tab. 3.2 summarizes the observed procedures regarding the SSC use in the two days.

In the two days of the observation, and of the 14 observed surgeries, only 2 surgeries met the requirements for the three phases of the SSC, as defined by the World Health Organization (WHO). Of the remaining 12 observed surgeries, 9 surgeries completed the last phase at the correct time. The SSC was always filled by the nurses (circulating, anaesthesia or instrumentalist) that were available, except for a surgery that a surgeon helped the nurses to fill one of the last phases.

It was also observed that in only 2 surgeries all items of the SSC were read aloud to the team. In 8 surgeries at least one item was asked aloud, and in 4 procedures only a few items of some phases. Finally, in 7 surgeries, several items were pronounced aloud but not recorded right away.

Tab. 3.2: Observations to the SSC procedure in operating room at public health center.

Surgery ID	Items without immediate registration	Sign In	Time Out	Sign Out	Actors	Read Aloud
1 st and 8 th	—	During surgery	During surgery	Before patient leaves operating room	Circulant Nurse or Circulant and Instrumentalist Nurse	Only the items that were unknown to the user or no item
2 nd	Sign In	Anaesthesia	When anaesthesia	Before patient leaves operating room	Circulant Nurse and Surgeon in Sign Out	Only Sign Out
3 rd , 6 th and 9 th	Sign In	During surgery	During surgery	During surgery	Circulant Nurse	No item
4 th , 5 th , 7 th , 10 th and 11 th	Sign In	Before patient leaves operating room	Before patient leaves operating room	Before patient leaves operating room	Circulant and Instrumentalist Nurse or Anaesthetist Nurse	No item or Anticipated blood loss and completion of instrument, sponge and needle counts
12 th	Sign In, Time Out	During surgery	During surgery	Before patient leaves operating room	Circulant Nurse	Time Out and Sign Out
13 th and 14 th	—	Before induction of anaesthesia	Before skin incision	Before patient leaves operating room	Circulant Nurse	All itens

The first day

In the morning period we have observed two surgeries. In each surgery there were three surgeons, one anaesthesiologist, three nurses (circulating, instrumentalist and anaesthetist) and one assistant. At the moment that the observer enters the OR, the patient was already anaesthetized and the surgeons were starting the skin incision.

Only then, the circulating nurse, began to register, in the computer of the OR, the first phase of the SSC. During the course of the surgery, the circulating nurse has completed the second phase asking aloud only the questions that she did not know how to answer. In the end, before the patient leaves the OR, the same nurse, alone, filled out the last phase of the SSC, no questions was asked aloud.

In the second second surgery, the patient was being anaesthetized when the observer entered the room. At the time, the first and second phases of the SSC were already registered. Everything went as normal as expected during the surgery, nevertheless, in the middle of the surgery, a surgeon alerted for the lack of a special needle required for a specific operation, which delayed the procedure. This oversight did not raised a problem but was enough to make the surgeon to reinforce the idea of adapting the SSC to each type of surgery. The last phase of the SSC was filled out aloud by the circulating nurse, with the help of the surgeon.

During the afternoon period, six surgeries, with different staff, were performed. In all of them we had two surgeons, one anaesthesiologist, three nurses (circulating, instrumentalist and anaesthetist) and one assistant.

When the patient entered to the OR, a surgeon asked the patient his name, if he would give consent for the surgery and if he knew the site of the body that was going to be operated, however, nobody registered anything in the SSC. The nurses began to prepare the material for the surgery and the anaesthesiologist with the anaesthetist nurse started to monitor the patient while the surgeons were getting ready in the sterilization room. Before administering anaesthesia, the anaesthesiologist asked the patient if he had some allergy and the patient answered that had allergy to the penicillin but, again, nothing was registered in the SSC. After the skin incision, the circulating nurse, in the computer, began to fill the first and second phases of the SSC. This register was interrupted sometimes because the circulating nurse had to help her colleagues during the surgery. Finally, before the skin suturing, the circulating nurse filled out third phase, and no questions were pronounced aloud.

In the fourth surgery, the anaesthesiologist began to administer the anaesthesia to the patient and no question of the SSC were asked or answered. Following, the surgeons began the skin incision and everything went well. During the suturing of the skin, the instrumentalist and circulating nurses began to fill out the SSC but no question was said aloud. After completing the SSC, the circulating nurse asked the patient, since the anaesthesia was a local anaesthesia, his name and if he had some allergies.

In the next surgery the anaesthesiologist induced the anaesthesia and, again,

nothing was asked or told. Only in the end of the surgery, the instrumentalist nurse has completed the three phases and nothing was asked to the other members of team.

During the sixth surgery, the three phases of the SSC were completed during the surgery by the circulating nurse and no questions were asked aloud.

In the penultimate surgery, when the observer entered in the OR, the surgery was already half-way. Nevertheless, nothing was asked or registered from the moment the observer entered the room until the patient left the OR. In the end, the circulating nurse completed the three phases alone.

The last surgery of the day, all the phases of the SSC were completed in the end of the surgery, alone by the circulating nurse, just like the last three.

The second day

In the second day we have observed six surgeries. In the OR there were two surgeons, one anaesthetist, three nurses (circulating, instrumentalist and anaesthetist) and one assistant.

Before the first surgery started the patient was asked his name and if he already have been operated. Then, the anaesthesiologist took the patient to the OR and he asked the same questions and if the patient had some allergies, if he was diabetic and if he was taking any medication. Following, they started to monitor the patient while the nurses (circulating and anaesthetist), with the help of the assistant, prepared the OR and the instrumentalist nurse prepared the material. After, the anaesthesia was administered, the surgeons started the skin incision and the circulating nurse started to fill out the SSC. The nurse registered all three phases during the surgery without asking any question aloud.

In the second surgery, the anaesthesiologist and anaesthesia nurse began to monitor the patient while the rest of the team asked the patient his name and if he was diabetic. Then the instrumentalist nurse came from the sterilization room and prepared the necessary material with the help of the circulating nurse. Local anaesthesia was administered and they started the operation. In the end when the surgeons were suturing, the anaesthesia nurse started to fill the three phases of the SSC, two questions were asked aloud: estimate of loss of blood and the counting of instruments, compresses and needle counts.

When the third patient was waiting outside the OR, the anaesthesiologist asked his name, allergies, diseases, the medication that he was taking and if he knew what

was going to happen. Subsequently, the anaesthesiologist took the patient to the OR and a surgeon asked the patient if he knew what was the side that was going to be operated, but nothing was registered. At this moment, they started to monitor and prepare the whole material and equipment. In the end of the surgery, the SSC was filled out for the anaesthesia nurse. All the three phases were filled at the same time and nothing was asked aloud. When the patient had already left from the OR, the circulating nurse saw that the jar that supposedly should have a biopsy was empty. At that moment the room was already cleaned by the assistant and the circulating nurse asked where was the biopsy. The surgeon answered that he had left it in the top of the surgical equipment/material trolleys within a compress. In fact, during the surgery, the surgeon, said that he was going to leave the biopsy on surgical equipment/material trolleys, unfortunately, the circulating nurse did not hear him and when they gave permission to the assistant to clean the OR, she has collected the trolley and send it to the garbage, as it is usual. The circulating nurse assumed the error but stated that if everyone took the time to do the SSC according to the guidelines, this kind of miscommunication would be avoided. The rest of the room was also conscious that the mistake could have been avoided with the simple checks of the SSC. After this incident, the surgical team gave more attention to the completion of the SSC in the correct time and aloud.

In the fourth surgery the patient entered in the OR with the assistant and the anaesthesiologist asked his name, known diseases and if he had already been operated, if he had eaten something, medication that he usually did, his weight, but nothing was registered at the moment. Three nurses with the assistant prepared the OR and they started to monitor the patient. The SSC was started halfway of the surgery and the questions “has antibiotic prophylaxis been given within the last 60 minutes?” and “what is the anticipated blood loss” were asked by the anaesthetists nurse aloud. After the surgery, the circulating nurse filled the third phase aloud and in the correct time.

After this surgery, the surgical team called back the third patient for a new biopsy. The whole team apologized and they asked if the patient would not care to be operated again, the patient authorized. In this surgery all the proceedings of the SSC were carried out within the guidelines.

In the last surgery, the circulating nurse, before induction of anaesthesia filled the first phase of the SSC and he asked some questions to the patient aloud and registered them at the same time. After the incision the circulating nurse asked aloud all the items of the second phase of the SSC. When the surgeons gave the surgery

as finished and before the patient left the OR, the same nurse, aloud, asked each question of the last phase, and registered the answers at the same time.

3.2 Interviews to the professionals

After the observational study a set of questions were made to the stakeholders and other related professionals.

3.2.1 Methods

After the observational study, the researcher conducted the interviews to these professionals, using a semi-structured approach. One of the objectives of the semi-structured interviews was to know the opinion of health professionals on the use and utility of the SSC. The respondents were surgeons, anaesthesiologists and nurses in the same OR of the observational study. The semi-structured interviews followed a previously prepared questionnaire that served as a guideline, without requiring for a strict order of questions, managing to adapt the development of the interview to the respondent, ensuring that participants responded to these same questions outlined, but with a high degree of flexibility depending on the answers given. The guideline was as follows:

- What is your profession?
- Is the SSC used in the operating rooms of your hospital according to the rules explained in the WHO manual:
 - Each item of SSC is validated at the time that statement is read?
 - How is the validation performed (item by item, phase by phase, all at once)?
 - All questions are listed in the predetermined order?
- In your opinion, are all the questions correctly formulated?
- Did the checklist change the way you work?
- In your opinion, what are the benefits and disadvantages of implementing the checklist, defined by WHO / “Direção Geral de Saúde” (DGS) in 2010?

- In your opinion, would it be advantageous to adapt the checklist to each type of surgery?
- In your opinion, would it be advantageous to use a Tablet / Smartphone for implementing the SSC?

In addition of the health professionals, the ITs professional of the hospital were also interviewed. The semi-structure guideline of the interviews followed the same rules of the script of health professionals. The questions were as follows:

- In your opinion, would it be advantageous to adapt the checklist to each type of surgery?
- In your opinion, would it be advantageous to use a Tablet/Smartphone for implementing the SSC?
- Do external application may be added into the hospital software?

3.2.2 Answers

Over the two days, several health professionals and technicians (surgeons, circulating nurses, anaesthesiologists and IT) were interviewed. Their opinions are presented in Tab. 3.3.

In general, the circulant nurses think that the use of the SSC is very important, but report that not all health professionals involved collaborate the same way. When the SSC became mandatory they tried to follow with all the rules of the WHO, but due to lack of cooperation of the surgical team, they decided to stop asking a few items aloud, stating: “if the checklist was a team work, this time would not be a waste, and its use would be improved”. In their opinion, a mobile application would not help to improve the functioning of the SSC. They consider that the SSC could be adapted to each type of surgery, for example, they consider that the item of confirming all team members and introducing themselves by name and role, in most of the Portuguese hospitals would be unnecessary, because normally the teams know well each other. Additionally, they refer that the necessary material is very different in minor surgeries when compared to major surgeries (last phase of the SSC).

The anaesthesiologists were also in favour of the SSC application. In their opinion, the problem of its bad functioning is that even if there are errors for not filling out the checklist according to the WHO guidelines, nobody is held responsible in

case of a preventable complication: “it is fulfilled with some rules but I admit that not all, there is not much rigour in its register”. The anaesthesiologists also do not find the use of a mobile application a surplus value for the surgery but on the contrary, stating that the adaptation of the SSC would be a good improvement.

Several surgeons (orthopaedics, urology and plastic surgeons) were interviewed, and presented very divergent opinions. Some considered that the use of SSC is very important for the safety of the patient, mainly in the points of the laterality and name confirmation, but recognize that many health professionals, mainly the surgeons, still have not adapted to its use. Also, they state that if the professional who did not collaborate with the SSC procedure would be held accountable for any complication related to this, they would rapidly change their attitude towards the SSC. Other surgeons state that the checklist may be important but they do not usually do it. Actually they consider that the years of experience are more important than a single SSC. Finally, one of the problems cited is the fact that “the register of the SSC or any register of another computerized program, for example of the consultations, was much easier when everything was in paper”. Regarding the mobile application, they consider it to be useful in the confirmation of the material and equipment necessary for the procedures, so the nurses could register that information in the place where the material is stored. The SSC adaptation to different surgery types, in their opinion, would be ideal, since they consider some items superfluous.

The ITs of the hospital was surprised with the working of the checklist because they never thought people did not comply with the WHO guidelines. Also, they explained that it is possible to adapt the SSC software available at the hospital to a new application (software that may for example adapt the SSC for each type of surgery), after approval from DGS. Other proposals have been suggested, more specifically the use of a mobile application: a pre-checklist that on the day before surgery if it could to request the room, the material needed , repossess the concerns / problems that the patient may have or their exams.

3.3 Discussion

The positive points of the observational study were the full collaboration of the health care professionals involved, and also from the IT team of the hospital. Also, observing the SSC use was of paramount importance in the understanding of the entire process at the operating room. It should be highlighted, that due to the study

Tab. 3.3: Interviews to the health professional (surgeons, anaesthesiologists and nurses) about SSC use.

Nurses	
Pros	“The use of the checklist is important and should be enforced properly” “If the checklist was a team work, this time would not be a waste, and its use would be improved” The adaptation of the SSC to the type of surgery would be a good solution.
Cons	At the beginning of the implementation of the SSC, professionals complied with the rules of the user manual, but due to the attitudes of some surgeons they have stopped doing it. The collaboration of surgeons is scarce. The registration of the SSC in the hospital software is done by these professionals, their names can be held liable if an incident occurs. The use of a mobile application would not improve the functioning of the SSC.
Anaesthesiologists	
Pros	“The use of the checklist is important and should be enforced properly” The adaptation of the SSC to the type of surgery would be a good solution.
Cons	The use of a mobile application would not improve the functioning of the SSC. The SSC is not used properly because no one is blamed if an incident occurs due to lack of data completion.
Surgeons	
Pros	The adaptation of the SSC to the type of surgery would be a good solution. “It is a memory aid, because we are human and we all fail” “The first questions should be asked before the patient is sent down to the operating room, and surgeons should have access to them”
Cons	It is difficult to apply the SSC when experienced health professionals do not set an example, especially to the younger ones. It is necessary to change minds, they are aware that many colleagues do not collaborate with the nurses. “If anyone who did not fill up the SSC, or did not cooperate in their fulfilment was punished, it was possible to work” Demotivation of health professionals with the health system at the moment (possible justification for not completing the SSC). “When there are new implementations, especially surgeons, are very reticent” “It would take several serious incidents to open the minds of these professionals” Many of the resident surgeons, do not know the function of the SSC. “There is always a way to not comply with the rules of the checklist or other computerized program”

design and specificity, data volatility may be an issue, since everything was noted down in a phone after every interview or observation, and with so much simultaneous events happening at the same time in the OR we may have missed some events.

The observations of the observational study lead us to conclude that the SSC is not filled, in the majority of times, according to the WHO guidelines. Therefore, it is urgent to change the mindset of many health professionals, and that there is a need to raise awareness to the SSC utility.

Surgical Safety Checklist application proposal

In accordance with the World Health Organization (WHO), the Surgical Safety Checklist (SSC) can be adapted to the hospitals, services or to the type of surgery. After an analysis of the results obtained in the observational study and the opinions gathered in the interviews (Chapter 3), the next step of this thesis was the development of a SSC application responding to the health professionals' requests, that may be adapted to the type of surgery, and easily introduced in the hospital's application software.

This chapter describes all the development of the application proposal. It is divided in five sections: Design and architecture, Web languages, Support tool, Development and Discussion. The first section shows the initial idea to the application development. The other sections explain the choice between three support tools, all steps that was performed to the application development and justification of our choice, respectively.

4.1 Design and architecture

The Fig. 4.1 shows the use case diagram of the SSC application proposal that represent the actors and their actions in the application. The actors in this use case are: surgeons, anaesthesiologists or nurses, IT Staff and Healthcare Administration. The first actors are the health professionals that are inside operating room (OR) that need to use the SSC. The actions that these actors should be able to perform are: the ability to select a SSC from all the existent and to complete the SSC after

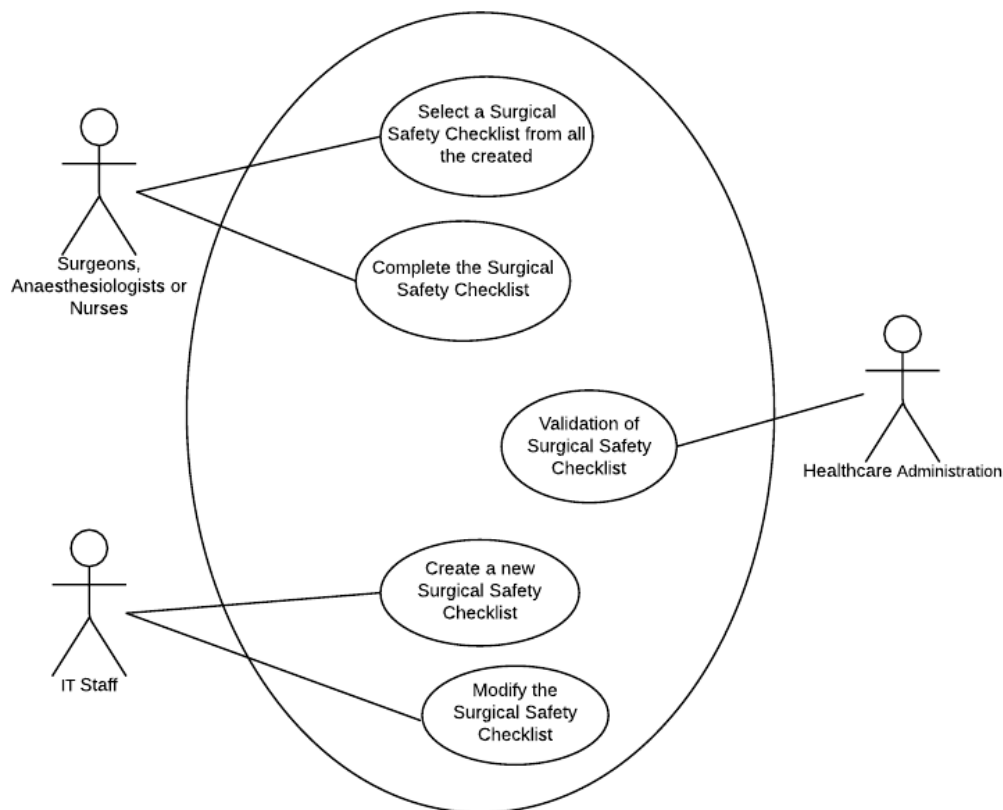


Fig. 4.1: Use case diagram of the SSC application proposal.

the selection is made. The IT Staff is responsible for all the information systems in the hospital and they should be able to create new SSC, requested by doctors or nurses or to modify any existent SSC. Healthcare Administration actors represent the service surgery that have the function of validate the SSC created by the IT Staff, according to the WHO rules, in other words, when health professionals need of a new SSC, all the service defines the new items of the SSC. After, there is a central hospital validation that subsequently sends the IT Staff to create a new SSC.

The flow of the SSC application proposal is present in Fig. 4.2. The main menu of the application will provide the possibility to surgeons, anaesthesiologists or nurses to choose the option “Select a form”, that redirects (number 1 of the Fig. 4.2) to another page where the actors can choose from a pre-existing list. The forms that appear in this list are all the forms created in online questionnaire builder. After the choice, we jump to the questionnaire itself. We believe that with the quantity and quality of the available tools to build forms online it not necessary to create one ourselves. Therefore, it is presented to users the chosen form through of the connection to the online questionnaire builder (number 3 of the Fig. 4.2). Before

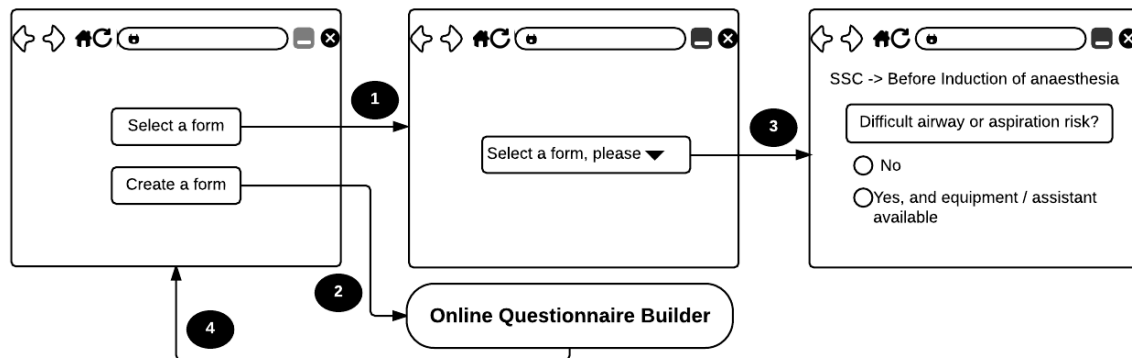


Fig. 4.2: Mockup layouts of the application proposal. In this mockup it is possible to see some of the improvements proposed mainly in the third layout you can see the single question at time, the progress bar and the no go back option.

of the form be presented to the user, the application changes the way it will be seen, that is, the user chooses the form, the application will pick it up to the builder and then the changes are applied. In addition, in main menu, the IT Staff can choose the option to “Create a form”. The application redirect the user to an online questionnaire builder (number 2 of the Fig. 4.2) where they can create the form. When the form is completed, it is saved in a folder to be validated by Healthcare Administration actor, only after, it is moved to the pre-existing list, represented in the Fig. 4.2 as the number 4.

4.2 Web languages

To the development of the application, we choose to use the web languages (presented in sections below) due to the previous knowledge these web languages, to its simplicity of handling, run on various platforms, compatible with almost all servers used today and are free.

4.2.1 HTML - Hyper Text Markup Language

HTML is a markup language used to make Web pages. Every HTML document has tags that describes different document content. An element consists of a tag name, attributes, values and children (who may be other elements or text). The attributes modify the results of the standards elements and values characterize this change [29].

4.2.2 PHP Hypertext Preprocessor

PHP is open source scripting language, where his scripts are used to develop applications present and active on the server side, capable of generating dynamic content in browser. Which also generates the web page to be displayed on the client side. The PHP files can contain text, HTML, CSS, JavaScript, and PHP code, that can [30]:

- generate dynamic page content;
- create, open, read, write, delete, and close files on the server;
- collect form data;
- send and receive cookies;
- add, delete, modify data in your database;
- restrict users to access some pages on your website;
- encrypt data.

4.2.3 XML - eXtensible Markup Language

XML is a markup language that was designed to describe data, not to display data. The XML tags are not predefined, each one can define their tags. XML is a format for creating documents with data arranged hierarchically. Its principles are [31]:

- Separation of contents and format;
- Simplicity and readability;
- Possibility to create tags without limitation;
- Creating files for validation of structure;
- Interconnection of different databases;
- Information on the structure of concentration.

4.2.4 XSLT - eXtensible Stylesheet Language for Transformation

XSLT is used to transform an XML document into another XML document, or another type of document that is recognized by a browser, like HTML and XHTML. Normally XSLT does this by transforming each XML element into an (X)HTML element. The XSLT can add/remove elements and attributes to or from the output file and also rearrange and sort elements, perform tests and make decisions about which elements to hide and display. XSLT uses XPath to navigate in XML documents [32].

4.3 Support tools

The Tab. C.1 (Appendix C) presented a big list of tools that are used to build forms online. This table resumes these tools and its characteristics in the categories of: is it free; API; max number of questions; embedded survey into webpage; and validation.

Comparatively to the quantity of characteristics that each form has and to the number of questions that they allow to add, it led to evidence of 89 forms, three: Google Docs, JotForm and Form Site.

Subsequently to this choice, we have created a SSC in each one of the tools. In each site we carried out the respective subscription and tested some of its features. With the goal to have a better perception of all the advantages and disadvantages of each platform.

4.3.1 Google Docs

Google Docs is a free form builder, with drag and drop interface, developed by Google, Inc. The user needs a Google account and through the Google Drive it can access to the creation of forms. According to the target audience, he chooses a title and a subject and he can define the language that the form presents, too.

After chose the model, several types of questions can be added: text, text of paragraph, multiple choice, checkbox, to select from a list, scale, grill, date and hour. The fact this tool only has available 9 types of questions, makes it one of the major disadvantages comparatively to the other existent tools. Other one, it is the fact that Google Docs does not have the possibility to create sections inside sections.

For the time being, the maximum number of forms and questions allowed to add are unlimited, one of his biggest advantages.

This tool guarantees also has input validation, for example, if we ask for an e-mail, we can define our accepted format or we can define that a answer should not be left in blank. Only the questions of “Text”, “Text of the paragraph” or “Checkbox” are compatible for validation. Each type of question has his configurations of validation, according to the type of answer: number, text, regular expression or selection of fields.

This tool also allows to define a flow between pages, this is, we can break the form in several pages and in accordance with an answer, jump to a specific page. This feature allows us to create a unique flow where we can show only the questions that are necessary to answer and to leave the one that should not be.

After completing the form, the link of the form is sent for the participants through of the e-mail or shared in the social nets: Google+, Facebook and Twitter. Also, the form can be incorporate in a site or blog. There are other configurations that can be adjusted:

- Show the link to send another response. Thus, the users to submit as many form responses as they would like;
- Publish and show a link for the results of this form. The respondents will have access to the forms summary of responses.
- Allow responders to edit responses after submitting. The respondents could change their answers to the form, in other words, after of the respondents send the form, they can complete the form later.

In end, these answer are presented in form of tables or graphs for subsequent analysis. Both the forms and the answers can be exported in format CSV.

The forms of Google have a service of Google Apps where can to be added menus, dialogues, personalized sidebars through the Apps Script. The Apps Script allows to build applications Web and to interact with other services of the Google, like Google AdSense, Google Analytics, Diary, Drive, Google Finance, Gmail and Google Maps. [33].

4.3.2 JotForm

The JotForm is a paid tool but has a free packet named Starter. It is a tool developed by Interlogy, LLC and his interface is drag and drop. The user has the possibility

to choose one of the 5000 templates of forms, to import in an existent form or to begin the developing a form from scratch. If the user choose the option “blank form”, he has the possibility to choose a subject, title, type, colour and size of the letter, background, width and alignment and the width of the label that his form is going to present.

Subsequently, the user selects the type of questions that he intends to present. The maximum number of forms and questions that the user can show is unlimited but the maximum number of answers is 100 for month, one of his disadvantages. In contrast with the 40 types of different questions that this tool provides, being included images, videos and several templates of questions predefined, like e-mail and residence.

Along the form it is possible to write text and format it to the likes of the user. Besides it to be possible to do skip pattern / branching with the addition of the break of pages and the selection of the option to jump for other pages or for the end of the form.

All the types of questions have his general definitions, that change according to the type of question and it can be altered according to the objective of the form. The validations are an example of these definitions, all the fields can be validated and if the respondents do not answer in accordance with the configurations established the user will see an error message.

This tool still has the possibility to send notifications for e-mail, to create a thanks page, to embed the form in pages like: Facebook, WordPress, Google Sites, Blogger, between others, to copy the source code, to incorporate in the form applications like PayPal, Drop Box, between others and to choose a language.

The answers of the forms can be accessed into the user’s account of the JotForm and can be exported in format PDF, Excel or CSV. In this tool there is not the possibility to analyses the data through tables and graphs.

Other characteristics of this tool is the quantity of external applications that the users can use, being possible, with the API of the JotForm, to do a connection to our account and use the forms without using the official site [34].

4.3.3 FormSite

The FormSite is a paid tool developed by Vroman Systems, Inc. The free version allows to the user to create only five forms.

Its interface is drag and drop and the user has the possibility to: create its own

form, import a created form or choose one of the several templates available.

If the user choose to create a new form, he has to choose a title. It is available 41 types of different questions, like images or pre-definite questions.

In this tool is only possible that each form has at the most 50 questions and the 10 answers for form, with the possible of the break of pages. The design of the form, like background colour, letters colours of each question, size of the answer box, type and colours of buttons can be altered with the relish of each user.

The user chooses the type of questions that he wants for his form and he is presented with a box, that is different for each type of question. Where the user has the possibility to format the text, validate the answers, position the question, modify the size of characters, randomize answers in the questions of radio button and checkbox (characteristic unusual in the tools of creation), between others.

When the form is created, it can be sent to respondents by e-mail or can be inserted through a link on social networks: Facebook and Twitter, that is embed in website or blog.

The results are visualized in user's account of the FormSite through tables or graphs for further analysis. Yet it can to be exported in format XLS and CSV. One of the biggest disadvantages of this tool is the use of the API, this only is available in the paid packets [35].

4.3.4 Discussion

For the SSC application proposal, the essential characteristics in a form generation tool are the number of types of questions that each form provides. These types of questions have to be mostly checkbox, radiobutton and text, as these are typically items of SSC. Other important characteristic is the possibility to create subsections. The API is another essential characteristic in a form generation tool to make a connection to the user account.

Regarding the type of questions, the JotForm and the FormSite are the tools that have more type of questions, about 40 while that Google Docs tool has 9 type of questions, but all have the type of questions most important: checkbox, radio button and text. JotForm and FormSite tools have also the possibility of to create sections inside sections in relation with the Google Docs tool that have not this possibility. With regards to the API characteristic, the FormSite is only tool that have not this possibility.

Due to the advantages and disadvantages found in the construction of the SSC

in the tools cited previously, the JotForm was the tool chosen to help in the development of the application proposal because it is the tool that have the 4 characteristics more important to created of the forms.

In addition to these 4 characteristics, the JotForm tool presents 5000 templates of forms, the forms can be exported in format PDF, Excel or CSV and the data can be analysed through tables and graphs.

4.4 Development

To create forms or select created forms is necessary to have a registration in official site of the JotForm and in the same site, it create an API account to access the key and the source code in web language (PHP) with some necessary functions to this access, without the need to be connected to the site.

Therefore, the users can be able to connect with the API and being connected to the site JotForm, using the “include” and “require” statement, that takes the text / code / markup existent in the specified file to the current file. Other words, it is inserted the content of one PHP file into another PHP file, with the “include” or “require” statement [36]. In this case, the “conf.inc” file contains the key to access to the API of the JotForm and “JotForm.php” file contains the function “getForms()” to get a list of forms this account, as it is shown in the code below. The “include” and “require” statements are identical, except upon failure [36]:

- require will produce a fatal error and stop the script.
- include will only produce a warning and the script will continue.

```
<?php
require "conf.inc";
include "JotForm.php";

$jotformAPI = new JotForm($jotFormId);
$forms = $jotformAPI->getForms();
?>
```

After connecting to the JotForm, can to have access to the all forms through the “foreach” loop that works only on arrays, and is used to loop through each value pair in an array. Thus, the name that appear in the list the forms that the users choose, is the title of the forms, through the “foreach” loop. This loop only show to the user

the forms that has “enable” status. When the user choose the form that want to work, the “id” variable of the form is saved (as shown in the code below) [37].

```
<?php
foreach ($forms as $form)
{
$myformtitle = $form["title"];
$myformid = $form["id"];
$myformstatus=$form["status"];
$myformurl = $form["url"];

if($myformstatus=="ENABLED")
{
echo "<option value='{$myformid}'>{$myformtitle}</option>";
}
}
?>
```

With the code below, can to transfer one form to the server through of the function `getForm` of the “JotForm.php” file. This function give basic information about a form such as the variable “`$formId`”, the function “`file_get_contents()`” that reads a file into a string [38], through of the variable “`$myformurl`” that contains the url of the form and the function “`file_put_contents`” that writes a string to a file [39], it giving the include path and the reading url.

```
$form = $jotformAPI->getForm($_POST['formId']);

$myformurl = $form["url"];
$formHTML = file_get_contents($myformurl);
$xmlFilePath=$xmlFilesFolderPath.$_POST['formId'].".xml";
file_put_contents($xmlFilePath,$formHTML);
```

We think it is more feasible the SSC appear in a format different to improve any aspects that were referenced in the observational study as less positive. For this reason, it is necessary to transform download file of the JotForm. As the download form appear in HTML code, we transformed this file in XML format through a XSL file in other XML file, in other words, the code down it load xml file to after it load xsl file that configure the transformer and it attach the xsl rules.

```
$xml = new DOMDocument;
$xml->loadHTMLFile($xmlFilePath);
$xml = new DOMDocument;
$xml->load('Format.xml');
$proc = new XSLTProcessor;
$proc->importStyleSheet($xml);
echo $proc->transformToXML($xml);
```

The “Format.xml” file formats the selected form according to the following options:

- Display one item of the SSC at a time. This feature will force the user to focus on the question at hand and will not allow the user to answer other questions out of order;
- Display the stage where the SSC is, so the user knows what he is doing and to help him, guiding him through the SSC;
- Do not allow going back to the previous step. This feature forces the user to be fully aware of his answers. In this feature we will implement some safeguards such as highlighting the answers and only allowing keeping forward some time after the answer is given. A go back button should be implemented anyhow, but the user will be informed that action will be registered as a forced go back requested by the user;
- Do not allow going forward to the next item if the current is not filled;
- Do not allow going forward to the next item if the time it took to fill the item was too short. This feature tries to stop random inputs to just force the SSC to go further, or to prevent any by heart input;
- Log any action made by the user. This feature will allow to access if the SSC is being filled properly according to the WHO guidelines.

For this, the application was developed in web languages (HTML, PHP, XML, XSLT). The main menu presents two buttons to the users that can choose the option: “Create Form” or “Select Form”. In the option “Create Form”, the user will be redirected to official site of the JotForm to created the desired template. In the option “Select Form”, is presented a list with different forms.

4.5 Discussion

All these changes are alternatives to try to control the filling of the SSC, both in paper format as digital format, and make it more reliable. For example, the application presents the phase where the SSC is and displays one item of the SSC at a time, it helps the health professionals focus on this only question, forcing the user to read and respond to that question. The fact that the application does not allow going back to the previous question is an advantage because it forces, once again, the health professionals to be fully aware of their answers. Also, the application does not allow going forward to the next item if the current one is not filled or if the time it took to fill the item was too short. Only then are we able to avoid that health professionals do not automatically fulfil all the items of the SSC (forcing them to be with more attention).

Conclusion

In all the activities that the human being is involved, failures can occur because to error is human. Professor Bubb of the Technical University of Munich states that in average 15 errors per person per working day may occur [40]. The easiest way to prevent these errors is to use checklists as a memory aid. These checklists are designed to help to identify and correct errors and omissions before accidents or irreversible steps are made.

Without exception, any health professional is subject to error. Unfortunately, surgery is a major source of avoidable morbidity and mortality worldwide [41]. The complications of surgical care have become a major cause of death and disability worldwide. Although surgical procedures are intended to save lives, the statistics indicate that at least 25% of accidents occur in clinical intra-operative periods [42].

Being the patient safety one fundamental component of quality in providing health care, the SSC is crucial to promote that safety, as seen, for example, the article “The effect of the WHO Surgical Safety Checklist on complication rate and communication” published in the medical journal “Deutsches Ärzteblatt International” in 2012 that analysed 20 studies analysing the “Surgical Safety Checklist” through a selective search in the PubMed and Medline databases. One of the studies demonstrated that after the implementation of the SSC, there was a 36% relative reduction of the complication rate, from 151 in 842 cases (18.4%) to 102 in 908 cases (11.7%). Also, there was decrease in mortality, from 31 in 842 cases (3.7%) to 13 in 908 cases (1.4%). Another study revealed that the use of the WHO SSC could have prevented 14.9% of all wrong-side errors that did not lead to surgery being performed on the wrong side, and 85.3% of all wrong-side errors that actually did lead to surgery being performed on the wrong side. A further study documented a ben-

eficial effect of the SSC on the correct implementation of guidelines for thrombosis prevention [43].

But, the results of the observational study, indicate that the SSC is not properly filled, in the majority of times, according to the WHO guidelines. In the practical implementation, United Kingdom, where universal implementation of the SSC is officially required, only two-thirds of all National Health Service hospitals have adopted it to date for compulsory use in all surgeries. In Washington, D.C., interviews with five physician team leaders revealed that the quality of implementation of the SSC depends on these physicians ability to explain and demonstrate the use of the SSC and in France, at the Hospital Belle-Isle in Metz, one month after its introduction, only 70% of the individual items of the SSC were filled out. [43]

Therefore, we conclude that it is urgent to change the mindset of many health professionals, and that there is a need to raise awareness to the SSC impact, through, for example, interventions to various undergraduate courses related to healthcare, or lectures from aviation professionals as a parallel example of the checklists successfully used. We also believe that more hearings to the use of the SSC in the hospitals or a certification may incite is proper use. Reported incidents may serve as examples of the SSC impact, as it happens in the aviation [19].

The article referenced above advises that education and training (including in an operating room simulation) are needed to assure proper implementation. Interdisciplinary communication helps prevent conflicts in the operating room about proper implementation. Training videos demonstrating the implementation of the SSC are also helpful. Every surgical department can evaluate the effect of the checklist by keeping track of complication rates before and after its implementation [43].

According to the observational study the application, referenced in Chapter 4, it can to be a possible solution that may be integrated in the hospitals' systems, to control the use of the SSC, and it has new features which we believe may make the SSC more user-friendly, and reliable. For example, it display one item of the SSC at a time and it do not allow going back to the previous item forces the to health professionals fill the SSC with calmer and attention, without it fill the items by heart, without it reading them. Also, the application do not allow going forward to the next item if the current is not filled, forces that all items of the SSC are filled and it do not allow going forward to the next item if the time it took to fill the item was too short to the health professionals not fill the items of the SSC by heart, too. This needs to be investigated in further studies. Also the modification of the SSC to each type of surgery needs to be validated. Only then are we able to avoid

that health professionals do not automatically fulfil all the items of the SSC (forcing them to be with more attention).

The developed application can further be improved in some features, such as: the automatic detection of non-compliance with the guidelines, in other words, automatically analyze the completed forms; guaranteeing the confidentiality of the used tool (JotForm) in relation to information placed in the forms according to the “Comissão Nacional de Proteção de Dados” (CNPd) and the existence of an evaluation to all the features of the application by final users (surgeons, anaesthesiologists and nurses), allowing to identify problems that may exist with the practical operation of an operating room.

With this work, we expect to alert, to help and to change the mentalities of the health professionals to put patient safety always at forefront and that our application may help in this field. Because, the patients are the priority in health.

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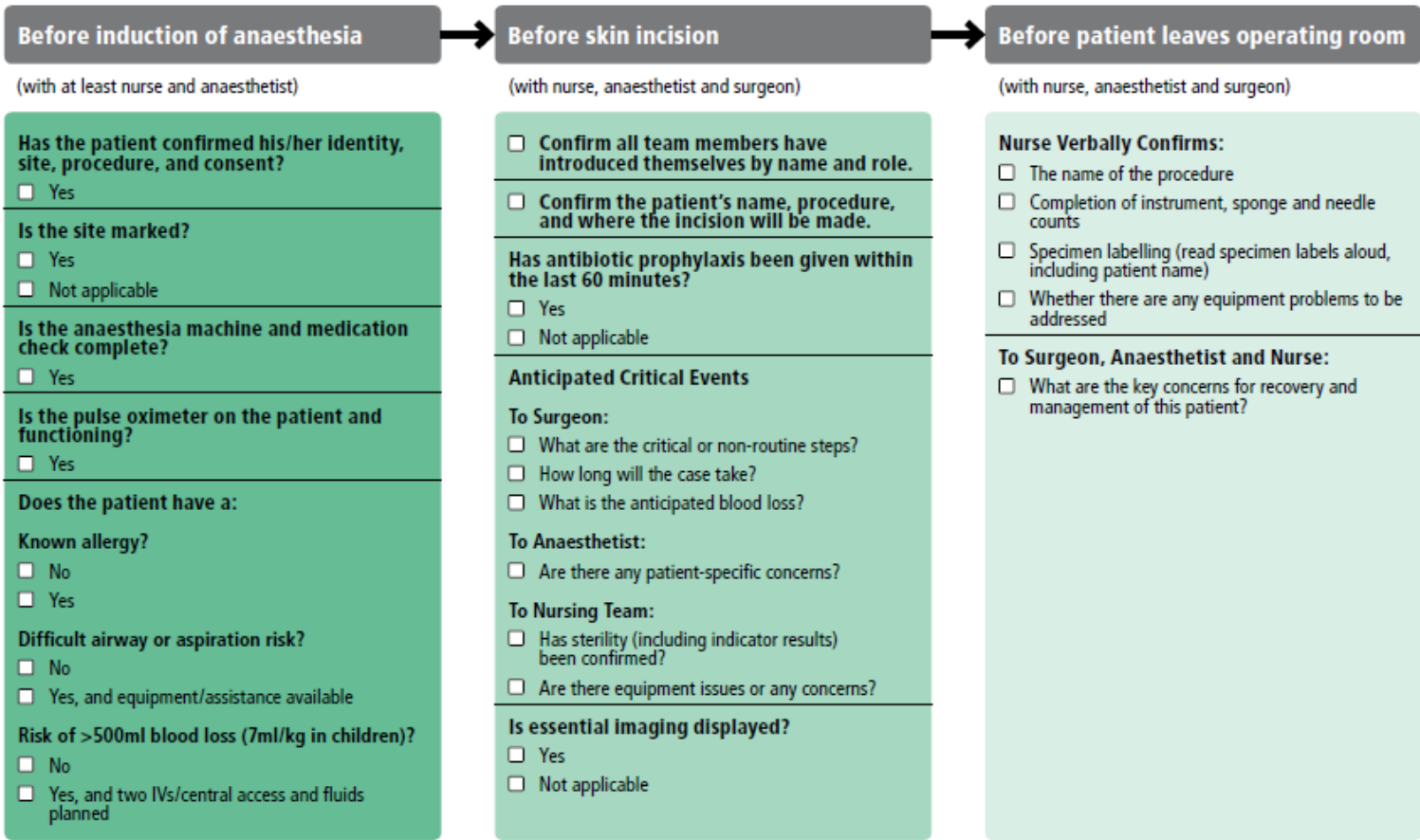
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Appendix **A**

Surgical Safety Checklist



This checklist is not intended to be comprehensive. Additions and modifications to fit local practice are encouraged. Revised 1 / 2009 © WHO, 2009

Fig. A.2: The new version of the Surgical Safety Checklist (2009).

Interviews to the pilot Armindo Martins

The pilot Armindo Martins of “Transportes Aéreos Portugueses” (TAP) has given us two interviews. The first by video conference (Skype) and the second interview was conducted in person (V Nursing Journey in Surgical Instrumentation - CESP), for a better understanding of the functioning of the aviation checklist.

B.1 26th March 2014

1. How long has the aviation checklist being used?

I do not know exactly how long we have started to use it but we started many years ago.

2. How do you carried all process of the checklist?

The checklist is a summary of the extensive manual “Quick Reference Handbook held by Standard Operating Procedures”. This summary is a laminated sheet printed front and verse. All process consists of the reading and answer, aloud, of actions distributed by various phases of the flight, and recorded by the black box. In addition, either the pilot and the co-pilot can and should alert each other when any check is not performed or if is performed incorrectly. The aviation checklist requires that the concepts of good communication and responsibility are always present. Each pilot must be aware that any mistake can cost the lives of many people. Currently there are not many accidents by mechanical failures. The statistics show that in four accidents, three are attributed to human error.

3. What is the format that your airline (TAP) uses the checklist?

Digital format.

4. What are the advantages of a digital checklist in comparison with the checklist on paper?

There are many advantages, but one of the most important is that pilots are able be sure that the items were validated and those that are yet to validate. This advan-

tage becomes particularly important during a flight with great turbulence, because it is complicated to read a paper sheet when the plane is not stable which may lead to missed checks.

5. Do all points of the checklist are recorded immediately on the computer?

Pilots do not record when the items of the checklist are read aloud. Simply the checklist is read and each topic is verified. For example, one of the procedures to check the position of the levers, in which case there is a mechanical gesture to confirm the position. The only records kept are the communications and telemetry that are on the black box.

6. If the pilots do not check one of the items of the checklist can they go forward?

They can in paper format. But, in order to achieve greater safety, the pilots at TAP check aloud all the steps that appear in the monitor of the plane. The topics checked disappear after being performed, leaving only in the monitor the checks that are still unfulfilled. This makes it difficult to move to another stage of the process if the previous is not fully completed.

7. If you do not complete the checklist can you move the plane?

I can. But, I need to justify why you have done so.

8. Who ensures that all pilots check all items from the checklist?

It is not possible to ensure that all items are checked. Once again, the responsibility of each pilot is responsible for his actions, especially the co-pilot that is watching all the procedure. According to the standards of the aviation, 75% of the flights have to be analysed through the aircraft safety. They check the voice recordings of the black box with the procedures done. At TAP, the fourth safest air company in the world, analyses 97% of his flights. When some problems or accidents occur, investigations are carried out and reports are presented with the called mistakes organizational. The pilotage team can be liable for not fully filling the checklist. With these reports, new checklist updates are made and often several steps are repeated more than once in certain flight situations.

B.2 5th April 2014

1. Who evaluated the functioning of the checklist in aviation when it was first implemented, for the first time?

I do not know which was the entity that evaluated the first aviation checklist. Today, the International Civil Aviation Organization (ICAO) at international level and the “Instituto Nacional de Aviação” (INAC) at national level evaluate the checklist. Possibly, this first evaluation was made by organizations of the same kind.

2. Who revaluated and changes the aviation checklist?

In Portugal, who revaluated the checklist is INAC in cooperation with the aircraft manufacturers. This revaluation is reported to ICAO and other international entities, which in turn may decide to modify the checklist.

3. Do the format of the aviation checklist depend on each airline?

Yes, every company defines the format to use and all aircraft of the same company have to use the defined format.

Appendix **C**

Tools to constructions of the forms

Tab. C.1: Tools to construction of the forms.

Online Surveys	Developer	License	Free	API	Max Surveys	Max Questions	Limits	Max Answers
Google Docs	Google, Inc	Proprietary	Yes	Yes	Unlimited	Unlimited		Unlimited
Wufoo Free	SurveyMonkey, Inc	Proprietary	Yes	Yes	3	10		100/month
Wufoo Ad Hoc	SurveyMonkey, Inc	Proprietary	No	Yes	10	Unlimited		500/month
Wufoo Bona Fide	SurveyMonkey, Inc	Proprietary	No	Yes	Unlimited	Unlimited		3000/month
Wufoo Carpe Diem	SurveyMonkey, Inc	Proprietary	No	Yes	Unlimited	Unlimited		15000/month
Wufoo Ad Infinitum	SurveyMonkey, Inc	Proprietary	No	Yes	Unlimited	Unlimited		100000/month
JotForm Starter	Interlogy, LLC	Proprietary	Yes	Yes	Unlimited	Unlimited		100/month
JotForm Premium	Interlogy, LLC	Proprietary	No	Yes	Unlimited	Unlimited		1000/month
JotForm Economy	Interlogy, LLC	Proprietary	No	Yes	Unlimited	Unlimited		10000/month
JotForm Professional	Interlogy, LLC	Proprietary	No	Yes	Unlimited	Unlimited		100000/month
FormFacil	arteTI	Proprietary	Yes	No				
Form TI Gratuito	arteTI	Proprietary	Yes	No	2	8		30/month
Form TI Bronze	arteTI	Proprietary	No	No	4	20		200/month
Form TI Prata	arteTI	Proprietary	No	No	10	80		500/month
Form TI Ouro	arteTI	Proprietary	No	No	40	Unlimited		2000/month
Form TI Diamante	arteTI	Proprietary	No	No	Unlimited	Unlimited		Unlimited
Form Site Free	Vroman Systems, Inc	Proprietary	Yes	No	5	50		10/survey
Form Site Deluxe	Vroman Systems, Inc	Proprietary	No	No	5	100		500/survey
Form Site Pro 1	Vroman Systems, Inc	Proprietary	No	Yes	10	200		1000/survey
Form Site Pro 2	Vroman Systems, Inc	Proprietary	No	Yes	25	300		2500/survey
Form Site Pro 3	Vroman Systems, Inc	Proprietary	No	Yes	50	1000		5000/survey
Form Site Enterprise	Vroman Systems, Inc	Proprietary	No	Yes	1000	1000		50000/survey
Form Logix Free	Form Logix	Proprietary	Yes	No	Unlimited			
Form Logix Starter	Form Logix	Proprietary	No	No	Unlimited			
Form Logix Professional	Form Logix	Proprietary	No	No	Unlimited			
Form Logix Elite	Form Logix	Proprietary	No	No	Unlimited			
FormAssembly Starter	Veer West LLC	Proprietary	Yes	No	Unlimited			
FormAssembly Pay-As-You-Go	Veer West LLC	Proprietary	No	No	Unlimited			
FormAssembly Basic	Veer West LLC	Proprietary	No	No	Unlimited			
FormAssembly Professional	Veer West LLC	Proprietary	No	No	Unlimited			
FormAssembly Enterprise	Veer West LLC	Proprietary	No	No	Unlimited			
FormStack Basic	Formstack, LLC	Proprietary	No	No	5	Unlimited		500/survey
FormStack Individual	Formstack, LLC	Proprietary	No	No	20	Unlimited		2000/survey
FormStack Manager	Formstack, LLC	Proprietary	No	No	100	Unlimited		10000/survey
FormStack Teams	Formstack, LLC	Proprietary	No	No	1000	Unlimited		100000/survey
Gravity Forms Personal License	Rocketgenius, Inc	Proprietary	No	No	Unlimited	Unlimited		
Gravity Forms Business License	Rocketgenius, Inc	Proprietary	No	No	Unlimited	Unlimited		
GravityForms DeveloperLicense	Rocketgenius, Inc	Proprietary	No	No	Unlimited	Unlimited		
Survey Monkey Basic	Survey Monkey	Proprietary	Yes	Yes		10		100/survey
Survey Monkey Plus	Survey Monkey	Proprietary	No	Yes		Unlimited		1000/survey
Survey Monkey Gold	Survey Monkey	Proprietary	No	Yes		Unlimited		Unlimited
Survey Monkey Platinum	Survey Monkey	Proprietary	No	Yes		Unlimited		Unlimited
123ContactForm Basic	123ContactForm	Proprietary	Yes	Yes	5	10		100/month
123ContactForm Gold	123ContactForm	Proprietary	No	Yes	20	Unlimited		500/month
123ContactForm Platinum	123ContactForm	Proprietary	No	Yes	Unlimited	Unlimited		20000/month
123ContactForm Diamond	123ContactForm	Proprietary	No	Yes	Unlimited	Unlimited		100000/month
ioDeck One-Man Show	ioDeck	Proprietary	No	No	Unlimited	Unlimited		
ioDeck Small Team	ioDeck	Proprietary	No	No	Unlimited	Unlimited		
ioDeck Web Agency	ioDeck	Proprietary	No	No	Unlimited	Unlimited		
ioDeck Unlimited Users	ioDeck	Proprietary	No	No	Unlimited	Unlimited		
Fluid Surveys Free	Fluid Surveys	Proprietary	Yes	Yes	Unlimited	20/month		150/month
Fluid Surveys Enterprise	Fluid Surveys	Proprietary	No	Yes	Unlimited	20/month		Unlimited
Fluid Surveys Ultra	Fluid Surveys	Proprietary	No	Yes	Unlimited	20/month		Unlimited
Fluid Surveys Pro	Fluid Surveys	Proprietary	No	Yes	Unlimited	20/month		Unlimited
Kiwk Surveys Free	Kiwk Surveys	Proprietary	Yes	No	Unlimited	Unlimited		Unlimited (with advertis
Kiwk Surveys Student Only	Kiwk Surveys	Proprietary	No	No	Unlimited	Unlimited		1000
Kiwk Surveys Extra Monthly	Kiwk Surveys	Proprietary	No	No	Unlimited	Unlimited		1000
Kiwk Surveys Extra Annual	Kiwk Surveys	Proprietary	No	No	Unlimited	Unlimited		Unlimited
Kiwk Surveys Enterprise Annual	Kiwk Surveys	Proprietary	No	No	Unlimited	Unlimited		Unlimited
Lime Surveys	The LimeSurvey Project Team	GNU GPL	Yes	No	Unlimited	Unlimited		Unlimited
Rational Survey Free	Rational Survey	Proprietary	Yes	No	10	100		1000
Rational Survey Basica	Rational Survey	Proprietary	No	No	50	500		5000
Rational Survey Pro	Rational Survey	Proprietary	No	No	Unlimited	Unlimited		Unlimited
Create Survey Starter	Imposant, LLC	Proprietary	Yes	No	5	10		100/survey
Create Survey Personal	Imposant, LLC	Proprietary	No	No	10	Unlimited		1000/month
Create Survey Professional	Imposant, LLC	Proprietary	No	No	Unlimited	Unlimited		Unlimited
Create Survey Corporate	Imposant, LLC	Proprietary	No	No	Unlimited	Unlimited		Unlimited
QuestionPro Free	Survey Analytics, LLC	Proprietary	Yes	No	Unlimited			100/survey
QuestionPro Professional	Survey Analytics, LLC	Proprietary	No	No	Unlimited			Unlimited
QuestionPro Corporate	Survey Analytics, LLC	Proprietary	No	No	Unlimited			Unlimited
QuestionPro Team Edition	Survey Analytics, LLC	Proprietary	No	Yes	Unlimited			Unlimited
Survey Share Free	Research Tools, Inc	Proprietary	Yes	No	Unlimited	12		50/survey
Survey Share Pro Unlimited	Research Tools, Inc	Proprietary	No	No	Unlimited	Unlimited		Unlimited
Survey Share Enterprise	Research Tools, Inc	Proprietary	No	No	Unlimited	Unlimited		Unlimited
SurveyGizmo Free	SurveyGizmo	Proprietary	Yes	Yes	Unlimited	Unlimited		50/month
SurveyGizmo Solo	SurveyGizmo	Proprietary	No	Yes	Unlimited	Unlimited		Unlimited
SurveyGizmo Basic	SurveyGizmo	Proprietary	No	Yes	Unlimited	Unlimited		Unlimited
SurveyGizmo Professional	SurveyGizmo	Proprietary	No	Yes	Unlimited	Unlimited		Unlimited
SurveyGizmo Enterprise	SurveyGizmo	Proprietary	No	Yes	Unlimited	Unlimited		Unlimited
MySurveyLab Basic	7 Points Ltd.	Proprietary	Yes	No	10	10		100
MySurveyLab Standard	8 Points Ltd.	Proprietary	No	No	Unlimited	Unlimited		1000
MySurveyLab Standard Plus	9 Points Ltd.	Proprietary	No	No	Unlimited	Unlimited		2500
MySurveyLab Professional	10 Points Ltd.	Proprietary	No	No	Unlimited	Unlimited		Unlimited
MySurveyLab Enterprise	11 Points Ltd.	Proprietary	No	Yes	Unlimited	Unlimited		Unlimited
Question Form Free	FWS Software Lda	Proprietary	Yes	No	2	5		Unlimited
Question Form Basic	FWS Software Lda	Proprietary	No	No	4	15		Unlimited
Question Form Plus	FWS Software Lda	Proprietary	No	No	20	Unlimited		Unlimited
Question Form Premium	FWS Software Lda	Proprietary	No	No	Unlimited	Unlimited		Unlimited