Having the Final Say: Machine Support of Ethical Decisions of Doctors

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Abstract Machines that support highly complex decisions of doctors have been a reality for almost half a century. In the 1950s, computer-supported medical diagnostic systems started with “punched cards in a shoe box”. In the 1960s and 1970s medicine was, to a certain extent, transformed into a quantitative science by intensive interdisciplinary research collaborations of experts from medicine, mathematics and electrical engineering; This was followed by a second shift in research on machine support of medical decisions from numerical probabilistic to knowledge based approaches. Solutions of the later form came to be known as (medical) expert systems, knowledge based systems research or Artificial Intelligence in Medicine. With growing complexity of machines physician patient interaction can be supported in various ways. This includes not only diagnosis and therapy options but could also include ethical problems like end-of-life decisions. Here questions of shared

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responsibility need to be answered: should machine or human have the last say? This chapter explores the question of shared responsibility mainly in ethical decision making in medicine. After addressing the historical development of decision support systems in medicine the demands of users on such systems are analyzed. Then the special structure of ethical dilemmas is explored. Finally, this chapter discusses the question how decision support systems can be used in ethical dilemma situations in medicine and how this translates into shared responsibility.

1 Introduction

Using suitable machines to support the highly complex decisions doctors have to make every day has already been done for almost half a century. Starting with computer supported medical diagnostic systems with "punched cards in a shoe box" in the 1950s, following intensive collaboration between physicians, mathematicians and electrical engineers in the 1960s and 1970s medicine became, to a certain extent, a quantitative science; then the focus of research shifted from a numerical probabilistic approach to medicine to knowledge based techniques that came to be known as (medical) expert systems (ES), knowledge base systems research or Artificial Intelligence (AI) in Medicine. The aims were high and the expectations were not always fulfilled.

The technological development and gain of knowledge also have clinical consequences. Doctors can keep patients alive in a fragile state like the case of the 11th Prime minister of Israel Ariel Sharon (born 1928).[1] Further examples are very old patients who are tube fed, cases in neonatology, and also discussions about terminating a pregnancy after prenatal diagnosis or organ donation [40]. Due to medical progress applying every therapy or any possible diagnostic that is available seems no longer the ethically correct way to decide. The ethical dimension of decisions in medicine needs to be integrated with processes of medical decision making. This chapter explores the question how decision support systems can be integrated and used, especially in ethical dilemma situations in medicine, and how the interaction of machines and doctors in decision processes influences questions of responsibility.

Artificial Intelligence (AI) in medicine was initiated in the 1970s by artificial systems such as Edward Shortliffe's expert system MYCIN at Stanford University [67], QMR (quick medical reference) [46] and HELP (health evaluation through logical processing) [28, 47, 55].[2] HELP and other clinical systems have been developed at academic medical centers, and have been integrated and used for clinical decision support in the 1980s.

[1] In 2006, Sharon suffered a (second) stroke with a massive cerebral hemorrhage. Since then Sharon was in a permanent vegetative state until his death in 2014.

[2] The former was developed by Randolph A. Miller at the University of Pittsburgh in 1980, based upon the INTERNIST-I patient diagnosis system by Jack D. Myers, Miller and Harry E. Pople. The latter was created by Homer Richards Warner and his team.

Decision Support Systems (DSS) have changed over the last four decades. Sol and co-authors describe their development as follows: In the 1970s, a DSS was understood as "a computer-based system to aid decision making", but later in this 1970s, the focus of DSS development was "interactive computer-based systems which help decision-makers utilize databases and models to solve ill-structured problems". In the 1980s, DSS provided systems "using suitable and available technology to improve effectiveness of managerial and professional activities" [69]. However, in the late 1980s, DSS became part of intelligent workstations.

Decision Support Systems (DSSs) provide the user with a framework to easily characterize and analyze problem situations using predefined algorithms and models. This process is highly interactive, including the user in problem definition, the creation of possible solutions and using the correct model for evaluation and rating. A relevant question here is if the structure and complexity of ethical decisions can be modeled by DSSs.

So-called Expert systems (ESs) assemble the knowledge and experience of domain experts in machine interpretable form. They integrate expert knowledge for a particular domain to provide action alternatives, thus ready-made or adaptable solutions for a given problem. ESs help to capture, combine and distribute the expertise of human decision makers and hence lead to better and faster decisions [73]. Integrations of ES and DSS have been proposed in El-Najdawi and Stylianou [22]. These authors also proposed the standard model of a DSS as a collection of computer based tools to give support in decision making. It combines the content of chosen information sources with domain specific models to help the evaluation of potential problem solutions developed by the user [22].

To be evaluated within a DSS, the problem has to be defined according to quantifiable criteria, so the solution alternatives can be rated based on mathematical models. The DSS does not provide the user with action alternatives; it only gives support with ready implemented, adaptable models for evaluation. Solving ethical dilemmas can be understood as a selection process between two options and weighing possible consequences of actions. This can serve as an initial very basic model of an ethical dilemma. An example of this is a patient who does not allow a life-saving treatment and gives reasons the doctor regards as irrational. This situation can be modeled for different patients of different ages (children, middle aged adults and very old patients) and outcomes can be evaluated.

An extension towards ethical decision making was given by Drake et al. [18]. The DSS can ask the right questions, can suggest different ethical perspectives, as proposed in Turban and Aronson [73], and it can certainly inspire creativity. Creativity can be simulated in the system by stretching the given parameter ranges, using the perspectives of other actors, or even putting the problem description in another context. This can help the user to find solutions that are not limited by a restricted frame of mind that focuses on the situation at hand but frequently misses ideas on how to extend or modify decision spaces by integrating multiple perspectives and normative questions into decision making processes. An additional ES support can help the user to learn about causes and consequences of diseases for example by proposing novel and surprising views on the problem, with problem solutions that did not come to his mind before. These views do not have to be perfect, and can always be adapted in later steps.

For ethical decisions, this would imply that the typical structure of ethical dilemmas with two options that are both connected to unwanted negative results can be questioned as a whole, and a question can be generated to ask how those dilemma situations can be avoided in the first place. Technological progress enables DSSs to model more complex structures of ethical problems, thus broadening its capabilities.

The extensive use of simulation technologies not only enables a long-term projection of possible outcomes, it also makes possible to examine a situation by trial and error. An intrinsic problem in the evaluation of long-term decisions is the need for a wide temporal horizon [33]. Consequences stemming from the complex interactions usually involved in ethical dilemmas can present themselves at a later stage without any explicitly premonitory sign. From the early inception of Computer Science, simulations have been one tool of choice to evaluate a complex system, thanks to their time compression ability in a limited domain. In this spirit, we consider the claim that Serious Games would make a great tool to help in evaluating long term decisions, especially considering the flexibility in timeline management and the tree exploration possibilities opened by the availability of huge storage memory and massively parallel machines.

With few exceptions, Serious Games usually describe a closed time situation, where the actions of the players are carried out in a semi static, episodic and accessible environment (following the classification of [57]). Discretionary action is fairly comparable during a game. Simple modifications can be applied to existing routines to give Serious Games the capability to reduce the players' ability of acting on variables in a time dependent manner, to simulate the effects of time, or to end the game not just after the usual episodic end, but in a different point in the timeline, which may be correlated to the number, quality, difficulty, consequences of decisions. Serious Games allow for an even more complex understanding of ethical decision making by encompassing the dimension of time as well as limiting frameworks.

Using machines not only for medical decisions but also for the normative ethical dimension of decisions in medicine poses questions about how far ethical decisions can be supported by algorithm based machines on the one hand and questions of shared responsibility on the other.

This chapter will explore the possibility to support ethical decision making in medicine by DSSs. It is organized as follows: in Sect. 2, we give an analysis of ethical dilemmas and describe the possible role of DSSs to handle such dilemmas in medicine. In Sect. 3, we give a short historical survey of computers and their support in medical diagnosis and will name prerequisites for the support of ethical decisions. In Sect. 4, we discuss a possible implementation of Serious Games as a development aid for teaching ethics and aiding the evaluation of DSS. Finally, in Sect. 5, we will discuss the use of DSS and Serious Games from an ethical perspective with a special focus on computerized decision support versus learning tools followed by a short conclusion.

2 Ethical Decision Making: Structure and Possible Support by Decision Support Systems

In decisions about medical therapy, different perspectives come together. Informed consent procedures, which are at the heart of ethical considerations in medicine, can serve as an example of how DSSs can be used. Informed consent procedures in a simple model can be described as an exchange of information (doctors) and personal preferences (patients) [23]. Doctors suggest a therapy that is medically indicated based on a diagnosis. Patients get information about this therapy, possible risks, side effects and prognosis and based on their personal preferences give (or deny) their consent to this therapy. The combination of medical indication and patient's consent constitutes the basis of an informed consent. Informed consent procedures in practice should be designed in a way that gives patients time and the possibility to ask questions and have their wishes respected.

Most of the time, the ethical dimension of decisions in medicine can be taken care of without much problem. In trust based relationships, doctor-patient communication about the aims of therapy, personal ideas of life quality or dealing with risks leads to informed consent [25]. Technological support for ethical problems therefore needs to be problem-specific and based on a thorough analysis of ethical dilemmas in order to be helpful.

This can be done in two ways. First, situations where problems occur involving a doctor asking for support (from a colleague or ethics consultant) can be identified and analyzed in order to get a better understanding of the moral dimension. Second, examples of best practice in solving such problems or completely avoiding them in the first place can be used to identify aims and criteria to measure the improvement of decision making.

When talking about moral or ethical conflicts,[3] we can distinguish between two types: moral conflict and moral dissent. There is a *moral conflict* when the moral guidelines one lives by do not lead to a clear conclusion, or not all obligations one sees in a certain situation can be fulfilled at the same time. In most situations these conflicts are easy to solve—the solution is clear—but usually there still remains a feeling of uneasiness for not being able to fulfill all obligations. For example, someone promised to meet a friend and feels obliged to keep this promise while at the same time the school calls that his daughter is sick and he needs to see a doctor with her. While it is clear that immediate support of the sick child is more important in this situation, the person might feel bad about breaking the promise. The obligation of the promise is not simply overruled in this situation but remains an obligation in itself. This can best be seen from other obligations following from that situation such as apologizing for not coming or maybe offering a new meeting. In medical ethics, the four principles approach by Beauchamp and Childress

[3] We will understand the term "moral" in the sense of normative ideas in everyday practice and "ethics" as theoretical reflection of morality.

[7] is currently the most well-known approach in medical ethics. The four principles, autonomy, beneficience, non-maleficience and justice, that are equally important, might also lead to moral conflicts when applied in concrete situations when it proves difficult to weigh the principles one against the other. The following case may illustrate this: A patient who is a Jehovah's Witness could be rescued by a blood transfusion but refuses to give his consent to it based on his religious beliefs. The doctor in charge might experience this as a conflict between respecting the patient's autonomy and the duty to cure by using the blood transfusion. While different cultural backgrounds might lead to different solutions, in most settings the answer to this dilemma is clear. For example, western bioethics and the legal framework in many European countries give priority to patient autonomy.

The conflict between patient autonomy and beneficence can serve as a typical example of moral conflict. Other conflicts can be identified using the four principles approach as a heuristic framework. The following shows examples of conflicts between each pair of two principles:

1. Autonomy and non-maleficence: A patient demands to have a healthy limb amputated and argues for this reasonably. The doctor is unsure if he should perform surgery.
2. Autonomy and justice: A doctor is unsure how much time he should spend informing an especially time-consuming patient who feels not well informed enough to decide. The doctor does not have time to inform all patients in detail in the same way.
3. Beneficence and non-maleficence: A doctor has to weigh the chances of curing a condition versus the risks of therapy with heavy side effects of a therapy.
4. Beneficence and justice: In a hospital, questions of allocation can lead to conflicts between beneficence and justice: Providing the best possible therapy available can be so expensive that other patients cannot be treated using the same therapy.
5. Non-maleficence and justice: Not harming vulnerable groups such as pregnant women or patients in a coma usually is used as an argument for not including them in clinical trials. This leads to a lack of empirical evidence and consequently lack of safe possible treatments for those groups. Should they be included for reasons of justice?

This list shows a few examples of possible moral conflicts in medicine using the four principles approach [7]. When moral conflicts happen in everyday practice the description of a situation still needs to be structured. It needs to be made transparent what principles or obligations are in conflict. Here DSSs can help to find a structure for ethical deliberation and get a better understanding of the moral conflict.

Different methods of analyzing a moral conflict have been discussed in the literature [44]. They can serve as a first basis to understand the nature of problem solving and practice in moral deliberation. They can be divided into different phases. First, the problem has to be described from a factual medical perspective. Then moral principles or obligations relevant in the specific case have to be named. This often helps to get a clear picture of the conflict's moral dimension. Some use the four principles approach by Beauchamp and Childress as a heuristic tool for this. Here DSSs can be used to guide analysis. In a third step, these principles have to be compared and their importance for the specific case assessed. Weighing the principles relevant in the case can also be trained using DSS by interactively discussing cases. DSS can also provide additional information such as legal regulation or ethical guidelines (e.g., [83]). Furthermore, DSS can provide possible future scenarios to compare consequences or to help evaluate the decision.

While a moral conflict is an intrapersonal conflict due to conflicting moral obligations or principles, *moral dissent* is characterized as an interpersonal problem: a moral dissent is a situation where different participants favor and argue for different solutions based on their different personal moral positions. This might occur due to different moral positions. For example, deontological and consequentialist approaches have different perspectives on lying, or because agents weigh the same principles differently. The following case is an example of this type of conflict that could happen in practice: in an intensive care unit an 85 year-old multimorbid patient is treated after a severe stroke. The patient cannot eat sufficiently and grows weaker. Doctors want to apply life prolonging treatment by applying tube feeding while nurses vote for withholding further treatment and applying palliative care instead. Here two different perspectives on the same situation lead to conflict. Both positions can be well argued for. The dissent can have different causes: different (descriptive) perspectives on the situation can lead to different decisions: how much a patient is suffering, if a treatment is considered futile or not, or the interpretation of a patient's will and advance directive. Different professional backgrounds can be one basis for such differing perspectives.

Another possible cause is different (explicit or implicit) moral assumptions. For example, religious people might refer to the sanctity of life while secular people dismiss such a concern. Differences can be more subtle on the level of nuancing or interpreting similar moral principles in different ways. Relatives and doctors might agree that respecting the patient's wishes is most important, but disagree how to weigh personal communication versus an advance directive, or even how to interpret an advance directive. Different moral or cultural backgrounds might also lead to moral dissent. For example, when a doctor is asked not to tell a patient the truth about her diagnosis that she will die soon based on different ideas about how to weigh patient autonomy and keeping the patient from harm (the stressful information about her diagnosis).

In order to provide support in cases of moral dissent, DSS can be used in a similar way as described above. This can help to better understand the conflict and might lead to a solution. But when dealing with interpersonal conflicts aspects such as who is affected, the perceived options within a decision situation, or questions of hierarchy and responsibility for a decision need to be taken into account. Furthermore, the best solution would be if the dissent could have been avoided in the first place. Here different structures of decision making need to be in place such as advance care planning [16]. DSS can guide users to structure decisions and get people who are affected by decisions involved. Empirical evidence shows that while this does not solve the conflict it helps to avoid situations of confrontation and supports shared decision making [24].

These few examples already show that DSS needs to be culture sensitive. Simply applying an approach in ethics will not prove helpful, and might lead to new conflict. The value basis of a DSS needs to be agreed upon by users and the community that is involved in the decisions. Furthermore, DSS for clinical use needs to be tailor made for the often hectic day to day practice under conditions of time constraints, working in shifts, rules of documentation, as well as multidisciplinary teams. The already long history of DSS in Medicine can help to understand how DSS can be implemented and what type of support is considered useful.

3 A Brief History of Decision Support Systems in Medicine

After World War II, when the first electronic digital computers became public, physicians certainly did not rank among the most euphoric users of these so called "thinking machines", machines that gave rise to powerful misgivings among doctors, who feared that medical diagnosis and decision-making would eventually be completely usurped by computers [41].

Several activities in the US were initiated to overcome the physicians' and life scientists' reluctance to use computers:

- The journal *Science* published Robert Steven Ledley's survey "Digital Electronic Computers in Biomedical Science" where the author predicted that in the long run, "perhaps the greatest utilization of computers will be in biomedical applications" [38].
- In the same year the Conference on Diagnostic Data Processing took place at the Rockefeller Institute on January 14th, 1959, organized by the Russian-American inventor and pioneer Vladimir Kosma Zworykin, who was then the first President of the *International Federation for Medical and Biological Engineering* [21, p. 232].
- Two hearings on the use of automatic data processing in medicine that have been held before the US Senate's Subcommittee on Reorganization and International Organization, (July 9th and 16th, 1959) came to the conclusion that corresponding developments ought to be organized and fostered by the government.
- In July 1959, the journal *Science* published the article "Reasoning Foundations of Medical Diagnoses" authored by Ledley and Lee B [42].

The last-mentioned article was a widely read paper that gave instructions to physicians to build diagnostic databases using punch cards to prepare for future times when they would have the opportunity that electronic computers will analyze their data. Today this article is considered to mark the beginning of "medical informatics". It was "frequently cited as the most influential early paper to propose the use of computers as diagnostic assistance" [63, p. 209] and it "mapped a research program for the next 15 years, as investigators spun out the consequences" that "medical reasoning was not magic but instead contained well recognized inference strategies: Boolean logic, symbolic inference, and Bayesian probability. In particular, diagnostic reasoning could be formulated using all three of these techniques" [3]. The authors showed that computers could support doctors in the task of drawing conclusions about patients' illnesses based on symptoms, signs and the results of their examinations and it was their hope that by harnessing computers, much of physicians' work would become automated and that many human errors could therefore be avoided.

Medical diagnoses, Ledley and Lusted argued, were based on logical conclusions, and these could be inferred from information about relationships that exist among symptoms and illnesses and about symptoms a patient exhibits, from which other pertinent information can be inferred for this patient. Thereupon, Ledley and Lusted published numerous texts permanently steering biomedical research in the new direction to initiate the use of computers in medical scientific procedures, i.e., in research and teaching as well as in diagnosis and therapy,[4] and these great efforts caught the attention of US newspapers. A headline of *The New York Times* was "Computer may aid disease diagnosis". *AMA NEWS* (The newspaper of American Medical Association) in an article entitled, "Electronic Diagnosis: Computers, medicine join forces"; wrote: "Doctors are inclined to insist that diagnosis is an art. Perhaps it is—now. But must it be? And is that good?" [4, 50] The article already hints at the ethical dimensions of "electronic diagnosis": who is responsible for the diagnosis (doctor or machine?), and if doctors ought to refer responsibilities (e.g., for diagnostic errors) to machines. Connected to this is not only the hope that less mistakes will be made but also the fear that computer systems make mistakes unrecognized due to naive belief in progress, mistakes nobody feels responsible for. Furthermore, introducing machines into the process of diagnosis might raise fears that doctors will be replaced by machines in the future and that professional knowledge based on experience is replaced by statistics. But overall, hopes connected to machine supported decisions outweighed fears and the latter did not hinder further developments.

In reaction to Sputnik, in October 1957, the U.S. Congress allocated about US $40 million to the *National Institutes of Health* (NIH) for the purpose of stimulating computer use in biomedical research. During those years, the NIH's *Advisory Committee on Computers in Research* (ACCR) established several major biomedical computing centers around the USA. Also toward the end of the 1950s, the

[4] At the Third Annual Symposium on Computer Application in Medical Care in 1979 [41], when Lusted looked back on a terrific success story in a text entitled "Twenty Years of Medical Decision Making Studies", he was able to note that in the period from 1959 to 1968 he and Ledley, working solo or as co-authors, had published some 45 articles in 23 American and nine overseas journals as well as seven proceedings of international conferences, all of them dealing with the subject of computer assisted medical diagnostics or decision making.

physician Martin Lipkin and his mentor James Daniel Hardy began to wonder how new computer technology could be used in medical research within the scope of a doctor's activity.

In the department of medicine of New York Hospital-Cornell Medical Center, Lipkin and Hardy sought ways to master the constantly growing flood of information. They were well aware of the developments in computer technology, thanks to the writings of Vannevar Bush but also from other publications reaching back to the 1940s and even the 1930s, and touching upon "mechanical" computing and sorting machines that used cards and needles or punch cards. The idea arose of using machines of this type to build collections of data sets that were being accumulated during medical research, to carry out classifications and to develop interconnections among them. It was also thought that it might be possible to use this method to mechanically store data from patients' medical histories and to study whether this technology might be helpful in medical diagnostics. In 1958, Lipkin and Hardy reported their project in the Journal of the American Medical Association, in which they sought to classify all diagnosis data from hematological cases by means of a "mechanical apparatus" and to identify relationships between them [39].

A brief description of this "first "computer diagnosis" of disease, in this case hematology disorders is given in the biographical memoir on Hardy by Arthur B. Dubois:

> The computer consisted of punched cards in a shoe box. Diagnostic criteria had been obtained from a hematology textbook and were wedge-punched at the edge of each of 26 cards to match the symptoms and laboratory findings of the 26 blood disorders. Knitting needles were run through the holes that corresponded to the symptoms and laboratory findings of each of 80 patients, matching those to the diagnostic criteria wedge-punched into the edges of the set of 26 hematology cards. Shaking the box made the card whose criteria matched those of the patient drop out of the shoe box to show the diagnosis printed on the hematology card [19, p. 13f].

Starting with such computer supported medical diagnostic systems with "punched cards in a shoe box" in the 1950s, followed by intensive collaborations between physicians, mathematicians and electrical engineers, medicine became, to a certain extent, a quantitative science in the 1960s and 1970s. When the University of Utah installed a digital computer in 1960, the Director of the computer center Robert Stephenson showed physician Homer Warner the already mentioned *Science* article by Lusted and Ledley [42]. One section in Lusted's and Ledley's article gave "an introduction to Bayesian statistics and pointed out the relevance of Bayes' Rule to the problem of medical diagnosis" [63, p. 209]. Warner and Stephenson agreed to realize this proposition to use Probability Theory to model the medical diagnostic process and to apply this idea to congenital heart disease using the digital computer and they proved that it could diagnose as well as or even better than cardiologists.

More than 30 years later, Warner explained in his third-person narrative:

> To aid the patients coming through Warner's laboratory, they decided to make their model to diagnose 35 different forms of congenital heart disease. First, they collected data on

> how frequently each of 50 different findings, such as murmurs of different kinds and cyanosis, occurred in each disease and how common each disease was in the population of patients referred to the laboratory. After collecting several hundred such cases, a matrix showed the disease on one axis, the findings on the other. At each intersection of the symptom with the disease, a number represented the frequency of that finding in patients with that disease. This table formed the basis for the diagnosing patients based on findings recorded by their referring physicians. A comparison of the computer diagnoses and those of the referring physicians showed the computer to be right more often than any of the physicians, based on diagnosis following heart catheterization [77, p. 479f].

Warner and Stephenson presented their findings at an *American Heart Association* meeting and their article appeared in 1961 in the *Journal of the American Heart Association* (*JAHA*). This article was "among the most frequently cited" papers to "determine whether Bayesian techniques could be effectively applied to diagnostic problems" wrote E. H. Shortliffe in 1988 and "the first published example of automatic diagnosis using real patient data and comparing computer derived results with human diagnostic abilities" wrote Paul D. Clayton, a former student of Warner, then chair of Medical Informatics at Columbia University, in 1995 [12, p. 139; 63, p. 209]. The article became one of the most important and crucial papers in the history of medical decision making.

Various approaches to computerized diagnosis emerged in the 1960s and 1970s, using Bayes rule [76, 82], factor analysis [74], and decision analysis [42]. On the other hand, artificial intelligence approaches also came into use, e.g., DIALOG (Diagnostic Logic) [53] and PIP (Present Illness Program) [52]. These were programs to simulate the physician's reasoning in gathering information, as well as to simulate the diagnosis using databases in the form of networks of symptoms and diagnoses. Progress in computerized diagnosis thus enabled increases in the complexity of decisions simulated and supported, and integration not only of different types of facts and knowledge, but also different types of reasoning.

As a next step, we should mention the introduction of medical expert systems shortly after general expert systems appeared in the 1970s. The first of these being MYCIN [62], INTERNIST [47] and CASNET (Causal Associational Networks) [78, 79].

Then, the focus of research shifted from a numerical probabilistic approach to knowledge base techniques later known as (medical) expert systems, knowledge based systems in Medicine and clinical decision support systems (CDSS). In clinical practice today, those expert or knowledge based systems are most prevalent that perform decision making at the level of a domain expert [70]. In general, CDSS patient data are compared against a knowledge-base and an inference mechanism is used that can incorporate a rule base of 'if-then-else rules' with Bayesian prediction or fuzzy logic methods.

The aims were high and the expectations were not always fulfilled. So far only few systems are in clinical use. Experiences so far have been mixed and the full potential of clinical decision support systems for optimizing the healthcare system is far from realized. One reason is that "the greatest barrier to routine use of decision support by clinicians has been inertia; systems have been designed for single problems that arise infrequently and have generally not been integrated into the routine data management environment for the user" [64, p. 14]. Other reasons are insufficient acceptance and utilization of such systems, missing integration into a Hospital Information System (HIS), inappropriate software architecture and others. On the other hand, systems have been efficient as learning environments by simulation.

The path of Medical Expert Systems and Clinical Decision Support Systems that we have followed in this section shows that these systems are mainly developed to support diagnosis or suggest possible therapy focusing on specialized medical problems. They were not designed to replace doctor patient communication or to communicate directly to patients in informed consent procedures. Communication between doctors and patients, getting patients involved in decision making processes, what is often called the "human side" of medicine, is important for trust building between doctors and patients. Here also ethical questions arise and legal regulations frame decisions. Ethical considerations and dilemma solving so far remains the responsibility of doctors in cooperation with other healthcare professionals and patients. With the development of further advanced technology the complexity of ethical decisions could also be modeled in DSS. But actually integrating DSSs that encompass the full complexity of decision making in medicine, and thus integrating the knowledge base and the normative aspects of medicine, will pose further problems that will be addressed in the following section.

4 Clinical Decision Support Systems: From Diagnosis to Ethics

4.1 Acceptance Problems of CDSS

The idea to get help from computers to support doctors in the task of drawing conclusions about patients' diseases based on symptoms, signs and the results of their examinations, could be a solution to the big problems that became more and more visible in medicine in the first half of the 20th century, as is shown by a comment from the foreword of a textbook: "The belief has been expressed that errors in diagnosis are more often errors of omission than of commission" [56, p. vii]. In another textbook, the physician Logan Clendening wrote on this matter: "How to guard against incompleteness I do not know. But I do know that, in my judgment, the most brilliant diagnosticians of my acquaintance are the ones who do remember and consider the most possibilities. Even remote ones should be brought up even though they may be immediately rejected" [13, p. 59f].

It is a difficult task for physicians to exhaustively consider every factor relevant to the decision, due to either limited memory or limited information. About a decade later a medical doctor described this problem in the following way: "What is needed is a device which will answer the question 'What are the possible causes of the group of symptoms and signs I have elicited from my patient?'" [49, p. 874]. Patients demand that doctors are always aware of the evidence, results of latest research and new technologies in diagnosis. Therefore, a correct diagnosis is getting more and more complicated to achieve and the possibilities of false diagnosis are increasing. A false diagnosis is not only a medical problem but also poses ethical questions of harming the patient and responsibility for mistakes in a hierarchical system like hospitals. Today, it is acknowledged that besides diagnosis and therapy there is also an ethical side to medical decision making in almost all medical decision procedures and that medical decisions should also follow ethical guidelines. This means that not only rapidly growing knowledge in medicine needs to be taken into account when coming to a decision, but also ethical questions like life quality, autonomy or values based in the cultural background of patients as well as values derived from the professional ethos [33]. With regard to decision making, physicians experienced a time of great research progress which resulted in a collectively perceived “knowledge explosion” in the mid-20th century. This development was accompanied by growing interest in computer technology on the one hand and growing relevance of ethical questions on the other, which can be seen from the growing number of ethical guidelines for doctors, like the Declaration of Geneva [83].

Medical expert systems and CDSS machines have been construed to solve these problems and about 10 years ago, roughly 70 known proprietary medical CDSS machines were listed, but only 10 of them geared towards routine use [26]. Unfortunately, there is no information available about a real daily average usage of these systems. However, CDSS machines still suffer from insufficient acceptance. Medical doctors are reluctant to use such systems for different reasons:

1. Doctors are afraid that computer systems will be used to substitute physicians [60, 65, 66]. CDSS machines should assist physicians in their daily routine work in the doctor’s practice or in hospitals whenever they need support. CDSS machines should be built in a way that helps to avoid mistakes and improve decision making. This can cause fears that CDSS based decisions are better than doctors’ decisions that are prone to human flaws. However, such systems can also take the role as a teaching system and physicians will learn from a CDSS how to consider criteria, facts or process issues in specific decision situations. These systems realize “rationality” in diagnosis and decision making. They are intended to support but not to replace physicians [11]. As the discussion about responsibility will show later, doctors need to have the final say about medical decisions. Doctors should remain the ultimate authority, and he or she will have the ability to “overrule” or to ignore the recommendations of the CDSS at any time [59, p. 261]. Doctors also have the role of justifying and explaining decisions to patients and making decisions transparent. For this, they need to be involved in the decision making process. CDSS machines that try to replace doctors therefore stand little chance of acceptance.
2. Integration of a CDSS into well organized and equipoised everyday practice and clinical guidelines is difficult for various reasons, for example:
   (a) One drawback to acceptance of a CDSS is workflow integration. Many of these systems are stand-alone applications, and they require the clinician as

an operator to cease working on their current report system, switch to the CDSS, input the necessary data, and receive the information [75].

(b) The input process that has to be done by the doctor or a nurse is very time consuming and costly.

(c) The use of a computer system interferes with the important contact between patient and doctor. The doctor will not be able to focus on the patient, his trouble and pain and the patient feels unappreciated.

Therefore, CDSS machines should not only be easy to handle but not interfere with doctor-patient communication. This calls for systems that do not interrupt or prolong daily routine but for applications usable for training in very different contexts.

3. Medical decision support systems are not all-round systems but very specialized systems and are concerned with just a very specialized cutting of a medical field, e.g., hepatology or pulmonary diseases in internal medicine. A CDSS for ethical questions would ideally be integrated into already existing and well established systems. Since experiences with CDSS machines on a broad level do not exist, further demands of users besides ethical dilemma solving need to be assessed and integrated for better acceptance.
4. There are limitations of CDSS machines because an optimal physician's treatment requires that physicians can get important information almost without lag of time: information on the present and the possible future consequences of his or her actions. To this end, they "require data that are factual, factual inferential (why type questions) and predictive (what if questions). To date, the best support that a CDSS has been able to provide is data that answer factual and maybe some forms of predictive questions […]. Physicians have no shortage of data available to them. Thus, physicians have found that currently available CDSS machines are not able to meet their more complex information needs" [59, p. 261].
5. Also, most of the present CDSS machines have not progressed beyond the prototype stage [81]. There exists no standard or any universally accepted evaluation or validation methodology to ensure that the system's knowledge base is complete and correct [5].

This is also a problem for supporting ethical decisions: with the plurality of ethical approaches and views a universally accepted evaluation therefore seems impossible in this case. But what might be easier to achieve and well accepted is to evaluate the outcome of CDSS machines along the values that built the basis of the CDSS itself. This means that there is still reflection necessary if those values are shared and accepted in a concrete situation but the idea of coherence can be argued for more easily.

6. We do not know whether the use of a CDSS improves the quality of decisions produced. Also we do not know whether the economic or other benefits, e.g., the patients' well-being are attributable to the use of the CDSS, because there is no well-defined or universal evaluation methodology. "To date, an

examination of the literature indicates that there is virtually no information available related to the cost or cost effectiveness of CDSS machines. Most of the CDSS machines are university based developments, and still in prototype stage. These costs regarding the initial investment of CDDS tend to be hidden and therefore difficult to access. This frightens or hinders industry interest in funding and encouraging the development of CDSS in healthcare in general [48]. Still, many physicians have a positive outlook on the potential for these systems, particularly relating to practitioner performance. However, until the use of CDSS machines in general is as routine as the use of the blood pressure cuff, it is important to be sensitive to resistance to using these systems" [59, p. 261].

4.2 *From CDSS to Serious Games: Learning Ethic Concepts in Medicine Through Computer Assisted Machines*

In the context of developing support systems for ethical decisions, an approach is called for that goes beyond simple fixed interaction that CDSS machines usually supply, to produce an interactive environment that allows doctors to practice with concrete problems and that can move the boundaries of the decision above and beyond the moment in which the decision is made. One main benefit of such an approach would be the creation of a learning environment for complex decision making processes. This can be used for teaching or team coaching in order to train for decision situations where different forms of expertise as well as values have to be taken into account, something which is usually precluded in standard CDSS. Furthermore, the use of such an environment can reframe decision situations, integrate different perspectives and get relevant actors more involved at different times or stages of the decision than in current practice. This cannot be done with the basic tools that have been the staple of medical decisions education, such as textbooks, medical scripts, questionnaires and simple role play games, neither with the ones used by standard CDSS systems, but need more refined thought. We speculate that the use of Serious Games (SG) can be beneficial to help developing better CDSS, while at the same time they have the potential to become a standard tool in training ethical medical behavior.

Following the revised definition by Zyda [84], based upon the original definition by Abt [1], an SG is "a mental contest, played with a computer in accordance with specific rules that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives". While SGs are conceived, programmed and developed with the tools and general aesthetic usually reserved for video games, they are used for purposes other than mere entertainment [72]. The principal advantage of SGs is "allowing learners to experience situations that are impossible in the real world for reasons of safety, cost, time, etc" [14, 71].

4.3 How Do Serious Games Work

SG follows the convention of standard games we play on a computer or smartphone: a 3D immersive simulation can be developed to ensure that the user can empathize with his avatar, the character can be depicted with classical medical equipment such as a white coat and stethoscope for a better identification of his role; other actors can be easily distinguished by external traits, and the same goes for Non-Playable Characters (NPC) (see Fig. 1). Avatars and NPCs in SGs, be they realistic or caricatural, are often represented wearing dresses of the trade, in order to solicit empathy (see Fig. 2) [31].

The simulation is multi-media based: graphical elements such as animations or cut-scenes can be included, while sounds and speech can provide feedback to the player. During the game, a collection of indicators, menus, gauges and other information useful for the player must be visible at all times in a heads-up display (HUD). Multiple HUDs can be used in different stages of the simulation [8]. A first-person point of view is usually tied with a direct interactive access to the virtual world. The main drawback of this approach is hiding the player character.

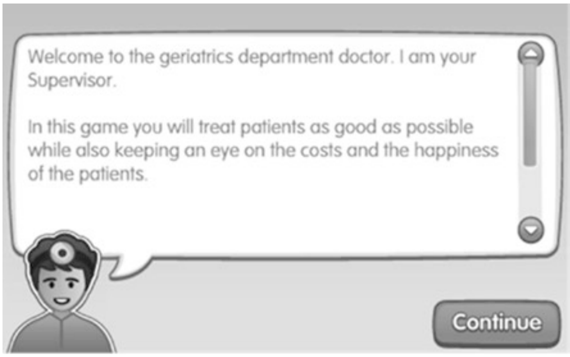

Fig. 1 Non playable character from GeriatriX [37]

Fig. 2 Screenshot from JDoc [68] showing the player's avatar (*center*) interacting with two NPCs

A third-person perspective instead allows the player to follow main character movements (see Fig. 2), but confusing camera angles can also complicate playing the game [51]. No custom peripherals should be used in this broad category of simulations, as complex physical interface may ruin the spontaneity of the actions.

A recent development of the field concerns the use of mobile peripherals and extended deployment of SGs: pervasive and ubiquitous computing also permits constant access to the game, using smartphones or other wireless handhelds (e.g., tablet, notebook) as input/output device. In this scenario, a game session needs to be saved and reloaded. In some cases, the player can be forced to start over if some constraints are not satisfied. Adding network connectivity can extend game longevity. Clocks or time counters can accentuate the feeling of time pressure. Timers may move at the same rate as real time or at different rates, such months and years, which elapse in a few minutes of play [80]. Time compression helps the player to focus on what is important [45]. Having to decide and act under conditions of time restraint is one of the main aspects mentioned by students when they argue that the best possible way to act is not feasible within the current medical system. Finding ways to model alternatives and evaluate outcomes would provide something close to experience based learning and strengthen young doctors to reflect on circumstances.

The simulation can be divided in stages. Each phase can have different durations and can be clearly separated during the game, using level closing material for providing feedback to the player or video sequences that provide a backstory. Mission briefing before starting the chosen level can guide the player through game controls and goals. The rules of game need to be clear to the user. In the first stage, the player must examine the problem. During this act he needs to connect information in an aggregate knowledge base. This task is the first important step in ethical decision making: describing the conflict on a factual as well as normative level. When using SGs for teaching purposes, this can also be useful in order to get players acquainted with different ethical approaches like the four principles approach [7], using them as the knowledge base of the game. Furthermore, players can learn to grow some sort of sensibility for hidden ethical assumptions on the first level. Connecting the description of a situation to theoretical knowledge will help to clarify the situation and options for decision making later on. In some cases, the player might have incomplete information, and this can become a separate task in problem solving and deciding. The main stage is related to the decision act. In this phase, life-like characters can be used as tutors or trainers and can supply helpful information to the player [54]. NPCs should seem intelligent and to behave coherently: NPCs should engage users or other characters in conversation, display of role appropriate knowledge and expertise, shape constructive user behavior and discourage disruptive user behavior [54]. An extensive and detailed logging of all choices and actions a player has made will be made available to the player for subsequent analysis. This information can be extensively reviewed for evaluation purposes.[5]

[5] Another way of evaluating is the implementation of a scoring algorithm. This is useful because a positive score can reinforce the player's behavior. The score can be displayed with a numeric value, a star system or a grade assigned in letters. The goals can be assigned in terms of score to achieve. Some bonus materials (e.g., additional level) can be added to push the player to work for the maximum grade. A high score list can be included and displayed after gameplay.

After the decision, the players need to watch and evaluate the consequences of their actions. In this phase, the time in the simulation can be speed up to show the long-term effect on the actors. In some cases, this step can be preliminary to a new phase of the decision process (e.g., someone is angry about the outcome of another case and mistrusts a doctor). However, in this new scenario, not all actions previously taken can be undone. For example, if a patient dies due to an irresponsible decision, the user cannot revive the person and needs to face the consequences of the loss.

4.4 Serious Games and Medicine

The use of SGs in medicine is nothing new by itself. In 2004, with support from the Lounsberry Foundation and the Woodrow Wilson International Center for Scholars, the Serious Games Initiative (www.seriousgames.org) started the Games for Health Project (www.gamesforhealth.org, [58]). In 2008 and 2009, the number of peer reviewed scientific publications surged as the clinical application of health games diversified. The sudden surge of health game publications can be attributed to the availability of specific funding for health games research (i.e., Robert Wood Johnson Foundation funding), advancements in commercialized gaming technology (e.g., Nintendo Wii), and the establishment of health game research networks through various scientific venues (e.g., Games for Health Conferences [36]). The Health Games Research Database lists over 430 games.

One thriving sector in this vein is the use of games in healthcare from a professional perspective; that is, the use of games in medical training and educating young professionals include practice exercises to refine skills for performing surgery, emergency response, disaster preparedness and for simulations for healthcare management situations [2]. An example of such approach is JDoc. The purpose of JDoc is to familiarize junior doctors with the day-to-day stress of a hectic hospital. The junior doctor simulator immerses the player in the believable world of a busy hospital at night and educates them as to the diagnostic procedures and medical criteria required while working on call in a hospital ward [68].

Another project is “Pulse!!” This SG is a three-dimensional virtual clinical learning platform developed at Texas A&M University Corpus Christi, in collaboration with the United States Navy, for teaching high-level critical thinking, diagnostic reasoning and skills to healthcare professionals that provides unlimited, repeatable, immersive clinical experiences without risk to patients [20]. In both simulations, junior physicians can practice procedures without life/death consequences. In particular, in JDoc we can develop entire scenarios, using parameters provided by senior doctors, in which we can reproduce the decisional process in ethical dilemmas such as abortion, euthanasia or treatment of people with disabilities, analyzing every step of this process. We can also evaluate the adherence to the four common moral principles: respect for autonomy, beneficence, non-maleficence and justice [29].

Another context where serious games and medicine meet is in simulations for healthcare management related situations. The aim of such software is to solve administrative problems faced by healthcare managers such as facility planning, resource allocation, staffing, patient flow and waiting time, routing and transportation, supply chain management, and process improvement [34]. An example of this is GeriatriX, a student training game for complex medical decision-making concerning elderly patients. The students explore different diagnostic and therapeutic strategies, and are given insight into the consequences and costs of their choices [37]. Because GeriatriX deals with elderly patients, the risk of harming the patient by the therapy needs to be weighed against the chance of healing, but also the expected quality of life during and after the therapy.

Multiple games have been developed to support health behavior of patients [32]. These include virtual environments that provide a safe and realistic simulation of exposing patients to a potential health threat [30]. Video games were also designed to improve prevention and self-care behavior among children and adolescents for asthma and diabetes [32].

More recently, we have seen the emergence of games designed to persuade users to change their behavior, better known as Persuasive Games [27]. Games for behavioral change related to diet, physical exercise, self management, etc., had positive patient outcomes [6]. In particular, active computer games (e.g., Eye Toy games, Dance Dance Revolution, Nintendo Wii games), also dubbed as "exergaming" [9], may have the potential to promote physical activity for obese children [15]. Use of games as a learning environment for preventive actions is cited as a possibility in the literature [32]. "The Great Flu" from the Ranj Corporation teaches users how a virus works and what resources are necessary to counteract/contain the spread of a pathogen and to prevent the outbreak of an epidemic [2]. "Persuasion is often involved in health prevention. This particularly applies to changing habits. The main goal of persuasive games is not to educate or to increase physical exercise, but to persuade the users to modify their behavior" [10, p. 132]. An example of a persuasive game is "Smoke?" The goal of this SG is to persuade people who are contemplating quitting smoking or have recently quit smoking, that quitting permanently will be beneficial [35].

4.5 How the Machine-User-Interface of a Medical Decision SG Should Work

As we said in a previous subsection, the principal aims of current SGs in healthcare are training medical professionals as well as future patients to enable behavioral change. In these simulations, the ethical aspect, when present, is a simple plug-in, and often a second thought. We maintain that the use of instruments such as SGs as a component for building and rating medical ethics decision systems is a novel approach that may bring satisfactory results.

A SG is the perfect environment where ethical dilemmas can be simulated without real world consequences to others, but with the added necessary element of deep personal involvement typical of a simulation. Even better, a SG can include a teaching consequence that is not present in standard CDSSs: teaching ethics from a textbook is often ineffective, as there are no incentives nor real examples that can be tested interactively, and even learning by enacting scripts, usually done with a role playing approach, has a very limited scope, and the interaction is too forced to be believable. On the contrary, deep immersion in a simulated world that is offered by SG, the level of realism, the possibility to develop rich and detailed case histories, the fact that consequences of decisions regarding ethical dilemmas can be evaluated in different turn points, and even in a long term fashion, the controlled repeatability offered by the approach, all are perfectly suited to the learning and to the aiding aspects of ethical decisions in medicine.

In order to build such a system, we need to approach ethical dilemmas in a different way: when we simply ask for a "smart" decision, we often obtain simplistic and short-sighted argumentations, because decisions in health-care have impacts that are hard if not almost impossible to predict by a single person. This "look-ahead process" might be forgotten when the human agent is left alone in carrying the burden of evaluating all the long-term consequences. If we exhibit a well-defined problem in binary win-lose logic, the user can acquire information only related to the specific problem. The knowledge of how an agent can reach one of the possible solutions in a state space often cannot be applied in other context, especially in healthcare. An intelligent behavior might seem rather stupid and dangerous if carried out in another environment.

The risk of assigning a specific goal, when such a goal exists, is that the simulation cannot successfully lead to a flexible and ethical behavior, as we need to balance between short-term and long-term goals. The same ethical problem can be shown in different forms to confirm the fact that the user can choose the better solution independently, without stepping in the pitfalls of a single specific case. Different responses to similar questions can be also considered valid; the step of the reasoning process does not even have to be logical, but can be based on a combination of incomplete information and personal values.

Because an ethical approach would include the evaluation of long-term effects of small changes on the people involved, especially patients, systems that are able to simulate effects of decisions and provide at the same time criteria to evaluate the impact on those affected, would strongly improve the quality of complex decision making processes and outcomes.

Serious Games make a great tool to help in evaluating long-term decisions, especially considering the flexibility in timeline management and the tree exploration possibilities opened by the availability of huge storage memory and massively parallel machines. In specific points in the game time line, an agent can be partnered to players in a prompting role dependent on the exploration tree's position and content. The repeatability of the game and its complete parameterization allows its use as a massive evaluation tool. The tools provided based on Serious Games would open opportunities to expansive, participatory, experience based and reflective learning. Many shortcomings of traditional teaching methods could be overcome: unidirectional conversation, cognitive centered reproduction, or inert knowledge, the practical transfer of acquired knowledge would be strongly enabled. Furthermore, the level and breadth of support given from the system during learning could be calibrated toward the quality of decisions, inducing a progressive learning pace and improving the dropout factor of the learning process.

A support system for ethical decisions should enable users to explore the state space, analyzing effects of alternative decisions and provide them with necessary information that lead towards ethical decision. Such machines would need a user interface that enables interaction based on alternative paths of decision. The user can directly experience the consequences of a certain course of action, thus coming to a deeper insight of the problem at hand. The evaluation phase can be carried out assigning different utility functions once connected to the timeline. As ethical decisions have wide impacts and very often long-term effects, at different times or stages, ambiguous, divergent and contradictory requirements are reinforced. For the user to reach decisions under time pressure or incomplete information, long-term strategies could be rolled back in order to increase awareness of extended consequences. Time compression ability can be used from the system in order to assess efficiency in presence of no single right solution.

5 Ethics of Ethical Decision Support

Serious Games seem to have many advantages when it comes to creating a learning environment for ethical decisions. But the technical feasibility needs to move parallel with a positive evaluation of the use of Serious Games. Using any type of technology in the context of decisions is only helpful if decisions can be improved. CDSS machines have already been object of ethical reflection [43]. Evaluating ethical decisions can be done on the level of the structure of the decision process as well as the medical and the ethical outcome. In this section, we suggest and discuss criteria for evaluating the process management as well as outcome when using a DSS or SG.

Decision making in medicine is highly complex. Decisions about diagnosis and therapy need to be founded on a broad base of knowledge about all kinds of different conditions, symptoms and diagnostic tools. Furthermore, today the aim of a therapy is not always clear bringing up ethical questions: is it better to prolong life (in its quantity) by all means or is it better to improve life quality, even at the cost of reducing life expectancy? Questions of life quality, patient autonomy and professional ethics also need to be taken into account in medical decision making adding to the already given complexity of medical decision making. (Wrong) decisions in medicine can have severe consequences including the death of patients but also moral distress or guilt to others. Different scenarios after a decision may exemplify this: accompanying a dying patient during his last days and letting the patient die in accordance with his wishes; providing a blood transfusion to a patient who is a Jehovah's Witness against his wishes and thus survives; administering tube feeding to a highly demented patient and whose wishes are unclear. Decisions can be evaluated based on the outcome such as if the patient is still alive or dead as the most simple criterion. Other possible dimensions are the gained life expectancy, the result of a therapy for the quality of life, but also the ethical dimension of the decision such as if the patient's autonomy is respected, if the patient does not experience unnecessary harm, his beneficence is considered or relevant questions of justice solved in an acceptable way.

In order to change decision processes the structure of dilemma situations and how they can be avoided needs to be understood by doctors. Learning how to frame decisions therefore is an important step. Empirical research shows that textbook based teaching in ethics as well as ethical guidelines do not lead to the desired effect [61]. Using Serious Games as a learning environment might enable experience based learning that provides insight into the possible consequences of different normative backgrounds in everyday decisions. Doctors need to experience how their own often intuitive interest in a situation can be made transparent and communicated to patients but also how different perspectives in a situation can be brought together and enable improvement in mutual understanding, empathy, and thus reduce potential conflict [17].

Using machines as learning environments might also help to overcome the above mentioned problems with usability and acceptance. To enable further reflection, it would also be interesting if users could introduce their own cases and experienced dilemmas, for example, by integrating characteristics of patients or persons involved.

Besides the decision making process, the outcome also needs to be evaluated. This seems to be an even more complicated task, due to intercultural differences and plurality of opinions. Therefore, using Serious Games can only be seen as a tool to initiate a reflection process but not as guiding decisions or even making better decisions. One main aim of using Serious Games must be to strengthen responsibility in the sense that doctors get a growing sensibility for potential ethical problems, how to avoid them and how to moderate shared decision making processes between different parties. The aim of the implementation of SG teaching ethics therefore is to explicitly place responsibility in the hands of doctors. Transferring ethical decisions to IT solutions would lead to the problem that the user is still responsible for the implementation of a decision and therefore needs to reflect upon the decision process, its criteria and possible outcomes. This implies having a deeper understanding of the ethical decision or, which is even more complicated, to understand the algorithms of the technical solution.

Possible outcomes and the effects of ethical decision support should also be evaluated on the basis of norms. The four principles approach can be used as one that is broadly accepted and useful as a heuristic tool to detect ethical problems [7]. Evaluation criteria should meet with the criteria used within the learning environment. Besides the four principles, aspects like truthfulness or confidentiality can play a role. It is important to mention that decisions should only be evaluated positively (within the system as well as an outcome of the system), if they cohere with the legal framework and existing binding ethical codes and guidelines (for example by medical associations) applicable in this field. The applications therefore should be culturally sensitive and the criteria, values or norms used for evaluation obtained from the communities affected by the modeled decisions.

6 Conclusions

In order to achieve its task of improving ethical decisions in clinical settings, Serious Games and other types of DSSs need to satisfy high standards. It seems that the high complexity of decision making can be met by using specific types of serious games that do not over simplify ethical dilemmas. Such systems can integrate a short and long perspective and enable learning with regard to decision processes as well as norms and principles. Though there is a reluctance to use machine support in medicine, the possibilities of experience based learning should be considered as an important aspect of behavioral change that could be used to improve the ethical quality of decisions in medicine. Serious Games can be used in order to encourage a change of medical behavior, and to enrich CDSS's with a learning stance and opportunity to grade and improve on current systems.

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