ИСТОРИЯ МЕДИЦИНЫ

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On the early history of quality management in healthcare: Pirogov, Nightingale and Codman

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The quality of healthcare organisations is often described with the model of Donabedian structure-process-outcome. But the foundation of the model were laid by earlier thinkers about medical and healthcare quality of the 19th and early 20th centuries. This article focuses on two surgeons, Pirogov and Codman, and one nurse manager, Nightingale who occupied themselves with the management and organisation of hospitals. They started with nothing to rely on, as they were pioneers in the field of quality management. Even the concepts of quality and management were not present at the time, as were many other areas, such as an adequate understanding of the causation of hospital infections, scientific thinking in medicine and nursing, and statistical and methodological tools to study and improve healthcare. We will show that although their thoughts were original, they were also embedded in the belief systems of their time. Following their development, we will understand how thinking about quality management evolved in their time. Their experiences have led to very significant improvements we nowadays take for granted.

Keywords: history of medicine, Pirogov, Nightingale, Codman, quality assurance, healthcare.

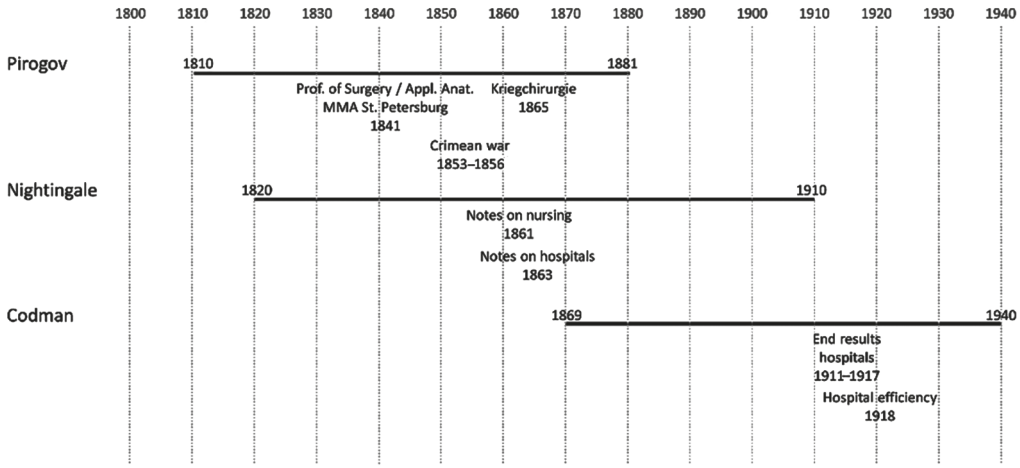

Fig. 1. Timelines of Pirogov, Nightingale and Codman with relevant events

Introduction

Healthcare organisations are trying to maintain and improve the quality of care they achieve in their care for patients. The ways healthcare organisations try to obtain good results are often described with the model of Averis Donabedian structure-process-outcome, which he proposed in 1996 [1]. But the grounds of the model were laid by earlier thinkers about medical and healthcare quality of the nineteenth and early twentieth centuries. This article will focus on three renowned historical persons, two surgeons and a nurse manager. Following their development, we will understand how thinking about quality management evolved in their time (Fig. 1). Their experiences have led to very significant improvements we nowadays take for granted. But they also were often confronted with problems that still exist today.

After introducing the three thinkers on hospital quality, we will discuss their thoughts on several topics of hospital quality management.

These topics are:

1) Hospital Design;
2) General hospital Management;
3) Evidence-based Healthcare Improvement;
4) Management of Hospital Infections;
5) Teaching and Education.

Introduction of the three thinkers on hospital quality

Nikolay Ivanovich Pirogov (1810–1881). Nikolay I. Pirogov was born in Moscow, where he studied medicine (Fig. 2). He finished his PhD at Dorpat University and had a postdoc in Germany. At the early age of 26 years, he became a full professor of theoretical, operative and clinical surgery at Dorpat University. From 1841 to 1860, he was professor of surgery and applied anatomy at the Imperial Medical and Surgical Academy (now Mili-

Fig. 2. Nikolay Ivanovich Pirogov (1810–1881). Portrait, oil on canvas, artist and date unknown. Wellcome Library, London

tary Medical Academy in St. Petersburg). In St. Petersburg he would also qualify in anaesthesia. Characteristic of his approach to develop medicine was his scientific approach using literature research, observation of cases and experimental procedures. He conducted animal experiments and applied experimental treatments on himself, volunteer students and colleagues. He carefully analysed and described his findings before using them to a larger scale to his patients. The advance of applied anatomy was always instrumental in increasing the surgeon's knowledge. He developed several coloured anatomical atlases and a four-part three-dimensional atlas in black and white. He devised new surgical procedures, among them the eponymous osteoplastic foot amputation. Also, several anatomical structures were named after him. Under his leadership, the profession of surgeon changed from craftsmanship to science [2, 3]. He was also one of the first to use ether on the battlefield, after extensive experimentation in animals and humans, for example, during the Caucasian (1847) and Crimean War (1853–1856) [4, 5]. Pirogov played an essential role as the overall head of the Russian medical forces during the Crimean War. He applied a triage system to provide as much as possible for the victims and the sick. He had access to Russian and foreign doctors and a large group of well-trained female nurses [6]. The impartial medical care treated Russian and counterparty wounded equally. Post-war, nurses found a place in civil and military hospitals and many nursing organisations and training courses were created. Nikolay Pirogov has described his vision of the organisation of war surgery in a renowned book, "Grundzüge der allgemeinen Kriegschirurgie" [7]. After the Crimean War and the battle of Solferino, Henry Dunant and international army doctors founded the International Red Cross and national Red Cross associations. At an old age,

Fig. 3. Florence Nightingale (1820–1910). Photograph by Millbourn. Available at: https://iiif.wellcomecollection.org/image/V0026906/full/full/0/default.jpg (accessed: 20.11.2023)

Fig. 4. Ernest Amory Codman (1869–1940). Image courtesy of the Archives of the American College of Surgeons. Available at: https://www.facs.org/about-acs/archives/past-highlights/codmanhighlight (accessed: 20.11.2023)

Pirogov acted as an auditor for the Red Cross on the battlefields of Alsace-Lorraine and other hearths of war.

Florence Nightingale (1820–1910). Others have written extensively on the life of Florence Nightingale (Fig. 3). There are over 50 biographies [8–11]. Nightingale has been the subject of reverence and beatification, whereas others are more critical of her role as a healthcare innovator [12]. Here, we will give a short representation of her life and achievements. She was one of the first to address the quality of care issue. In 1851, Nightingale trained as a nurse in Germany and Paris, where she stood at the bedside. After that, in 1853, she attained a supervisory role in London. Based on his appraisal of her managerial skills and experience, under considerable public and political pressure, Minister of War Sidney Herbert appealed to Florence Nightingale to lead a team of nurses to Crimea. Nightingale went with 38 nurses to the Barracks Hospital in Scutari (now Usküdar), Turkey. As Crimea was more than 200 miles from the hospital, many soldiers died during the trip by boat from Crimea (easily 13 days). Thus the Scutari hospitals served more as so-called fever wards than a

true military hospitals [13]. After the war, she was active in building hospitals in England, the design of which inspired increasing knowledge about (hospital) infections [10]. Later, she retired from public life to campaign for the adoption and development of educational programs. She wrote over 200 books, reports, and pamphlets, which profoundly affected the health situation in the army, living conditions in India, care in civilian hospitals, medical statistics, health care in general and nursing. Her main contributions to the development of education were the creation of new establishments for training military doctors and hospital nurses [14].

Ernest Amory Codman (1869–1940). Ernest Codman was a Boston surgeon who built up a track record in his profession, abdominal surgery and especially orthopaedics, anatomy, radiology, and anaesthesiology (Fig. 4). He developed new knowledge of hospital organization and quality of care [15–17]. He was extremely passionate about assessing medical care based on the end result, considered by some as a scientist of quality [18]. His outspoken views on demonstrating the quality of care led to constant clashes with his profession and personal financial misery [19]. He struggled with the strict hierarchy of medical organizations, where the quality of education was highly questionable [15, 20]. This was the main reason he gave up his position at Massachusetts General Hospital and founded the "end-result" hospital, where he wanted to show that he could build a competitive hospital based on excellent results and at low costs. He remained active in the broader medical environment. As chairman of the surgical section of the Suffolk District Medical Society, he organized an evening on "hospital efficiency" in January 1915. His presentation of the poor state of healthcare was an accusation against all involved, enraging all parties, surgeons, administrators, and professors. Consequently, patients were no longer referred to his hospital by other doctors, what led to his downfall [15]. He was left with a hospital in debt with no borrowing capacity. He later returned to Harvard Medical School and Massachusetts General Hospital. He developed the bone sarcoma registry (a kind of specialist registry of outcomes of bone tumours) [21]. He later wrote an extensive standard work, "The Shoulder", which he published privately in 1934. Codman died alone and destitute. He was buried in a grave with no headstone.

Quality of hospital design — Nightingale and Pirogov

Pirogov and Nightingale dealt in large with the same problems in hospital design. One of the biggest problems in their time was hospital-acquired infections, which was related to poor hospital design. The urgency of this relationship could not be better expressed, as Nightingale writes in her preface to her book "Notes on hospitals":

> *"It may seem a strange principle to enunciate as the very first requirement of a hospital that it should do the sick no harm. It is quite necessary, nevertheless, to lay down such a principle because the actual mortality in hospitals, especially in those of large, crowded cities, is very much higher than any calculation founded in the mortality of the same class of diseases among the patients outside of the hospital would lead us to expect. The knowledge of this fact first induced me to examine the influence of hospital construction on the duration and death rate of cases received into the wards…"* [22, p. II].

She extended her analysis, pointing to the differences in mortality rates between hospitals because of differences in case mix, age of the patients and the sanitary state of the

hospitals. She acknowledged the death rate of principal hospitals in England in 1861 on average 57 %! She literally noted that the sanitary state of a hospital could not be inferred from the greater or lesser mortality rate "because killing patients is not the function of hospitals" [22, p. 4] and the spread of infectious diseases is a much better test. She attributed infections to the closeness of wards, defective ventilation, and bad architectural and administrative arrangements, causing illnesses that differ from the diagnosis for which the patient was admitted in the first place. Thus, she related the structure of healthcare delivery directly to outcome and safety.

Pirogov went a bit further. During his vast experience over 25 years of private and military surgery, he had practised surgery in the open field, in ordinary soldiers' tents, in farm huts, and large well-equipped hospitals. Pirogov was a ruthless opponent of huge palace-like hospital buildings. He was convinced that the idea of a large, well-equipped hospital did not exist and that hospitals often bring uncertainty to surgery and do more harm than good to the well-being of patients [7]. He observed that barracks used in previous wars, meant to be temporary, were still in use in Berlin (Augusta Hospital and the Charité barracks), Kiel, Heidelberg, and Leipzig (with 400 beds). Also, single-storey houses were used as hospitals, though equipped with the latest air cleaning, heating, lighting, sanitation, and disinfection equipment. Pirogov thinks hospitals will only achieve their goals if the sick patients are distributed over smaller units and, if possible, separate rooms and enough sick rooms or buildings are available to allow periodic patient transfer.

Pirogov and Nightingale share many ideas as to what is required. Nightingale links the poor outcome to 4 defects of hospitals: agglomeration of sick under one roof, deficiency of space per bed, deficiency of fresh air and lack of light. After detailing the analysis of the defects in hospital construction, she lays down the principles of hospital construction. Like Pirogov, Nightingale sees it as a first principle to divide the sick among pavilions. A pavilion is a separate detached hospital with as little connection in its ventilation with the other parts of the hospital, with nothing else in common with the other pavilions than a joint administration. She uses 120 beds as a criterium to split up a hospital into separate pavilions. Pirogov insists on dispersing the sick to barracks of 20–30 [23]. Nightingale and Pirogov agree on many specifics, such as the location of the hospital on the right site (not damp or densely populated), number of floors and size of the wards, free circulation of external air, adequate drainage and sewer constructions, proper use of materials for walls, floors and ceilings, construction of hospitals kitchens, laundries, nursing accommodations.

Quality of general hospital management — Nightingale and Codman

Nightingale makes a strong case for the idea that the basis of hospital management is the study of hospital statistics [22]. She wrote that uniform and accurate hospital statistics would enable the value of particular treatment methods and special operations to be brought to statistical proof [22]. The problem, however, was that the statistics kept by hospitals in Nightingale's time were neither uniform nor consistently accurate. To remedy this, she developed, with the aid of Farr and other physicians, a Model Hospital Statistical Form. The form was approved at the International Congress of Statistics in London in 1860 [10]. The new scheme set out the basic categories of data that hospitals should collect. Yet, gathering uniform hospital statistics was far ahead of the time, and

the new scheme was never put into general practice. The proposed form was overly complex and included a distinctive system for the classification of diseases devised by Farr with which many pathologists strongly disagreed. Nightingale herself saw little return on her excellent ideas.

Codman used a similar approach. In the article, "The Product of a Hospital", Codman asserts that a hospital has many products, including new knowledge and well-trained caregivers [24]. But the end result counts when it comes to health, whether delivered by an individual practitioner or provided by an institution. Specifically, the desired product is the satisfied and relieved patient [24]. More abstractly, the product is the health improvement that can be attributed to care. He extended the causes of failure beyond the individual physician as he noted that failures could be attributed to either the physician or surgeon responsible for the treatment, the organization carrying out the detail of the treatment, the disease, or the condition of the patient or the personal or social needs preventing the cooperation of the patient [25, 26]. Codman even puts monetary value to the effect of complications as he writes that additional postoperative days due to complications should be multiplied by the daily costs per capita. This 'loss' can be significantly reduced by efficient organization. As the greatest hindrance to implementing the end result system, he pictures the staff and management agreeing to admit and record the lack of perfection. In his opinion, once the end result system is installed, it will act as an authoritative method of recognising and recording failures in diagnosis and treatment. For Codman, the idea of the end result became the essential link between the science of medicine and the science of management. Here, Codman shows himself as a true child of his time, in which Frederick Winslow Tailor (1856–1915) developed his scientific management approach to industrial work. Like Codman, others, like Gilbreth and Dickinson, applied it to hospital settings [27].

Scientific methods and statistics to improve medical results — Pirogov, Codman and Nightingale

Scientific methods to improve healthcare can be distinguished in what we shall term the *epidemiological* and the *clinical* approach. The epidemiological approach is based on centralised statistical analysis and comparison of estimated rates for various outcomes. Nightingale is an example of the statistical approach in her early work on hospital statistics. In contrast, the clinical approach is based on carefully analysing case histories to determine the source of an individual surgeon's errors.

Pirogov and Codman are advocates of the clinical approach. Codman developed the approach as his "end result" method, and Pirogov in his analysis of cases both during wars and in hospitals. They used statistics to evaluate the results of the innovation. Be aware that mathematical statistics with methods like correlation analysis or hypothesis testing after the scientific life of Pirogov and during the lifetime of Nightingale and Codman did not exist. Therefore, all three used primarily descriptive statistics to evaluate clinical and epidemiological studies. In the next part, we will illustrate the scientific approach of the three scientists.

In mid-nineteenth century Russia, Pirogov was one of the first surgeons to actively evaluate the quality of surgical treatment because of his scientific view. Throughout his work, Pirogov hammered the importance of scientific approaches for the develop-

ment of medicine in general and in surgery and anaesthesia. Pirogov has conducted extensive anatomical research, presenting his findings in topological, three-dimensional, and surgical atlases. To supplement his anatomical research, Pirogov utilized an experimental approach to the development of new surgical techniques. He would perform prototype operations on laboratory animals before applying them to humans. For example, he experimentally investigated the effect of binding the abdominal aorta, finding that smaller animals could withstand this better than larger animals (dogs and horses). To clarify the aetiology of pyaemia, Pirogov conducted experiments by injecting pus, starch, oil and water into the veins of dogs. Finally, his now classic studies on the analgesic effect of ether were carried out, in which he investigated how the effect came about and whether alternative forms of administration were possible (rectal administration) [28].

Next to his experimental approach in his works, many examples of his (clinical) statistical elaboration of his results can be met. In "Die Grundzüge der Kriegchirurgie", Pirogov discusses the use and reliability of statistics, exemplified by the discussion whether to amputate or not [7].

He recommends that with using statistics, three points should be taken into consideration:

1) a rational, individualized comparison of the pros and cons of amputation in the individual case of injury;
2) the already available surgical statistics;
3) the personal experience of the surgeon.

He argues that using only the available statistics has limited value. The senior surgeons are guided by their own experience with performed amputation; the young, on the other hand, are more or less driven by the results of surgical statistics. However, using statistics is challenging. Especially during war, correct counting is a big problem. When is the amputee or the conservatively treated considered completely cured, shortly postoperative in the war hospitals or the rehabilitation centres later in their recovery? Patients may already have died before they are even admitted to rehabilitation centres. Transportation is another source of attrition, leading to errors creeping in unnoticed. He also warns against sources of bias from personal interests of the observers, officials and persons involved in the statistical calculation. Therefore, it is essential to him that statisticians of (war) surgery indicate precisely how they arrived at their results. It should be explicitly stated how and by whom the results were evaluated, possible sources of error and attrition, the statistical comparison method and the number of patients in the comparison is very significant and comparable in both groups. When evaluating amputation versus conservative treatment, one also has to consider the overall trauma to the patient. For amputation versus conservative treatment, one must consider the short-term risk of death and the long-term limb salvage advantages. Even mortality has limited value in evaluating amputation results versus conservative treatment. One should take into account the causes of death, like pyaemia, nosocomial infections sustained due to unhygienic circumstances, death from other causes that already existed in the patient before the injury (like typhoid fever), exhaustion due to the rigours of war, age of various soldier populations. Therapies also differ in the degree of the certainty of outcome, as some treatments may show a more significant potential added risk of adverse outcome than others, adding risk to an already injured patient.

Pirogov also dedicated his thoughts to the statistical evaluation of the effect of newly developed private nursing care on the fate of the wounded and sick during the Franco-Prussian War [23]. He thinks that statistical data could significantly contribute to correct decisions about infections and the construction and use of hospitals, barracks and tents. However, the statistical figures, results and conclusions must be treated with extreme caution. Based on the statistics, he concludes that the efficacy of private care became measurable as the English succeeded in decreasing the death rate in their Crimean army from 23 to 4 % (possibly referring to the statistical results of Nightingale). Likewise, using private care by the US federal troops of 1861–1862 resulted in a death rate no higher than 3.9 %. However, the French government could not get it below 10 % even in peacetime in its army; Pirogov is convinced that private care's success depends, above all, on a competent and well-organized administration. He considers a few factors very significant, such as the increased resources under private care, the greater variety of food and drinks, the effect of female care on the cleanliness of the premises, air ventilation, laundry and dressing material and an adequate surgeon-to-patient ratio. Where charity and private care were unrestricted and independent, hospital infections could not gain sufficient ground to spread on a large scale.

While Nightingale is applauded for her role in the development of nursing, less well known is her equally pioneering use of the new advanced statistical analysis techniques, skills she started to develop during and after the Crimean War [10, 29]. Nightingale was an ardent admirer of Lambert Adolphe Quetelet in Belgium, who was the first to apply statistical methods in social sciences. At Scutari, apart from the all-important sanitary reforms, she also systematized the chaotic recordkeeping practices; until then, even the number of deaths was not known with accuracy. When she returned to England in 1856, she met with William Farr, a physician and professional statistician, Head of Statistics at the Office of the Registrar General for England and Wales [30]. This agency had collected statistical data and published annual reports under his supervision for 40 years, which were used to evaluate public health problems. Under Farr's guidance, Nightingale soon recognized the potential of the statistics she had gathered at Scutari and medical statistics in general as a tool for improving medical care in military and civilian hospitals [10]. In January 1857, Nightingale excitedly wrote to Farr about the comparative death rates she had received from London hospitals, the death rates being 7.9 in the general hospitals, 9.38 in the workhouses and 11.48 in exceptional hospitals. Hospitals varied in the number of patients treated and the severity of the disease at the time of admission. Shortly afterwards, Nightingale compiled with the help of Farr the health statistics in the Crimean armies, providing the causes of death in military hospitals during war, with communicable diseases playing a major role. Nightingale recognized that reliable data on the incidence of preventable deaths in the military made compelling arguments for reform.

She after that applied the military's statistical methodology to hospitals (Fig. 5). Workhouse and hospital statistics, in her opinion, were a raw gold mine for institutions created to reduce people's suffering, but it is unknown whether they do so. Thereby, she applied the concept of evidence-based thinking to hospital care. That research led her to write in the third edition of *Notes on Hospitals* that "it seems a strange principle to make the very first requirement in a hospital that it must not harm the sick. It is necessary to establish such a principle because the mortality in hospitals is far higher than any calculation based on the mortality of the same class of diseases among patients treated out of hospital" [22, p. II]. The increased mortality was likely the result of the appalling hygienic conditions in the hospital

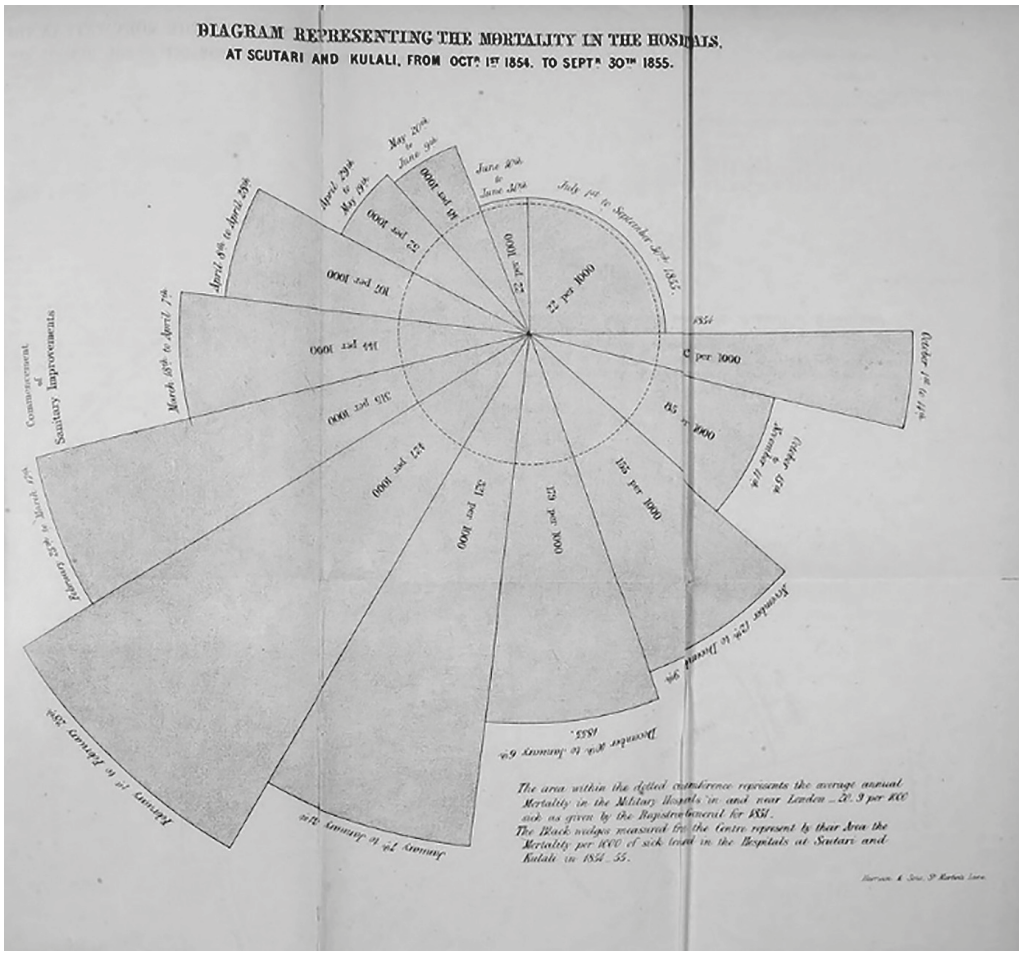

Fig. 5. The polar diagram of the hospital mortality between October 1854 and September 1855 [*Nightingale F.* Notes affecting matters affecting the health, efficiency, and hospital administration of the British Army founded chiefly on the experience of the late war. 1858, London: Harrison and Sons]

because of the construction of the hospital and the total ignorance of infection prevention among the employees. She also advocated not mixing statistics with claims of causation. Statistics should reflect only the boring numbers and not be combined with claimed connections.

To enable comparison of hospitals, Nightingale developed a standard model hospital statistical format approved by the International Congress of Statistics in 1890. But the form was too complicated to end up in practice because it was too complex and included a classification system of the diagnoses that was not widely accepted. She pleaded for carrying out new interventions first on a small scale. By evaluating the consequences of the intervention, improvements could be made, as these would suggest themselves [31]. Nightingale polar maps, in which the displayed statistic is proportional to the area of a wedge in a pie chart. She hoped this approach would make it easier for policymakers to understand. She struggled to get the study of statistics introduced into higher educa-

tion. However, her dream of installing a university chair in statistics did not become a reality until after her death [10]. Nightingale stood well in what is called the statistical movement in the nineteenth century [32]. This movement held the conviction that the fate of groups of people was based on poor social conditions and that improving their circumstances would improve society. The movement was surpassed by the development of mathematical statistics, in which Francis Galton and Karl Pearson played a dominant role in Britain. Next to their development of enormously improved statistical techniques, they strongly believed in the importance of the individual qualities of people for the development of society, which later developed into eugenics. When Nightingale turned in 1891 to Galton for advice on obtaining a professorship or readership on teaching "social physics" in Oxford, Galton thwarted her idea by trying to steer her away from the classical universities.

Codman's respect for scientific principles explains his use of the word "efficiency" (the catchword of his time) rather than "quality" when describing the structure, purposes, and consequences of his end result system. The word efficiency has many meanings for Codman. Most fundamentally, it was "therapeutic efficiency" a property that equires the best possible application of recorded knowledge to each case [25] so that treatment can be as successful as possible. Codman is also concerned with avoiding useless visits, unnecessarily long hospitalizations, and especially those avoidable mistakes which cumulative costs, he reminds us, exceed the cost of good medical care. We would now refer to that as a lean concept of waste.

Moreover, inefficiency not only occurs because doctors fail but also because, in organizations and systems, the work is not performed in a way that produces maximum output per hour. Codman's sovereign efficiency concept becomes almost a moral principle when he says that efficiency must recognize truth and use it truthfully. It's the scientific use of science [25] From the late sixteenth century on, a few British and American hospitals reported on the outcome of the admitted patients in general terms ("cured", "relieved", "incurable", "died"). Still, their statistics did not show any relation with treatment [27]. As a surgeon, Codman was particularly interested in the end result of surgical procedures. The idea of the end result was, in Codman's own words just common sense that every hospital should monitor every patient and their treatment long enough to determine whether the treatment has been successful, and then ask, "if not, why not?" to avoid a similar failure [25]. To carry out the idea, Codman devised what he called the end result system. Each patient had to have a 'final results card', that showed in the shortest possible terms the symptoms, the diagnosis that governed the treatment, the treatment plan, complications encountered in the hospital, diagnosis at discharge, and the outcome each year after that until a definitive determination of the results could be made. If long-term follow-up was not possible, at least the events during hospitalization should be recorded and assessed. All cases could be studied, and much could still be learned from research into hospital deaths, too. An Efficiency Committee in every hospital with representatives from the supervisory board, the managers and the medical staff should briefly review the care recorded. The commission would identify unsatisfactory results, determine the reasons for failure to achieve perfection, and take appropriate action to address individual cases of failure and improve the hospital's general policies, organization, and operations. The committee would keep a written record of its activities and perhaps publish a periodic summary of its comments and actions.

He argues that the application of the end result system surgery to surgical science as surgical knowledge is recorded and transmissible through facts and formulated general principles. The end result system demands an analysis of the reasons for success or failure and the utilization of the knowledge thus obtained to avoid errors and secure future achievements [33].

Codman applied the system in his small private hospital with 12 beds (1911–1917). He publishes these results in the article "A study of hospital efficiency as demonstrated by the case report of the first five years of a private hospital" [25]. This report included the summarized results of 887 cases, including coded causes of errors. The simultaneous assessment of care and its consequences characterizes Codman's method. In his system, adverse outcomes merely prompt an evaluation of what we would now call *process*.

To better establish the relationship between care and outcomes, Codman used a classification of the causes of failure to achieve perfection with the classes:

1) lack of technical knowledge or skill;
2) lack of surgical judgment;
3) lack of diagnostic skills;
4) lack of care or equipment;
5) personal or social conditions impeding patient cooperation;
6) the invincible illness of the patient;
7) the disasters of surgery or accident and complications beyond our control.

Some of these can be attributed to the doctor, some to the hospital, some to the patient or his circumstances, and some to the nature of the disease itself. Some are fixable, while others are not.

Codman tried through various medical and surgical associations to have the end result system adopted as the standard, which failed [15, 26]. Donald Berwick wondered why Codman's system was not widely adopted [34].

He mentions 4 causes:

1) ambiguous goals: the result of care is not binary (dead/alive; recovered/unrecovered), but there are countless categories;

2) identifying the results with the physician, but physicians act within a system and success and failure depend on both the physician and the system;

3) money: we don't want to spend much money to evaluate the quality of care;

4) fear of litigation: nowadays, Codman would become embroiled in one process after another by so openly reporting his failures.

Compared to the quality systems, Codman did not have predetermined criteria against which actual practice could be objectively measured. Judgment was based on second-guessing of reviewing physicians who only based their view on the information on the cards [29].

David Spiegelhalter [35], in his article on both Nightingale and Codman, stresses that both the epidemiological and clinical approaches are necessary for improving the quality of healthcare since an epidemiological approach will highlight quality differences between institutions and professionals but will not explain why these differences occur. Therefore, a clinical approach is needed to analyse the cause of failure in individual cases. Pirogov also stressed that the circumstances of the patients and the healthcare provider/institution must be investigated to explain further differences, just like Nightingale stated in her "environmental" theory.

Management of hospital infections — Pirogov and Nightingale

The discussion of managing hospital infections is limited to Pirogov and Nightingale, as Codman did not extensively discuss this subject. Both Pirogov and Nightingale lived in a period when the beliefs about infection's causation changed significantly. The prevailing theory about infections at the start of their carriers was the miasmic theory. This theory was passed on from Hippocrates through Vitruvius, Galen, and Lancisi [36]. Miasmic theory maintained its currency through the middle of the nineteenth century, even as evidence mounted for germ theory. The Miasma theory of disease contagion was popular for centuries in Western cultures. It held that diseases were spread through the stench of decay. Greater exposure to such a stench would increase the likelihood of contracting a disease [37]. During the Victorian Era, Miasma Theory was loaded with a moralistic connotation. As miasmas seemed prevalent among the poor slums, diseases were seen as God's punishment for immoral lifestyles.

During Pirogov and Nightingale's lives, the miasmas concept was challenged. Ignaz Semmelweis discovered that handwashing between patients eliminated the high infection rate in obstetric patients, drastically reducing the mortality of women following birthing [38]. During the cholera pandemic of 1826–1828, John Snow hypothesised that the cholera's leading cause and spread had not been bad air. Instead, cholera could be spread in water, food or hand-to-mouth. Snow concluded that a germ cell caused cholera, not bad air. But Snow's hypothesis was not accepted in the 1850s because he was not a member of the medical elite. William Farr, the dominant epidemiologist in the mid of 19th century, initially refuted Snow's theory. However, by 1856 Farr realized the direct cause of chorea was spread through contaminated water. After that, the germ theory of disease emerged and gradually replaced the miasma theory by the second half of the 19th century [39]. Thanks to his prestige, Louis Pasteur greatly influenced how measures to prevent infections were undertaken. He inspired Joseph Lister to use antiseptic methods to reduce mortality associated with surgery [40]. Now that we have given some background on the prevailing theories during their lifetime, we will discuss the ideas and opinions of Pirogov and Nightingale.

During his post-doc study in Dorpat, Pirogov got the possibility to visit Europe and observed unhealthy conditions in hospitals in Europe, especially in the Charite in Berlin, which he called a Murder Pit. Once he came into function, Pirogov immediately decided to isolate all patients with pyaemia, isolated gangrene and burns. Since then, this division was also applied to all patients suspected of infections. He attributed the favourable results to this separated department and its organization since no more terrible infections or gangrene had been found in his clinic. His vision of the isolation of infectious patients developed further during the care for the wounded and the sick in the Caucasian war in 1847. He was inspecting the transportation of wounded soldiers from Alma and Inkerman to Bachtschi-Saray when he met a (young) senior physician who claimed that isolating infected patients in his hospital was unnecessary, as not isolating patients had better results. This surgeon was shown wrong as of all 200 patients, almost none were free of erysipelatous-phlegmonous inflammation or gangrene of gunshot wounds. Pirogov used this example of poor thinking in his books "Medical Report of a Journey to the Caucasus" [41] and "Kriegchirugie" [7]. Pirogov encountered the same situations in several other Military hospitals, where in the absence of hygienic measures, he was sure to find wide-

spread infections. Based on his experiences with infectious patients, he developed a set of requirements, which included the need for robust and consistent ventilation around the sick bed, complete segregation of operating personnel, instruments and wound dressing from the patient rooms, hand hygiene, and setting up latrines out of the airflow to the chambers [23].

Pirogov thought that since many miasmas are not so volatile that they can be destroyed by simple ventilation, he quantifies the required airflow as approximately 42–56 cubic meters for each bed used. Despite this ventilation, he argues that infections will spread if the beds have been occupied for some time by patients with large festering wounds. Therefore, he insists on dispersing the sick, with no more than 20–30 patients in a barracks. The more barracks, wards and beds that are empty to move the ill from one place to another to disinfect the evacuated premises, the less there is the possibility of an accumulation of (solid) infectious substances in hospital wards, beds, mattresses, bandages and in the body of the sick person himself.

Additionally, Pirogov assumed that further research would also show that the contagious poison is transmitted and spread through hands, instruments, clothes, etc., due to a concentration of sick people. In general, Pirogov considers any place where several hundred patients with purulent wounds have accumulated, potentially ready for the reception and spread of contagion. Thus, any building with 300–400 injured people in a closed area will become a development site of infectious toxins. He considers pus, decomposed blood, and blood clots accumulated in the wound, near the injury, and in nearby blood vessels as media contributing to the formation of the various ferments (microzymes). They also contribute to external transmission (spores, fungi and "infusoria"). In addition, yeasts can also be considered the cause of infection of the whole organism. Even the usual traumatic (after external injuries) fever can, in many cases, be considered a consequence of the fermentation in the wound. It looks pretty likely to him that the organism becomes infected in two ways: *either* through ferments and poisons that develop from the components of the pus and decomposed blood *or* through the introduction of the ferments from the surrounding air and other objects. Therefore, he strives to prevent infection by ventilation, airtight closure of the wounds and the constant removal of pus or contact with it.

Pirogov also dealt with cholera [42]. During that pandemic of the Asian cholera, its height was in 1847 in Russia, Pirogov performed over 500 autopsies in Moscow, in the Caucasus and in Dorpat, now Tartu, Estonia. The findings during these autopsies he published in a cholera atlas. He concluded from his findings that the intestinal canal was the seat of cholera, and mainly the mucous membrane of it only as the main place of detection of the cholera process. He thinks a special affinity between the intestinal mucosa and a mysterious "X" is the pathogenic origin of cholera, without going into any of the assumptions about the nature of this principle and about how it enters the body: whether it initially infects blood or affects the nervous system, — assumptions that cannot yet be satisfactorily resolved under the current state of science [42]. Thus he is very close to an external cause of cholera, an infection, but he cannot definitively conclude on the pathogen.

Nightingale developed many ideas based on her statistical analyses of death in armies, general hospitals and populations. Nightingale wrote on miasmatical theory in "Notes on Nursing" that the first essential to the patient is to keep the air he breathes as pure as the external air [43]. Nightingale was a firm believer that foul air was the most critical and

prominent cause of infection. She also attributed smallpox, measles, and scarlet fever to "the practice of building houses with drains beneath them from which odours could escape and infect the inhabitants" [44, p. 18]. The miasmic theory drove her ideas on fighting hospital infections and hospital architecture. She, on the other hand, disliked the idea of infection. In "Notes on Nursing", she wrote:

> *"…"we must not forget what, in ordinary language, is called infections"– a thing of which people are generally so afraid that they frequently follow the very practice in regard to it which they ought to avoid… Does not the popular idea of "infection" involve that people should take greater care of themselves than of the patient? That, for instance, it is safer not to be too much with the patient, not to attend too much to his wants…"* [43, p. 15].

To continue directly with the remark that proper nursing knows nothing of infection except to prevent it. Cleanliness and fresh air from open windows, with unremitting attention to the patient, are the only defence a faithful nurse either asks or needs. Wise and humane patient management is the best safeguard against infection [43, 45].

Gradually Nightingale developed what is coined by some as an Environmental Theory [46]. Nightingale's assessment of the "health of houses", hospital design, organization and nursing practice contribute to the ongoing development of an environmental theory. For instance, the five essential points of the health of the personal environment were expressed in "Notes on Nursing" as the health of houses in securing: 1) pure air; 2) pure water, efficient drainage; 3) cleanliness and 4) light [45]. She firmly believed that prevention by taking adequate measures like hygiene was the best way to keep patients free from infections.

Teaching and education — Pirogov and Nightingale

The quality of healthcare depends strongly on the quality of the providers of care, both doctors and nurses. At their time, the work of doctors was, of course, well-known. Still, the nursing work had to be (further) developed from simply delivering household services and bedside service to the patient to an educated nurse that provides her portion of medical services in connection with the doctors.

Pirogov first started to develop the education and training of medical doctors. Later, he also was involved in the development of nursing, starting during wartime in Crimea, which evolved into the development of the nursing profession in Russia, both during war and peace.

At the end of 1839, Pirogov was invited to take over the surgical chair of Professor Savenko at the Imperial Medico-Surgical Academy in St. Petersburg. He initially refused because there was no clinic associated with this department. Pirogov proposed to set up a hospital clinic parallel to the existing surgical academic clinic by adding the 2nd military land hospital to the Imperial Medical and Surgical Academy. Pirogov argued that what had been learned should be applied in practice. Contrary to his personal experience, young people would no longer be formed on cramped school desks by a teacher of practical medicine. They also should learn through the actions of practising physicians at the bedside of the sick, developing their own opinion. Bedside teaching should result in learning methods of clinical examination and the formation of individual treatment plans. The professor should present the listeners with a whole series of identical cases, showing their unique shades and with statistical evidence for the usefulness of one or another

method. He proposed that these lessons should be taken in the fifth year of the study. He also suggested the enlargement of the collection of anatomical-pathological and surgical specimens for teaching the students. To his proposal, the Conference of the Imperial Medico-Surgical Academy added organizational proposals to support the surgical professor in his duties, an adequate budget to develop the department and appropriate compensation for the officers. Once in St. Petersburg, Pirogov started with the fulfilment of his plans. At his insistence, an operating room was set up in one of the chambers of the embankment building. Pirogov turned one of the hospital's wooden outbuildings into a special clinic department for pyemic and contagious patients in general.

Pirogov was an influential practising teacher. During his appointment as a professor, his practice consisted of a daily clinic visit, where he analysed with the students on the various departments of the newly admitted patients, the differential diagnosis, and the various alternative therapeutic options. If surgical treatment was indicated, he evaluated the different operative procedures practically. In addition, Pirogov gave clinical lectures, which mainly involved comparing several cases, representing individual changes in the same disease. Finally, he performed operations on the sick and performed autopsies. During lectures and the bedside analysis of patients, Pirogov constantly followed the anatomical and experimental directions in surgery that he started to develop at the Dorpat university. An inseparable part of the clinical education was pathological and anatomical autopsies, accompanied by case lectures, in which Pirogov related the application of the obtained anatomical and pathological data to the patient's case study. The fame of Pirogov's extraordinary teaching talent spread far beyond the Academy, attracting students from other universities.

Simultaneously with his appointment to the Imperial Medico-surgical Academy, Pirogov was appointed a member of the Highest Approved Committee under the Ministry of Public Education for transforming the medical curriculum at the Universities. Likewise, he was elected as a member of the newly reformed Medical Council of the Ministry of Internal Affairs. As a member of the Medical Commission of the Ministry of Public Education, Pirogov participated in all matters and further elections of the medical faculties of all universities. At the suggestion of Pirogov, the revision of the rules on examinations for medical degrees resulted in replacing six degrees with three: Doctor, Doctor of Medicine and Doctor of Medicine and Surgery. Following his suggestion, practical anatomy, therapy and surgery exams were introduced at medical faculties. Finally, the university hospital surgical clinic model was also established at all universities.

Participation of women was accepted in Russia, but up to the Crimean War, women had never been deployed in a theatre of war. Care for patients by women was already present in Russia from early days on in civilian hospitals in St. Petersburg and Moscow at the instigation of Empress Elizabeth the Great [47]. Wives of sick soldiers and soldier's widows worked as ward orderlies and were authorised to admit patients, examine sick women and administer simple treatments. After two years of work experience, they could also provide home medical care.

Pirogov visited Paris in 1837, where he saw how women were involved in the daily care of hospital patients [48–50]. History and his observation led to the development of a professional role for women in the Russian healthcare system. With the support of Grand Duchess Elena Pavlovna, sister-in-law of Tsar Nikolas I, he attained a significant role for women as nurses in civilian and military hospitals, initially during and after the Crimean

War (1853–1856), in which the Russian army suffered huge losses. The large numbers of casualties and miserable conditions forced a reorganisation of nursing care.

In the autumn of 1854, Elena Pavlovna turned her Mikhailovsky Palace in St. Petersburg, into a military medical backup centre [6, 50]. Volunteers from all sections of society entered training as nurses, most well-educated, including women of the nobility. But also nuns from nursing orders and women from the poorer classes with limited education. The volunteers underwent a short (few weeks) intensive training at the St. Petersburg Medico-Surgical Academy by Pirogov and his colleagues before they were sent to the Crimea to support surgeons working at the battlefront. Starting in November 1854, a regular flow of new female staff arrived in Crimea. When Pirogov considered having sufficient female staff, he divided them into *operating assistants* and *bandage masters* helping surgeons, *pharmacy assistants* preparing drugs and supervising its distribution, housekeepers taking care of clean linen and the sick, and overseeing the doctors and administrative staff. They also worked as operating assistants. This supervision brought Pirogov into conflict with the hospital management because the housekeepers discovered that the administrative staff abused their position by withdrawing goods, food and money meant for the injured soldiers. The idea to send organised groups of women to the battlefield was risky, but Russia became thus the first country to send trained and well-organised female nurses to the battlefront. After the Crimean War, this organisation became the starting point for the Russian Red Cross, founded with Elena Pavlovna's and Pirogov's support in 1867 [6, 50].

After the peace treaty of March 18, 1856, the social recognition the nurses had received resulted in the establishment of still more nursing Communities [50]. The considerable public appreciation paved the way to the acceptance of nursing and more generally, the role of women in Russian society. The Holy Cross Community of Nurses of Elena Pavlovna continued its nursing work after the Crimean War. This community was regarded as the model for the Russian Red Cross nursing societies, established from 1867 onwards, to provide nurses not only for times of conflict and emergency. The regulations of the Russian Red Cross formed part of the statutes of the various Merciful Communities. They described the requirements for admission, the guidelines of the organisational educational programmes and the rights and obligations of the nurses/sisters and the Communities. One of the main functions of the Red Cross Societies was the training of nurses. Training lasted 1.5 to 2 years and consisting of the following components: theoretical education, which included anatomy, physiology, pathology, knowledge of epidemiology, pharmacy, prescriptions and selected topics about women, children, skin, nervous and mental diseases. Practical education had the emphasis on internal medicine, general surgery, outlines of bandage knowledge, minor surgery and vaccination.

The teaching was conducted in the building of the Russian Red Cross, in independent medical institutes, in military hospitals and in city and village hospitals and private clinics. Under the supervision of qualified nurses, the students first worked in wards, in operating rooms, in outpatient clinics assisting the doctors and in pharmacies where they were taught about the preparation of medicines. After passing an examination followed by a two-year work experience in the Communities, which paid for their education, they worked in that institution as a registered nurse. Students who did not belong to a Community and paid themselves for their education received a certificate. They were assigned to the reserve sections of the Red Cross and the Executive Committee of the Red Cross could

call on those during emergencies. This obligation to be always available when the need arose proved to be invaluable in the fight against cholera, typhoid and diphtheria during the epidemic of 1891–1892.The Russian Union of the Red Cross and the Red Crescent Societies nowadays still play an important role in the development of national health care and in the activities of the International Red Cross.

Florence Nightingale was convinced that women in their younger life needed an occupation to satisfy their intellectual needs. In 1851 she described the institution in Kaiserwerth on the Rhine (the institution where she trained in her younger years), and she stated the institution for the training of Deaconesses as an apostolic institution for the employment of women's powers directly in the service of God and used historical arguments to support her statement [51]. She uses this argument to defend the development of a new and respectable occupation for women, which was not widely accepted in her surroundings or her parents. She sees disease as a Divine means to soften the heart. Christian nurses are teachers of patients to improve their immorality and impropriety. The Christian-moralistic tone of this early work disappeared, and she frequently advised against proselytism by religious nurses in her later works.

In November 1854, she arrived as a superintendent with 39 nurses and sisters in Scutari, Turkey, to which a second group of 46 nurses, sisters and untrained 'ladies' was added in December. Numerous additions followed these groups until July 1856. The groups were generally distributed over the Barack and the General Hospitals in Scutari. It is apparent that the practical experience of nursing work, as she later understood it, was minimal. In her later work, "Notes on Nursing", Nightingale laid down her nursing principles [43, 45]. She wrote her concepts of nursing down in separate chapters in her books, addressing ventilation and heating, the health of houses, petty management (which we would translate into daily management), noise, variety, taking food, bed and bedding, light, cleanliness, chartering hopes and advice and finally observation of the sick. The chapters on ventilation, health of houses and cleanliness are very much conceived from the perspective of miasmic theory. The chapter on chartering hopes and advice concentrates on bedside behaviour. The chapter on observation of the sick urges the nurse to detect any change in the patient's condition and report it briefly to the attending physician when he visits the patient. The final chapter addresses what a nurse is, which depends mainly on her observational skills, checking medication and dedication to the patient. She concluded the book with the statement that nursing can only be learned by working at a surgical ward and that perfect nursing is rarely accompanied by high infection rates.

In 1855, 4 years after the first publication of "Notes on Nursing", she described her findings on the introduction of female nursing during war and peacetime [52]. This is followed by her vision of improving and implementing female nursing, hospital nursing management and hospital construction (discussed above). The implementation of female nursing was significant as, at the time of writing, she met with considerable opposition in, for instance, the Military and Navel hospitals, where the role of nurses was limited to taking charge of the linen and superintending the issue of extras. The introduction of nursing in civil hospitals was much easier as nurses were accepted there. Next to the hierarchical organization with an explicit subordinate position to the medical staff, she lays down the structure of the nursing organization with roles like matron, superintendent, nurse, and probationer. Furthermore, she suggests a payment struc-

ture, including pensions, housing of the nursing staff, patients/nurses' ratios, or patient/orderlies' ratios with budgetary consequences and duty descriptions. Next to these elements of structure, she considers to a large extent rules and procedures to be kept by the nursing staff, recommendations for conduct and discipline and classification of cases by which staff can be allocated.

With money from the Nightingale Fund (almost 50,000 pounds, raised by public subscription to honour the 'Popular Heroine') she realised an early goal, founding the Nightingale Training School for Nurses in 1860. She could not, as she had hoped, superintend the school, but it followed her principles: 1) that nurses should have their technical training in hospitals specially organized for that purpose; 2) that they should live in a home fit to for their moral life and discipline [10].

Conclusion and discussion

In the present article, we have highlighted the thoughts and actions of three original thinkers that occupied themselves with the management and organization of hospitals. They often started with nothing to rely on, as they were pioneers in the field of quality management. Quality and management concepts were not present at the time, as were many other areas, such as an adequate understanding of the causation of hospital infections, scientific thinking in medicine and nursing, and statistical and methodological tools to study and improve healthcare. We have seen that their thoughts were original but also that they were embedded in the belief systems of their time.

The evolution of the thinking of Pirogov and Nightingale on quality and efficiency in healthcare cannot be understood without a reference to their profound experiences during the Crimean War in which they both took part. Pirogov went to Crimea as the overarching head of the medical troops on instruction of the Emperor. In "Grundzüge der allgemeinen Kriegschirurgie", Pirogov stated that Russia was in no way prepared for the Crimean War in 1854–1856, which involved mass casualties. Neither the provisions for the care of the sick nor the vital supplies required for the active number of troops on the peninsula were present in the war theatre. Treatment of the wounded and ill took place in local buildings, hospitals, office buildings, palaces (in Bakhsh-Saray), casinos, schools, larger private houses and barracks. Pirogov devised and applied a triage system, the so-called 'distribution system', dividing the wounded into five groups to deal with the massive influx of wounded soldiers. He also separated tasks into subgroups of doctors and nurses, increasing their efficiency in treating the wounded.

Nightingale went with a small group of nurses to Scutari, Turkey, to take part in caring for British soldiers during the Crimean War. Through her work, by the spring of 1855, half a year after she arrived at Scutari, mortality in the hospital had dropped from 42.7 to 2.2 %. By the end of the war, according to Nightingale, the death rate among sick British soldiers in Turkey was not much more than among healthy soldiers in England [10]. Comparison of various nursing practices in Crimea by Nightingale led her to state that the position and role of nurses in the Russian hospitals was by far the best she had known since the Russian nurses took charge of all that relates to the bedside, including the communication with the attending physicians, feldshers and supervising the orderlies [52].

Nightingale and Pirogov differed somewhat in their vision of wartime care. Nightingale was probably confronted with a different patient population than Pirogov, with

notably more infected patients than surgical patients suffering from wounds. While probably half of the patients of Pirogov died from injuries sustained at the battlefront, only 20 % of British patients died from that cause [13]. Injured soldiers were sent to Scutari by a boat trip of 300 miles and 8.6 days. The most serious wounded were not admitted to the boat or would have died by that time. She calculated that 6 % of deaths in the regiments could be attributed to wounds and the rest to infections [53]. Therefore we may conclude that Pirogov and Nightingale deald with a somewhat different patient population and thus differed in their focus on their management on the battlefield. She had in Scutari ample opportunity to prove that improvement in nursing would decrease the death rates and that improved nursing principles and reliable hospital management would improve results [13]. Based on the success of interventions, she concluded that 90 % of mortality was preventable in the hospitals. Pirogov spent the most attention on treating gunshot wounds and other traumas and good surgical organisation on the battlefield. The Crimean War and the battle of Solferino led on August 22, 1864, to the formation of the International Red Cross, soon followed by the emergence of national red cross organizations. It also led to the further development of nursing in England and Russia likewise.

Codman was enriched by the thinking of Frederick Taylor, the godfather of scientific management, and the concept of efficiency. He directed the discussion of quality towards the end result of any medical procedure, which should be evaluated after admission or one year. He also thought, like Pirogov, that lessons should be drawn from failures by explicitly addressing them and studying the causes of failure. He included causes of failure other than individual surgical shortcomings and tried to widen the discussion by having surgeons and administrators participate in the evaluation. He failed as the time was not ripe for the concept.

Donabedian synthesized the elements of the three thinkers into his well-known model structure-process-outcome. Through the works of our early thinkers on quality in healthcare, a path was laid to healthcare improvement, on which later generations could further develop the methods of healthcare improvement. Remarkably, some of the subjects they studied are still relevant to our present-day problems; others have entirely disappeared due to significant improvements, particularly the quality of our hospital buildings and equipment.

We have covered the subject of our study, displaying the tree thinkers' work and comparing each other on a small scale. Our description of the three individuals could not be complete, as their work is extensive. Yet, we hope, however, that we have done them justice.

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К ранней истории управления качеством в здравоохранении Пирогов, Найтингейл и Кодман

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Качество медицинских услуг часто описывают с помощью модели Донабедиана («структура — процесс — результат»). Вместе с тем основа этой модели была заложена в работах более ранних мыслителей, занимавшихся вопросам здравоохранения в XIX и начала XX в. В статье основное внимание уделяется двум хирургам Н. И. Пирогову, Э. А. Кодману и одной медсестре-заведующей Ф. Найтингейл, которые принимали то или иное участие в управлении лечебными учреждениями. У них не было теоретического и практического опыта, поскольку они были пионерами в области управления качеством. В то время не существовало даже концепций качества и управления, как и многих других областей, таких как верное понимание происхождения госпитальных инфекций, научное мышление в медицине и сестринском деле, а также статистические и методологические инструменты для изучения и улучшения здравоохранения. Идеи по совершенствованию здравооранения были оригинальными, но вместе с тем укорененными в систему мировоззрения своего времени. В публикации прослеживается развитие представлений об управлении качеством трех выдающихся специалистов, чей опыт привел к значительным улучшениям в медицине, воспринимаемых нами сегодня как данность.

Ключевые слова: история медицины, Пирогов, Найтингейл, Кодман, обеспечение качества, здравоохранения.

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