v. 4, n. 94, 2024

International Journal of Health Science

Acceptance date: 25/10/2024

FROM SEMMELWEIS TO SOFTALIND®: THE EVOLUTION OF HAND SANITIZING IN THE OPERATING ROOM

William Augusto Casteleins
Surgical Oncologist, Director of the Gastrointestinal Center at Vinmec Central Park International Hospital in Ho Chi Minh City; Affiliated Faculty at the Graduate Medical Education Program of the College of Health Sciences, Vin University (VinUni), Hanoi, Vietnam
http://lattes.cnpq.br/4734328516584608
https://orcid.org/0000-0002-8728-5875

Ana Paula Norberto Sbalqueiro
Cardiologist at São Marcelino Champagnat Hospital; Preceptor in the School of Medicine at Pequeno Príncipe Medical School, Curitiba, Paraná, Brazil
http://lattes.cnpq.br/4267196668666151
https://orcid.org/0009-0002-1237-4731

Abstract: This article chronicles a brief historical evolution of hand hygiene practices in surgery, starting with the pioneering work of the renowned Hungarian physician Ignaz Semmelweis in the mid-19th century. Semmelweis's introduction of handwashing with chlorinated solutions marked a pivotal shift in preventing puerperal fever, laying the groundwork for further discoveries and applications of hand sanitizing protocols. Joseph Lister advanced antiseptic techniques in surgery, followed by the germ theory of Louis Pasteur and Robert Koch, who proved to the world the existence of microorganisms. The introduction of surgical gloves by William Halsted added another chapter in infection control, just as the 20th century saw the development of a diversity of alcohol-based products that revolutionized hand sanitation, along with a growing number of surgeons and public health practitioners who solidified the importance of aseptic practices. We also examine innovations that proved their valor during the COVID-19 pandemic, such as touchless dispensers and technology for tracking hygiene compliance in healthcare settings. The historical trajectory outlined here culminates with the adoption of standardized guidelines in the operating room, who also have been changing in the first decades of the 21st century, migrating from harsh brush scrubbing techniques to soft novel antiseptic formulations, making it simpler - although still safe – the old routine of washing hands.
Keywords: hand disinfection, hand sanitizers, germ theory of disease, surgical gloves, disinfectants

INTRODUCTION

Hand hygiene is a fundamental aspect of infection prevention and control in healthcare settings, serving as the first line of defense against the spread of pathogens. Its historical evolution, beginning with Ignaz Semmelweis's relentless work in the mid-19th century, underscores its importance in safeguarding both patient and healthcare provider safety. His advocacy for handwashing with chlorinated lime solutions dramatically reduced puerperal fever rates in obstetric clinics, establishing a pivotal moment in medical history that highlighted the necessity of cleanliness in clinical environments. This awareness laid the basis for modern hand hygiene protocols, emphasizing the role of sanitization in preventing healthcare-associated infections.

Around the world, every graduate student in Health Sciences, regardless of major, would it be in Medicine, Nursing, Nutrition, Physical Therapy, Biomedicine, Dentistry, Phonoaudiology, learn the importance of hand sanitizing. However, not everyone is aware that 150 years ago, washing hands before performing a healthcare procedure, or even before/after touching a patient, was something unthinkable and even unacceptable by the great majority of health practitioners. Medicine is the science of the temporary truths, some shall say. Indeed, the history of sanitizing is a remarkable example of that.

THE PIONEERING WORK OF SEMMELWEIS

The year 2024 marked 206 years since the birth of Ignaz Philipp Semmelweis (born July 1, 1818; in Buda, Hungary – today Budapest – part of the Austrian Empire), the pioneer of hand hygiene in healthcare (Figure 1). He received his doctor's degree at the University of Vienna in 1844 and started working as an assistant to an obstetrician in 1846, being also responsible for medical necropsies,

at the *Allgemeines Krankenhaus*, a large hospital and a maternity clinic of nearly 4000 annual births. After he was put in charge of the First Clinic for Labour, where medical students were employed (at that time the term ´resident´, for training physicians, was not yet created), he observed that puerperal fever less frequently observed for women cared for only by midwives at the Second Clinic.

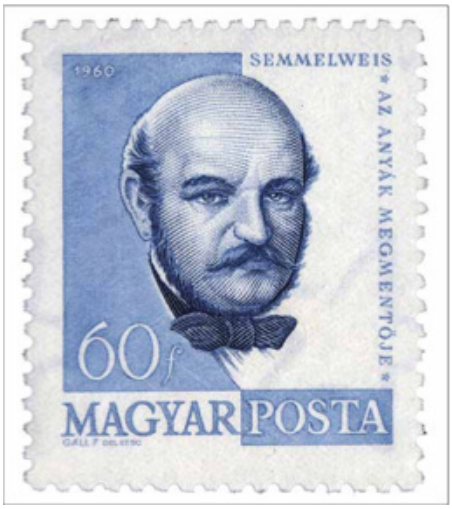
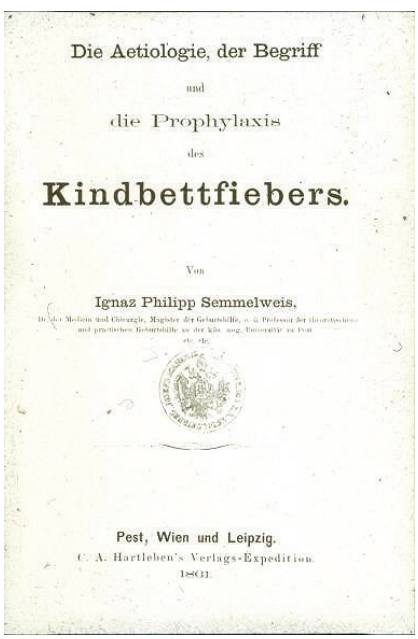


Figure 1: the portrait of Ignaz Philipp Semmelweis in a stamp issued by the Hungarian post service in 1960 (ATAMAN et al, 2013)

Initially, he did not attribute vital importance to that finding, until 1847, when his friend, professor Kolletschka died after hurting his finger with a knife used for cadaveric dissections. His autopsy showed a widespread infection, including peritonitis and meningitis, urging him to connect that fact with death from puerperal fever. Semmelweis hypothesized that cadaverous particles had been introduced into the vascular system of both from the hands of students and doctors during pelvic examination (BHOPAL, 2002). He figured that something stronger than soap would be necessary for cleaning hands in the First Clinic, and he introduced chlorine liquida, replaced by chlorinated lime for economic reasons. The maternal mortality dropped, reaching the numbers in the Second Clinic. This intervention was not only revolutionary but also controversial, as it challenged the prevailing medical beliefs of the time. Many physicians resisted those recommendations, attributing the high mortality rates to miasma rather than to their own practices.

Unfortunately, his contract with the University was not renewed in 1849, forcing him to move back to Budapest, were he kept working on the same theory, achieving the same results. During the next few years, he experienced difficulties in being accepted in several hospitals, due to his resolute ideas. His prominent work was published in 1861 (Figure 2) *Die Aetiologie, der Begriff und die Prophylaxis des Kindbettfiebers* (The etiology, concept and prophylaxis of childbed fever) (PITTET AND ALLEGRANZI, 2018). So much pressure and disappointments led him to mental disorders, being admitted to an asylum in 1865, dying in the same year. Today, the medical community worldwide officially recognizes his struggle and findings in the field of epidemiology and infectious diseases.


Die Aetiologie, der Begriff

und

die Prophylaxis

des

Kindbettfiebers.

Von

Ignaz Philipp Semmelweis.

Pest, Wien und Leipzig.

C. A. Hartleben's Verlags-Expedition.

1861

Figure 2: original cover of Semmelweis´s publication on childbed fever (PITTET AND ALLEGRANZI, 2018)

THE GERM THEORY OF DISEASE

Joseph Lister expanded upon Semmelweis's ideas by introducing, in 1865, carbolic acid (phenol) as a disinfectant in surgical settings (Figure 3). Lister's experiments demonstrated that the application of antiseptics to surgical instruments and wounds could drastically reduce infection rates, according to his series of articles published in the Lancet, in 1867 (MICHALEAS et al, 2022). His approach not only improved patient outcomes but also set the stage for the systematic use of antiseptics in various medical procedures. The acceptance of Lister's methods marked a significant shift in surgical practice, leading to the establishment of sterile techniques that are fundamental to modern medicine.

Figure 3: the Lister´s carbolic spray (MICHALEAS et al, 2022)

The germ theory of disease, published in 1878 by Louis Pasteur, revolutionized medicine by identifying microorganisms as the cause of many illnesses. Pasteur, a French chemist, conducted experiments disproving the long-standing theory of spontaneous generation, demonstrating that microorganisms present in the air caused fermentation and spoilage (LAPENOS et al, 2024). His work paved the way for the acceptance of germ as the cause of infections. His studies, later on, led to the development of pasteurization, remaining until today a vital process for killing microorganisms in the alimentary industry. Pasteur inspired Lister and both met during the celebration of Pasteur´s 70th birthday in a memorable event at the Sorbonne University in 1892 (Figure 4).

Figure 4: photograph after a painting by Jean-André Rixens, in which Lister acclaims Pasteur in his Jubilee on December 27, 1892 (MICHALEAS et al, 2022).

Another key figure in germ theory was Robert Koch, a German physician who identified specific pathogens responsible for diseases. Koch is best known for his identification of *Bacillus anthracis* (1876), and later the discovery of the bacteria responsible for tuberculosis (1882) and cholera (1884). His formulation of "Koch's Postulates" established a scientific method to link specific microbes to specific diseases, a foundational principle in microbiology research. Koch's systematic approach and discoveries earned him a Nobel Prize in Physiology or Medicine in 1905 (LAKHTAKIA, 2014).

THE INTRODUCTION OF GLOVES FOR MEDICAL PROCEDURES

William Stewart Halsted, a prominent surgeon in the USA, pioneered the use of surgical gloves in medical practice, particularly in surgery, in the late 19th century. In 1889, he introduced the first rubber surgical gloves at Johns Hopkins Hospital, primarily to protect the nurse Caroline Hampton, his future wife, who developed dermatitis from the harsh antiseptics used at that time (LATHAN, 2010). The gloves were initially created by the Goodyear Rubber Company at Halsted's request, mainly as a protective measure for the staff. However, he soon realized that gloves also had the added benefit of improving cleanliness and reducing surgical infections by preventing the transfer of bacteria from the surgeon's hands to the patient.

Figure 5: photograph of William S. Halsted in 1880

It is impressive to imagine today that at the beginning of the year 1900 the use of gloves was still a practice not consolidated in America or in Europe! Finally, the use of gloves became widespread, evolving from merely a protective barrier to a critical component of aseptic techniques in surgery. The first gloves were not disposable, being washed and sterilized after each use. Halsted's introduction not only advanced infection control in surgery but also helped shift medical practices toward more rigorous aseptic methods. It became a key step in building modern surgical practices, aligning with other developments like antiseptic techniques and sterilization to greatly reduce surgical mortality and improve patient outcomes.

DEVELOPMENT OF MODERN HAND SANITIZERS

The 20th century witnessed impressive advancements in hand hygiene practices, with influential figures in medicine playing crucial roles, actively enhancing public health awareness and promoting effective hygiene methods to prevent the spread of infectious diseases. Worth noting, is the work of Ernst von Bergmann (1836 – 1907), who introduced steam sterilization for surgical instruments. After him, the American urologist Hugh Hampton Young (1870 – 1945), promoted antiseptic practices and sterile spaces in the operating room. He was followed by the Norwegian physician Hjalmar Schønberg (1870–1960), who also advocated for strict antiseptic practices, and Milton J. Rosenau (1869–1946), dedicated to large studies in public health. His book *Preventive Medicine and Hygiene* (1913) emphasized the need for hand sanitation to control the spread of infectious diseases in hospitals.

The introduction of alcohol-based hand sanitizers in the 1960s represented another major milestone, offering a convenient alternative to traditional handwashing methods while proving effective against various pathogens. In 1965, Peter Kalmár developed in Hamburg (Germany) the first alcohol-based hand rub, a product known as Sterillium® (HANS et al, 2021; PAUL HARTMANN, 2024). This product marked a shift in healthcare, simply because the ease of using rubs increased compliance among healthcare workers.

ANTISEPTICS VS. DISINFECTANTS

Understanding the distinction between antiseptics and disinfectants is crucial. Antiseptics are agents that inhibit the growth of microorganisms on living tissues, primarily used for skin preparation before surgical procedures or injections. These substances are formulated to be safe for application on human skin, often containing ingredients such as alcohol, iodine, or chlorhexidine, which effectively reduce microbial load while minimizing irritation or toxicity. Their role in preoperative care is essential, as well-prepared skin can significantly reduce the risk of surgical site infections.

In contrast, disinfectants are chemical agents applied to objects and surfaces to eliminate or reduce harmful microorganisms. These substances are typically more potent than antiseptics and are effective against a broader range of pathogens, including bacteria, viruses, and fungi. Common disinfectants include bleach solutions, quaternary ammonium compounds, and hydrogen peroxide. The use of disinfectants is critical in operating rooms and on medical equipment, where the risk of cross-contamination can lead to severe health complications for patients (McDONNELL and RUSSELL, 1999).

INNOVATIONS IN ANTISEPTICS TECHNOLOGY

Until today most hand sanitizers still function primarily through the mechanisms of alcohol-based active ingredients. They act by disrupting the integrity of microbial cell membranes and denaturing pathogenic proteins, making them unable to replicate or cause infection. Alcohol, particularly in concentrations of 60% to 95%, is effective against most environment microorganisms. The rapid evaporation also contributes to its efficacy, allowing for a quick application that is particularly advantageous in high-traffic medical environments (PITTET et al, 2008).

In addition to alcohol, other active ingredients compose hand sanitizers, operating through different mechanisms. Chlorhexidine disrupts bacterial cell membranes and precipitates cellular components, leading to cell lysis. Quaternary ammonium compounds interact with the negatively charged surfaces of microbial cells, resulting in permeability changes that destroy the organism. The combination of these agents in some formulations enhances the spectrum of activity against various pathogens. Also, the development of gel matrices that maintain high alcohol concentrations while ensuring user-friendly application has proven effective in reducing pathogen load. Spray formulations have gained popularity, allowing for easy coverage of hands and surfaces alike (MATHAI et al, 2010).

The development of touchless and automatic dispensers, formulations with added emollients to prevent skin irritation, and the introduction of colored formulations that provide visual feedback on application have all contributed to improved compliance among healthcare workers. Recently, some dispensers are equipped with technology that tracks usage patterns, providing healthcare facilities with critical insights into their hand hygiene performance. This data can drive targeted interventions, ensuring that healthcare professionals adhere to best practices.

CHANGING PRACTICES IN THE OPERATING ROOM

The routine of preparation for surgery evolved through the years into a standardized practice called scrubbing: a set of steps developed from the basic technique initially employed as a simple hand washing, aiming to deeply disinfect the hands before dressing gloves and gowns. The real goal is not to turn the skin aseptic, which is virtually impossible, but to minimize the presence of microorganisms, reducing the risk of surgical site infections. The washing technique is performed with an antiseptic solution applied to a brush (usually chlorhexidine or povidone-iodine) that scrubs hands and forearms, up to the elbows, for 10 minutes, focusing on each finger, the spaces between fingers, and under the nails. After scrubbing, the hands and forearms are thoroughly rinsed with running water and dried using sterile towels. This is a process taught in all medical schools and repeated before every surgical procedure, moving from ¨dirty hands¨, in the offspring of surgery, to ¨as clean as possible¨ nowadays. On the other side, surgeons pay the price of disinfection by damaging their skin with rashes and allergies caused by the repetitive scrubbing (LARSON et al, 2006).

While many still consider brush-scrubbing the gold standard on hand sanitation, the 21st century brought to light new products that do not require brushing, while are still powerful in killing germs off the skin and protecting it from lesions. Those products reduce the scrubbing effort to a two-step procedure: hand wash with a pH neutral lotion (such as Softaskin®) followed by a disinfectant ethanol-based (like Softalind®), for a time no longer than 5 minutes. It is the science of the transient truths proving its rule once again. Who knows what the future holds in terms of preventing surgical contamination!

LESSONS LEARNED FROM COVID-19 PANDEMIC

The COVID-19 pandemic has profoundly reshaped the landscape of hand hygiene practices everywhere. Prior to the pandemic, adherence to hand hygiene protocols varied across institutions, often influenced by lack of awareness. The crisis underscored that effective hand washing is not merely a routine practice but a vital component of patient care, necessitating a reevaluation of existing guidelines and practices.

In response to the pandemic, healthcare facilities adopted stricter protocols, leading to the widespread integration of alcohol-based sanitizers in various environments. Studies conducted during this period demonstrated that when used appropriately, hand sanitizers could significantly reduce pathogen load, making them an indispensable tool in infection control efforts. In the operating room, scrubbing techniques were not affected during that time. However, many practices were adopted for personnel safety while handling patients, markedly during airway maneuvers, such as intubation (GOLIN et al, 2020).

Regulatory standards and guidelines for hand sanitizing were also revisited in light of the pandemic. The World Health Organization and the Centers for Disease Control and Prevention updated their recommendations to emphasize the need for accessible hand hygiene solutions in all healthcare settings (PRAJAPATI et al, 2022). These updates aimed to reinforce the message that hand sanitization is a shared responsibility among healthcare professionals, patients, and visitors, ensuring a collective effort in safeguarding patient health, going back to 1847, the whole world doing that Semmelweis observed, taught, advocated and died for.

CONCLUSION

The challenges for hand disinfection have always been the same: which is the most efficient biocidal for maintaining good medical practice against multi-resistant microorganisms that are safe for hands, carrying no toxic effects in long-term use, while providing pleasant personal hygiene. This brief historical article, covering three centuries of medical evolution reinforces the message that hand sanitization is a shared responsibility among healthcare professionals, patients, and visitors, ensuring a collective effort in safeguarding patient health. Looking back to 1847, the whole world is doing that Semmelweis observed, taught, advocated and died for.

DISCLOSURE

Both authors state that they have no conflict of interest with any pharmaceutical company or brand mentioned in this article, regarding disinfection and sanitation. The use of names from commercial products was done merely with the purpose of exemplifying and sharing observations done during the professional work developed in the healthcare facilities where the authors attend for working.

REFERENCES

Ataman AD, Vatanoğlu-Lutz EE, Yıldırım G. Medicine in stamps-Ignaz Semmelweis and Puerperal Fever. J Turk Ger Gynecol Assoc. 2013 Mar 1;14(1):35-9. doi: 10.5152/jtgga.2013.08. PMID: 24592068; PMCID: PMC3881728.

Pittet D, Allegranzi B. Preventing sepsis in healthcare - 200 years after the birth of Ignaz Semmelweis. Euro Surveill. 2018 May;23(18):18-00222. doi: 10.2807/1560-7917.ES.2018.23.18.18-00222. PMID: 29741152; PMCID: PMC6053623.

Bhopal RS. Concepts of Epidemiology: an integrated introduction to the ideas, theories, principles and methods of epidemiology. Oxford University Press Inc. New York: 2002. Page 101 – 103.

Michaleas SN, Laios K, Charalabopoulos A, Samonis G, Karamanou M. Joseph Lister (1827-1912): A Pioneer of Antiseptic Surgery. Cureus. 2022 Dec 21;14(12):e32777. doi: 10.7759/cureus.32777. PMID: 36686094; PMCID: PMC9854334.

Lepenos T, Sanoudou D, Protogerou A, Laios K, Androutsos G, Karamamou M. Louis Pasteur (1822-1895), Ignaz Semmelweis (1818-1865), Joseph Lister (1827-1912) and the Link Between Their Works Toward the Development of Antisepsis: A Narrative Review. Cureus. 2024 Jun 17;16(6):e62543. doi: 10.7759/cureus.62543. PMID: 39022474; PMCID: PMC11254094.

Lakhtakia R. The Legacy of Robert Koch: Surmise, search, substantiate. Sultan Qaboos Univ Med J. 2014 Feb;14(1):e37-41. doi: 10.12816/0003334. Epub 2014 Jan 27. PMID: 24516751; PMCID: PMC3916274.

Lathan SR. Caroline Hampton Halsted: the first to use rubber gloves in the operating room. Proc (Bayl Univ Med Cent). 2010 Oct;23(4):389-92. doi: 10.1080/08998280.2010.11928658. PMID: 20944762; PMCID: PMC2943454.

Hans M, Lugani Y, Chandel AK, Rai R, Kumar S. Production of first- and second-generation ethanol for use in alcohol-based hand sanitizers and disinfectants in India. Biomass Convers Biorefin. 2021 May 27:1-18. doi: 10.1007/s13399-021-01553-3. PMID: 34075327; PMCID: PMC8155184.

Paul Hartmann AG, website access at https://www.sterillium.info/en/why-hand-hygiene-programmes/the-history-of-hand-disinfection (accessed in October 17, 2024)

McDonnell G, Russell AD. Antiseptics and disinfectants: activity, action, and resistance. Clin Microbiol Rev. 1999 Jan;12(1):147-79. doi: 10.1128/CMR.12.1.147. Erratum in: Clin Microbiol Rev 2001 Jan;14(1):227. PMID: 9880479; PMCID: PMC88911.

Pittet D, Allegranzi B, Storr J. The WHO Clean Care is Safer Care programme: field-testing to enhance sustainability and spread of hand hygiene improvements. J Infect Public Health. 2008;1(1):4-10. doi: 10.1016/j.jiph.2008.08.006. Epub 2008 Oct 27. PMID: 20701840.

Mathai E, Allegranzi B, Kilpatrick C, Pittet D. Prevention and control of health care-associated infections through improved hand hygiene. Indian J Med Microbiol. 2010 Apr-Jun;28(2):100-6. doi: 10.4103/0255-0857.62483. PMID: 20404452.

Larson E, Girard R, Pessoa-Silva CL, Boyce J, Donaldson L, Pittet D. Skin reactions related to hand hygiene and selection of hand hygiene products. Am J Infect Control. 2006 Dec;34(10):627-35. doi: 10.1016/j.ajic.2006.05.289. PMID: 17161737.

Golin AP, Choi D, Ghahary A. Hand sanitizers: A review of ingredients, mechanisms of action, modes of delivery, and efficacy against coronaviruses. Am J Infect Control. 2020 Sep;48(9):1062-1067. doi: 10.1016/j.ajic.2020.06.182. Epub 2020 Jun 18. PMID: 32565272; PMCID: PMC7301780.

Prajapati P, Desai H, Chandarana C. Hand sanitizers as a preventive measure in COVID-19 pandemic, its characteristics, and harmful effects: a review. J Egypt Public Health Assoc. 2022 Feb 8;97(1):6. doi: 10.1186/s42506-021-00094-x. PMID: 35133535; PMCID: PMC8823197.