

## The Role of Hand Hygiene Compliance in Preventing Diseases

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Received: 17.08.2024

Revised: 13.09.2024

Accepted: 04.10.2024

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### ABSTRACT

Infections transmitted via the hands of healthcare workers are responsible for tens of millions of patient deaths every year. However, this can be prevented by the life-saving act of hand hygiene. It is concluded that ways must be found to ensure compliance with hand hygiene in the hospital scenario, as specific training and sensitization are recognized as obstacles to adherence. Mention can also be made of factors such as work overload and limited staff, which restrict hygiene. Strict adherence to hand hygiene is the only solution to mitigate this preventable infection. However, adherence does not always guarantee the effectiveness of the activity. Hand hygiene practices contribute to the reduction of cross-infection, especially of multi-resistant microorganisms, being simple, effective, and inexpensive measures, which can be harmful to preventing them from performing well, thus requiring the implementation of new strategies that aim for safe and responsible health habits. Actions should be taken by the health team in the promotion of hand hygiene, as their perception of patient safety is critical to modifying their care habits. It should also be emphasized that hand hygiene should be provided to visitors at the hospital, as their compliance can reduce the risk of hospital-acquired infections, contributing to the safety of individuals living in this environment. Currently, programs are available that teach the basic steps and importance of correct hand hygiene. This review aims to address the role of hand hygiene compliance in preventing diseases.

**Keywords:** Hand hygiene, Preventing diseases, Hygiene compliance.

### 1. Introduction to Hand Hygiene

One of the foremost activities to prevent the spread of diseases is hand hygiene, which necessitates washing or sanitizing hands with water or a suitable substance to eliminate bacteria and viruses (1). Effective hand hygiene is crucial at all times, particularly during patient care, as it is confirmed to be the most effective method of halting healthcare-associated infections (2). It also helps to reduce the microbial count and the probability of organisms being transmitted from one patient to another, particularly in surgical environments (3). A thirteen-fold increase in hand hygiene compliance rates is likely to reduce infections, taking into consideration the

transition in expectations from complicated interventions to simpler improvements (4). This raises the need for hand hygiene compliance and highlights the relevance of the available discussion on this subject (5).

Hand hygiene has hardly received attention in the past, and it is only in recent times that we have begun to appreciate the significance of hand cleaning and decontamination (6). It is hardly possible to come across older documents and narratives discussing hand hygiene. However, recently, there has been a change in mindset and attitude due to the substantial role it plays in preventing infections (7). Hand contamination is a major public health issue, as there is a chance of spreading infections such as pneumonia and respiratory infections to others (8). The practice of hand hygiene currently has implications. Previously, because the relationship between the two was not understood, less consideration was perhaps given to hand hygiene practices. Any substantial measures or activities to address the hand hygiene issue, including the methods used and the amount of money spent, will necessitate a better understanding (5). This review aims to address the role of hand hygiene compliance in preventing diseases.

### 1.1. Definition and Importance

Hand hygiene is the process and method in infection control, which is vital in reducing germ transmission (9). Hand hygiene is mainly divided into two practices: hand washing with soap and water, and using alcohol-based hand sanitizers (10). The importance of hand hygiene is to reduce the spread of communicable diseases; touching hands is the number one way that germs are spread. Hand hygiene practices could reduce the bacteria on palms by 47% and prevent gastrointestinal diseases by up to 31% (5). With good hand hygiene practices, it could reduce the frequency of colds, flu, and stomach illnesses by up to 50%. Furthermore, hand hygiene not only keeps one from getting sick, but also reduces the spread of infectious diseases to others by acting as the “do not disturb the germ” system (11).

Practicing good hand hygiene could save lives. In the 19th century, many women died from childbed fever due to poor hygiene practices (6). To lessen the number of women suffering, it was encouraged to wash hands with chlorine before delivering a newborn. Through this three-month experiment, it was discovered that hand washing could reduce women's death rates by 95% (5). This discovery has shown everyone that “washing our hands could save or take our lives or the lives of others.” (12). Despite this, there have been a number of misconceptions leading to poor hand hygiene practices, including the belief that catching certain diseases will make the body resistant to those diseases; for instance, Bovine Tuberculosis (13). Even though it was not spread through milk, the germs were excreted through fingers, which can be spread to various surfaces. For such reasons, hand hygiene practices are vital (4, 14).

## 2. Transmission of Diseases through Hands

Transmission of infectious diseases is frequently dependent on contaminated hands serving as vectors that link pathogens to subsequent hosts (14). Pathogenic agents, or germs, can be introduced to hands from a variety of different sources such as contact with contaminated environmental surfaces, sick patients, sick animals, and food, water, or air. Germs may survive for extended periods of time in the environment (15). Hands function as the intermediary agent in hastening the transfer of germs from a range of different surfaces (16). Germs can then be introduced to subsequent hosts on the hands by an individual's own direct contact, contact of others with the contaminated hands of an individual, or by the aerosolization of germs during behaviors involving the hands (17). After germ transmission to the hands occurs, the germs can subsequently be introduced to the nose and mouth when individuals touch their own face (18).

Consequently, the hands represent a critical proximity space where germs may enter the host in diverse situations ranging from sniffles to epidemics (19). Research and experiences in a number of high-risk environments such as healthcare and other facility settings, as well as measures of behavioral interventions, provide ample evidence for the effective role of hand hygiene in breaking the chain of infection that begins with contact with germs and ends with symptomatic illness (20). Behaviors of the hands manipulating the facial T-zone, which includes the eyes, nose, and mouth, may increase the opportunity for germs to access these proximity spaces (21).

Many people touch their faces repeatedly throughout the day. According to one study involving a group of medical students who volunteered to have their facial contacts counted, students had an average of 23 facial contacts per hour, with the majority involving contact with either the nose, mouth, or eyes (22). Reduced contamination of the hands may lead the individual to only infect themselves with the germs, rather than transmitting the germs to other subsequent hosts (23). Even where the only hand contact is with environmental surfaces, research shows substantial risk associated with scenarios where hands touch highly contaminated surfaces in conjunction with times when the hands are contacting the T-zone (24). Nearly all human environments and situations involve hands that will regularly come into contact with a range of differing surface (17). However, depending on the settings, the opportunities to come into contact with surfaces that may be contaminated with germs will vary. In some situations, many different people may be present, and this can lead to a high frequency of hand contact with germs or contaminated surfaces (25).

This can be especially true in public areas such as mass transit, retail stores, etc. Furthermore, there are a number of high-risk environments where either the consequence of infection or the implementation of a barrier is required (26). These include healthcare facilities, residential and commercial kitchens, daycares and schools, veterinary facilities, and animal care environments, and many others (27). From a pathogen perspective, there are at least two different transmission pathways by which germs can be delivered to the host: direct and indirect transmission (28). Hands function as the critical limitless agent for both of these transmission types.

### 2.1. Common Pathogens

It is widely recognized that hands are an important vehicle in the transmission of microorganisms that are capable of causing serious illness (29). Many common pathogens are transmitted by contaminated hands (30). The types of pathogens that are spread by hands can be divided into bacteria, viruses, and fungi (31). Many of the most common causes of foodborne disease outbreaks are spread from person to person directly, or as a result of touching a communal item or surface without proper hand hygiene (32). There are a few common culprits that fall into these categories, including bacteria such as *E. coli*, norovirus, and bacteria such as *Salmonella*, *Shigella*, and hepatitis A. Others include bacteria or fungi, including *Staphylococcus aureus*, or bacteria such as *Clostridium difficile* (33).

Simply put, proper hand hygiene may make the difference between causing or not causing harm to another person (34). Quite often, the illness that can result from causing harm to others is diarrhea, sometimes accompanied by other symptoms such as nausea and vomiting (35). However, the organisms listed include some that historically have caused more devastating, severe disease, such as rapid dehydration and death (36). Also, organisms that may not infect you or cause you to become ill may still get on your hands. They may also be the responsible cause of sporadic or cluster cases from time to time whenever they are not adequately treated with appropriate antimicrobials (37). The importance of recognizing these various microorganisms that could contribute to this type of disease transmission is so the barriers to their transmission could be accurately addressed in preventive measures (38).

### 3. Effectiveness of Hand Hygiene

Studies have provided evidence that proper hand hygiene compliance can reduce infection rates in different settings. Several studies have demonstrated a reduction in the risk of healthcare-associated infections as a result of improved hand hygiene compliance among healthcare workers. Research suggests that in community and healthcare settings, the use of alcohol-based hand sanitizers may be as effective as, or more effective than, handwashing with soap (39).

Two types of hand hygiene techniques are considered to be effective in reducing the risk of spreading infectious diseases: traditional handwashing with soap and water, and using alcohol-based hand sanitizers (34). It is often recommended that the preferred method of hand hygiene is according to the setting and whether hands are visibly dirty (5). The optimal method for hand hygiene depends on several factors, including the setting in which the technique will be performed, the infectious agents that may be present on an individual's hands, and the amount of dirt and grime that exists on the hands (34).

Proper hand hygiene techniques are of limited effectiveness against soils of organic origin, whereas proper decontamination techniques are of limited effectiveness against organic soils (40). Proper frequency of hand hygiene activities is essential for controlling the spread of infectious diseases. Regular maintenance of proper hygiene is equally important. People may be encouraged to use a systematic approach to good hygiene rather than performing it haphazardly (41). Effective use of alcohol-based hand sanitizers requires consistent use of leave-on products that are not rinsed off for a minimum of 15 seconds to effectively destroy transient pathogens. It is important to note that if an individual does not apply reagents properly, the risk of pathogen transmission is less likely to be reduced (42).

Compliance with a vigorous hand wash program should lead to fewer illnesses than if compliance was lackadaisical. Hygiene practices such as regular and proper cleanliness leading to a change in culture are those that are most likely to succeed in one-and-done intervention studies (43).

Thus, compliance with hand hygiene practices can reduce the risk of transmission of certain diseases in the community as well as the risk of nosocomial infections in the hospital setting (44). Modeled probabilities of acquiring a nosocomial infection are highly dependent upon the practices and commitment of healthcare workers demonstrated at all levels that are involved and committed to patient safety (45). Only by instituting an effective, comprehensive program that becomes a part of the culture of an institution can healthcare organization "tame" the monster of nosocomial infections and establish a system that goes beyond just compliance but is centered in the decades-old tenets of "do no harm." (46).

#### 3.1. Types of Hand Hygiene Products

There are many types of hand hygiene products available, such as traditional soaps, antimicrobial soaps, soaps with emollients, alcohol-based hand rubs, and waterless, instant antimicrobial products (47). Traditional soaps

are broad-based cleansing products that use water to create lather to remove soil and transient or resident microorganisms from the hands. Bar soaps and liquid soaps are the most commonly used traditional products. Bar soap usually consists of animal or vegetable fats treated with alkaline and scented and colored with botanicals or essential oils. Liquid soaps are basically the same but usually a combination of tallow, coconut, and palm oils and contain synthetic surfactants (48).

Alcohol-based hand sanitizers are products that contain an alcoholic ingredient such as ethanol, isopropanol, or n-propanol in a concentration that is a potent virucidal, bactericidal, and fungicidal (49). Alcohols destroy pathogens, including viruses, by denaturing the protective outer proteins of microbes and dissolving their membranes. While all of the different types of hand hygiene products by definition contain ingredients that help to reduce the numbers of germs on the hands when used correctly, they also have relative effectiveness in comparison to one another, and the situation dictates the product used (50).

The take-home message here is that while many products remove dirt and/or kill or remove microorganisms, the product of choice varies as to the situation. Thus, products must be readily available, easy to use, not irritating to the hands, and, of course, not overly costly (30).

Despite the many options available to consumers, reliance on a select number of products, such as antimicrobials, is common (51). The experience of users in trials of various hand hygiene products can differ significantly. Innovations in this area have often emphasized both convenience and effectiveness (52). For example, there have been developments in foaming and gel rinse alternatives that aim to improve the user's experience by creating thick, lathering rinse-off products that effectively combat pathogenic bacteria and viruses on the hands (53). Research has shown that the choice of hand hygiene products can impact a user's compliance rates, especially in places like healthcare settings, and therefore plays a crucial role in reducing the spread of diseases (54).

#### **4. Hand Hygiene Compliance in Healthcare Settings**

Healthcare-associated infections (HAIs) following patient care are a significant worldwide problem. Such infections can be mitigated by the prevention of pathogens that play an important role in their spread (2). Hand hygiene compliance among healthcare workers is one of the parameters that can cause HAIs. Effective hand hygiene practices have been adopted as a means to decrease cross-transmission and to avoid healthcare-associated incidences of illness or infection (56). It has many impacts not only on hospital-acquired infections but also on the safety of patients. Healthcare workers' compliance with hand hygiene regarding procedures and practices has a great impact on the spread of healthcare-associated diseases and on cross-infection (57).

Healthy behaviors and routine cleaning and use of hand sanitizers by healthcare workers significantly reduce the risk of contracting dangerous viruses (2). The compliance rate in Europe was, on average, 47% worldwide, while the lowest in Africa was 37% (58). This difference in compliance rates is significant and varies in terms of the working conditions of the health institutions providing protection (59). Practical interventions have included behavioral variables such as policies for institutional provision procedures that allow facilities to create favorable environments for handwashing to maximize availability (60). Healthcare workers have also utilized educational campaigns and training on hand hygiene practices and conducted full-scale assessments and retraining after the quarantine effect of hand hygiene practices (57). In situations where, human resource allocation and working conditions are unpredictable, the association between hand hygiene practice effects and work-related variables is scarce (61).

An individual who values compliance with hand hygiene policies of a hospital organization enters the structure of the hospital (62). This mindset affects compliance. Healthcare professionals wash and clean their hands less often when they are worn out or working under heavy workloads. However, non-compliance varies across cultures and is influenced by the environment (64). The views of the head nurse, team, and supervisors on hand health management and attitudes are important in explaining hand hygiene. Staff wash and wipe their hands more because senior nurses prioritize the idea of hand hygiene and the belief that high-level nurses do the right thing when promoting each other for compliance (65).

Several interventions have sought to improve compliance with hand cleanliness, of which evidence-based prevention is the most effective way to significantly enhance hand hygiene (66). Tools for patient care hygiene include small gifts, promotions, motivation, compliance, and reminders for hand hygiene (44). Tools for patients in the ICU have effective techniques for conducting interpersonal and environmental relaxation and investigation. Continuing training for nursing institutions is foundational, and many programs on employee protection and good management will be assessed in nursing institutions (67). Compliance and prevention among nursing hospital personnel must be a priority to minimize injury (68).

#### **4.1. Barriers to Compliance**

In health care settings, a number of barriers or reasons for not complying with hand hygiene have been presented in recent years, closely associated with system problems or staff perceptions (63). Some of the systemic barriers can be easily improved if researchers or managers identify them. Related to compliance is

adherence or the behavior of "cleaning" one's hands according to established guidelines and the five indications for "cleaning" one's hands with alcohol-based hand rub or soap and water (34). Compliance is the conformance of an individual to rules, regulations, and guidelines with minimal knowledge or awareness of the significance of such actions (69). Demographic and sociocultural characteristics, gender, or religion are also barriers to hand hygiene compliance by health workers and other associates or support staff. Some perceived barriers to hand hygiene compliance are not just related to individuals or personal characteristics, but are strongly influenced by systemic issues commonly facing the staff complying with hand hygiene, such as lack of knowledge, education, and research about the product properties (70). These reasons can even prevent staff from correctly understanding the differences between a branded and a generic alcohol-based hand rub. Therefore, all attempts and interventions to improve hand hygiene compliance must include organizational and management issues when improving facilities and supporting an improvement in systemic failures that are either real or perceived (71). In general, interventions must be based on the perceived beliefs and barriers of the individual staff. They must also encompass a leadership role within the organization. In facilities where the manager prioritized hand hygiene, staff compliance markedly improved (72).

## **5. Hand Hygiene Promotion Strategies**

### **5.1. Education and Training Programs**

Each organization studied provided training in hand hygiene through a combination of training and education techniques (73). The types of training used in health care organizations can be divided into five broad categories: program components, training methods, evaluation, frequency, and surveillance methods (74).

Organizational effectiveness research has established the role that training and development play in success. Knowledge, skills, abilities, attitudes, and other characteristics are incorporated into training models to measure and increase these traits in employees (75). Knowledge increases directly from training. Using learning model perspectives could result in training changes that minimize stress for health care workers (76). These models supply workers with the information needed for a new function. Workplace learning improvements as a result of training lead to more efficient organizational outcomes (77). Employee performance and every worker's response are strengthened by improved learning, allowing for both improved health care abilities and employee wellness (78). More frequent refresher training may allow an increase in education and health outcomes. Knowing the patient care effects of hand hygiene and the expected effects on patients of improved health care knowledge and practices are important insights. The findings of examinations or extended training programs could provide greater knowledge of hand hygiene problems and practical solutions for health care professionals (79). Staff in the departments of infection prevention use a variety of teaching and training strategies to deliver hand hygiene training to doctors, health care providers, and others, such as managers (80, 81).

## **6. Technological Innovations in Hand Hygiene**

Automatic wall-mounted touchless dispensers are technologically savvy soap dispensers that provide liquid and foam options and are formulated without any triclosans, parabens, or dyes. An automatic light sensor on the outside and a designed refill with built-in sensors are used by these dispensers, so people know the level of soap they are dispensing, giving a constant signal of "green, yellow, and red" (82, 83). The inside portion gives the facility a display of the remaining soap supply in the refill, as well as a notification when the refill is low, to help maintain the dispensers filled to capacity at all times (84). Sensorization, or converting a manual faucet to a sensor-operated sink, completely eliminates the need for patrons to touch handles, making sensorization one of the easiest hand hygiene improvements. Involving users more actively and effectively improving visibility, sensorization also helps to improve hand hygiene compliance. Apps are available for download that provide targeted reminders for hand hygiene (85). The production of reminders occurs at specific times, as well as for specific lengths of time, for both patients and HFMs, as well as for events. By providing visual cues to help reinforce the need for constant hand hygiene, some hospitals use time-of-day digital window coverings and programmable lighting displays (86, 87).

They can also be utilized to show critical process metrics and include special displays for service awards, birthdays, and other events. Technology can also help to track and report hand hygiene through either wearables, RFID, or ultrasound (88). By incorporating hand hygiene into the culture of the workplace, the only thing that really works well is a combination of oversight, training, feedback, and reminders followed by counseling, and, if necessary, disciplinary measures (89). In addition, many facilities use reward and recognition programs that integrate hand hygiene with Singing for Health. By recording Clean Fact videos in their facilities, employees can actually earn concert tickets. In order to win more credits for the company, the objective of the game is to have employees be healthy and clean by correctly performing hygiene tasks (44).

Building a new hospital with technology in mind is beneficial because the cost of technology can be integrated as savings from other sources. It's also assumed that all employees are comfortable using digital tools in a single facility. Since the fastest way to build a new wing overnight is using current construction practices as quickly as possible, using new tools at existing facilities is not going to help. 90While most of the items mentioned in this

report lack hard evidence, efforts are being made to find that proof. There is currently a pilot of some of the hospital's best technologies in a real-world setting to evaluate them (73). While a lot can now be done to make a hospital run more effectively with the power of the Internet, caregiving will continue to rely on the human touch and high quality of care for its operations, all of which may make some choose not to undertake cleaning technologies. The final decision should be taken wisely and, on a case, -by-case basis (91).

### **6.1. Touchless Dispensers**

Touchless dispensers are a fast-growing part of the hand hygiene technology market. They come in a variety of available dispensers, including soap, sanitizer, double bed, foam, mousse, glow foam, scalp, and towel dispensers, and offer several advantages (92). Most commonly, the touchless technology is used to reduce or eliminate cross-contamination of the original product guests use to clean and wash their hands. This not only protects the original product, ensuring that it is always in working condition, but also keeps the product attractive for later guests so they are encouraged to use it as well (93). The user often appreciates the convenience of these devices and may be more likely and encouraged to use these systems more often than non-touchless systems. As a result, there are many practical and financial reasons to promote touchless technology in the field of hand hygiene (94).

Studies have been conducted to test the efficacy of touchless dispensers, and the results have been overwhelmingly positive in terms of demonstrating compliance with proper hand hygiene maintenance (95). It was found in a "real-life" hotel setting at a large casino hotel that touchless soap and towel dispensers were successful in promoting hand hygiene compliance. It was noted that the products' benefits were offset by their initial cost, particularly due to their location in a 24-hour operation that catered to thousands of guests per day, presenting the need for pre-placement of products in offsite storage lockers in order to minimize ordering and delivery time (96, 97). Furthermore, it was noted that the availability of compatible goods to supply the dispensers was sometimes scarce (98).

## **7. Hand Hygiene Compliance Monitoring**

Hand hygiene is an essential tool in infection prevention and plays a role in preventing the spread of diseases and improving patient health. Despite the importance of this behavior, hand hygiene compliance is often poor in many healthcare settings (99). To improve compliance, hand hygiene practices must be monitored to identify areas for improvement. However, there is no clear consensus regarding how to monitor hand hygiene practices. Both observational and electronic monitoring strategies have their strengths and limitations, and to be effective, they must be accompanied by feedback mechanisms. However, electronic monitoring strategies can collect more data (34, 73).

One of the oldest methods of monitoring hand hygiene compliance is through direct observation. This can be done informally or following a standardized format, but generally involves one or more observers using a checklist to look for specific actions (100, 101). This directly observed data can then be used to calculate a compliance rate, usually by dividing the number of hand hygiene events by the number of potential hand hygiene events observed. One of the primary tools for monitoring hand hygiene compliance is electronic monitoring and feedback systems (102). These systems are often housed in a small device installed near patient beds or in patient and procedure rooms that trip when healthcare workers perform hand hygiene. Because this type of monitoring can be continuous, it offers several tools to use observational data in a variety of ways that are suited to the facility's needs (44). To understand how the electronic hand hygiene monitoring approach is being used in healthcare and how well the technology functions and supports the overall objective of hand hygiene, this protocol will allow the hospital to target rooms, develop staff, and implement hand hygiene efforts (73, 103).

### **7.1. Methods and Tools**

To more effectively monitor and encourage hand hygiene compliance within healthcare systems, a variety of methods and tools have been developed to measure staff behaviors. The following section introduces a selection of direct and indirect tools and methods proposed, categorizing them as self-reported compliance, compliance monitored through observation, and automated compliance monitoring. This is not an exhaustive list but provides a snapshot of the range of possible methods (104, 105).

#### **Self-Reported Methods**

One method for monitoring compliance that requires less labor is to ask staff to report back on their own compliance with hand hygiene guidelines. This method can be complemented by survey research that focuses on healthcare workers' perceptions and attitudes toward hand hygiene (106, 107). There are multiple forms of proxy measures for self-reported questionnaires that focus on the staff members' attitudes toward hand hygiene rather than their actual behavior, including the Hand Hygiene Beliefs Scale as well as the Hand Washing Questionnaire (108, 109). When combined with direct observations, this method could be used to minimize the

blind spot created by low levels of implied compliance and perceived high compliance. Other methods of self-reported means include the Staff Perception Survey and the Global Patient Safety Challenge Hand Hygiene Self-Assessment Framework (110).

### **Compliance Through Observations**

The most common method used within studies is direct observation to monitor compliance with hand hygiene guidelines. Direct observation is considered the gold standard of compliance monitoring within healthcare (111). In 2002, it was recommended that direct observation should be used to collect data regarding compliance rates within healthcare facilities. Automated compliance systems - Within the past few decades, a variety of companies have developed automated compliance systems to make it easier to monitor (112, 113). Some systems use RFID technology, while others use barcode scanning or video surveillance to record an individual's hand hygiene actions. Data is then analyzed in software or cloud-based programs.

#### **Implications of system data**

The conclusions of two systems differ and propose very interesting differences with implications for policy and the training of medical staff at a healthcare facility (100, 114). Necessary for accurate measurement: The bottom line is that to adequately measure hand hygiene compliance, not only are quantitative systems necessary, but qualitative systems must also be combined with them. Compliance measurement remains a labor-intensive enterprise, but it is vital to assuring positive patient outcomes and the opportunity to evaluate the effectiveness of patient safety programs (115).

## **8. Global Initiatives for Hand Hygiene**

An increasing number of global initiatives are ongoing around the world with the focus on improving hand hygiene actions through compliance and education in an effort to prevent the spread of HCAs (2). The first major campaign in 2005 advises five fundamental components: 1) system change at the national and international level; 2) active surveillance of HCAs by way of National Core Components; 3) monitoring hand hygiene standards of care utilizing a global mechanism for hand hygiene compliance statistics with the invitation to the world to transmit their data; 4) promoting regular health care worker training, including hand hygiene education; and 5) empowering and involving patients and their families (60, 73).

The Guidelines for hand hygiene were developed by a Guidelines Development Group and launched in 2009 (5). This development group represents over a nine-year period of multidisciplinary clinical expertise across specialist areas and widespread international geographical representation (116). The primary aim is to focus on spreading global infection prevention principles and strategies and promote key international infection prevention and hand hygiene initiatives across the globe (117). The use of the Guidelines is encouraged by translation into sought-after languages to further impact the daily lives of professionals and the public in order to raise awareness. This move is necessary if quality of care and patient safety improvements are needed or indeed expected, irrespective of the mode of disclosure (71, 62).

At present, 76% of all languages spoken in the world have been translated as a way of sharing knowledge and swapping experiences between cities and countries. A range of well-established successful initiatives have achieved relative compliance targets within various international settings. For instance, the European Regional Office, the Pan American Health Organization, and the first African nations to demonstrate support for HHC for the improvement of patient safety as our joint responsibility to support safer care (118).

### **8.1 WHO's Save Lives: Clean Your Hands Campaign**

The 'Save Lives: Clean Your Hands' campaign is designed to encourage a dialogue among all health care workers, patients, communities, occupational health services, professional organizations, ministries of health, other relevant government departments, non-governmental organizations, and international agencies - both within and outside the health care setting - on the importance of hand hygiene (119, 120).

Launched in 2009, the primary goal of the campaign is to increase global awareness and focus on the importance of hand hygiene (60). The strategies seek to assist 'clean care is safer care' teams to raise awareness of the crucial role of hand hygiene in infection prevention, as well as to ensure the sustainability of their hand hygiene programs through policy change, improved practices, and enhanced education and training (5, 34). Furthermore, the campaign provides tools and resources for different audiences that will assist in implementing, improving, and sustaining hand hygiene. The 'Save Lives: Clean Your Hands' campaign now has many different tools and products to assist with self-assessment, monitoring, and improved hand hygiene practices (71, 121).

Results from case studies of successful countries show that the campaign can increase awareness of the importance of hand hygiene in the promotion of patient safety and has had the impact of increasing the compliance of hand hygiene (122, 123). The data shows that compliance can be increased by directly involving national policy makers and key stakeholders in the improvement and monitoring of hand hygiene (71, 124).

Approaches that reach out to whole health care systems and link hand hygiene improvement with other patient safety and quality improvement activities show improved and increased results (5, 71). Implementing a

multimodal strategy at a system-wide level in a country indicates the synergy of impact achieved by engaging both health care settings, communities, and policy makers in a national or international initiative (125). The examination of international case studies shows how this campaign has grown over time and how the impact has been able to positively influence hand hygiene on a vast geographical level (126). Overall, the analysis of the campaign shows the significant impact that an international blueprint can have on infection rates of health care associated infections (127). It is hoped that the campaign and its many international products and tools will sustain these efforts in the long term, keeping both the public and the health care workers informed as to how, where, and when hand hygiene should be carried out (5, 128).

## 10. Future Directions in Hand Hygiene Research

Although there has been a great deal of research published in the past 20 years on the factors that influence healthcare workers' compliance with hand hygiene guidelines, there are still several gaps in the literature (106). An important area for future research is to further investigate healthcare workers' barriers to individualized hand hygiene compliance. Research is necessary to develop rigorous trials of behavioral interventions to determine their effectiveness at improving hand hygiene compliance (129). There are also potential improvements that can be made to the design and components of products that will make healthcare workers more willing and able to comply with recommended hand hygiene practices (130).

The faster and easier it is for a person to comply with hand hygiene guidelines, the higher the likelihood of compliance (122). One recent innovation in infection control policy is the guideline. However, the empirical evidence that has validated the effectiveness of stratifying intervention strategies on the basis of themes of healthcare worker hand presence and activity, accommodation to display format, middle panel size, and the performance of handwashing versus hand rubbing is still lacking (62). Further research is required into the cultural and religious aspects that may influence hand hygiene practices, including the use of various products and whether they are promoted in healthcare settings (131).

Interventions to improve hand hygiene are also moving into the 21st century, driven by new ideas, innovation, and technology that have emerged and are being tested. Multidisciplinary collaborative research projects, including public health, behavioral scientists, and engineers, are likely to be most fruitful, combining information from different disciplines to develop interventions that are more effective (5). The Ebola outbreak has taught us that the medium- to long-term response to public health crises does not rely on the ability to develop treatments or vaccines, but on standard infection prevention and control practices like hand hygiene (132). As such, we should be prepared to invest in both evidence and guidelines for hand hygiene. Although it cannot provide a magic bullet in hand hygiene, we can speculate about a future in which ubiquitous face recognition technologies and apps are used to monitor healthcare workers' compliance with hand hygiene—an entirely invisible intervention to the end user (133, 134).

### 10.1. Emerging Technologies

A range of new and emerging technologies can potentially aid the forward progress in the field of hand hygiene, as follows (135).

- Antimicrobial and virucidal coatings can be used on hand hygiene infrastructure, improving user compliance (136)
- New soap and hand rub dispensers are available that communicate short messages on hygiene (86)
- Mobile devices can be used as a reminder of hand hygiene. These new technologies all focus on improving user compliance. 100 Additionally, in modern society of digitalization, new technologies can help to promote a paradigm shift to user behavior change, enhanced user engagement with hand hygiene, and improved verifiable hand hygiene compliance (87).

The antimicrobial coating of hospital environment surfaces or the addition of antimicrobial surfaces has provided a reduction in infection rates in studies (137). However, ergonomically, aesthetically, and financially, in many instances, retrofitting will not be feasible in existing construction without new technologies coming online that can be incorporated into retrofitting methods or during new construction (138). Implementation of advanced technologies will prove to be crucial for driving social good in preventing these infections (139).

There are already advanced technologies in place in healthcare settings that can improve hand hygiene compliance with remarkable improvements from the base healthcare compliance level of 40% (122). The addition of mobile devices, antimicrobial coatings, smart dispensers, fully automated monitoring of hand hygiene, and the use of a remote video auditing system has provided improvements in hand hygiene compliance to greater than 90% (140). There are still improvements to be made with the decreasing use of silver-loaded coatings, and the improvements in IT continue to make hand hygiene tracking and monitoring faster, more efficient, and more accessible than in the past (141). Potential for future advancements by the development of innovative technologies that are widely adoptable for the improvement of hand hygiene should be a research priority (142). These products will serve to change the way that society views hand hygiene practices currently



in use, transforming them into new widely accepted best practices, and ultimately lowering rates of infection (143).

### 11. Conclusion and Recommendations

The transmission of pathogens spurs epidemics, hospital illnesses, and infections. This spread of diseases disproportionately affects children. The most effective way to prevent these epidemics is through improved hand hygiene compliance. Better hand hygiene compliance significantly reduces the spread of these pathological agents.

The importance of hand hygiene compliance is particularly relevant in areas with limited resources and younger populations. Indeed, the benefits could easily outweigh the costs in these program areas. Cultivating an understanding of the interconnectedness of effective hand hygiene compliance and health will foster a "culture of cleanliness," in which a lowered incidence of communicable illnesses enraptures communities. Effective hand hygiene programs must derive their focus from three main sources: education, policy, and technology. Each source is subtly but clearly connected, and together, they are greater than the sum of their parts. Stakeholders at every level must acknowledge the importance of contributing to resources and compliance to achieve the shifts in behavior needed to save lives. The implications of these findings for infection control programs, however, are less clear. Additional research is needed to further refine hypotheses regarding hand hygiene knowledge, attitudes, and behavior. Clearly, examination of all levels of a program, including training, evaluation, and how resources are allocated, is paramount. It will also be important in future works to focus on research that is longitudinal and interdisciplinary.

The impetus for this work has drawn from various motivations, including the recognition that an inadequate knowledge of how to wash one's hands and why it is important effectively negates supply-side strategies of technology provision. Given these goals, we conclude that significant investment in research on hand hygiene is a crucial public health strategy for the future. Most of all, this should be a collaborative endeavor. Tactics for preventing the spread of pathogens and treatment are inseparable; healthcare shall continue to devise intervention strategies to promote long-lasting hand cleanliness, but alliances with environmental and economic sectors are also crucial. Only a collective approach to infection control will garner progress.

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